Melvin A. Shiffman
Alberto Di Giuseppe
Editors

Liposuction
Principles and Practice

Springer

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With 352 Figures in 622 Separate Illustrations and 84 Tables

Springer

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ISBN-10 3-540-28042-1 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-28042-2 Springer Berlin Heidelberg New York

Library of Congress Control Number: 2006920795

Springer is a part of Springer Science+Business Media

springer.com

Printed in Germany

Editor: Gabriele Schröder
Desk Editor: Ellen Blasig
Production: LE-TEX Jelonek, Schmidt & Vöckler GbR, Leipzig, Germany
Cover desing: eStudio Calamar, Spain
Typesetting: Satz-Druck-Service, Leimen, Germany

Printed on acid-free paper 24/3100/YL 5 4 3 2 1 0

This book is dedicated to the memory of Francesco Di Giuseppe MD
(father of Alberto Di Guiseppe), who was a pioneer of cardiology
in Italy from 1950 to 1970.

Alberto Di Giuseppe

Introduction

This work was undertaken because there is no true "text" on liposuction that covers the gamut of techniques, indications, uses, complications, and medical legal problems. Even the term liposuction has been converted to such things as lipoplasty, liposculpture, lipostructure, lipexeresis, suction lipectomy, and suction-assisted lipectomy. This variety of terms is to attract patients to the individuals who have coined these terms or to describe a more artistic form of doing liposuction. The procedures and their variations are all (perhaps taking the glamour out of the surgery) simply liposuction.

Since 1974, when the procedure was first conceived by Arpad and Giorgio Fischer, [1,2] to its production of a variety of cannulas, suction machines, and attempts to make the surgery easier on the surgeon with power cannulas, laser assisted liposuction, external and internal ultrasound, and massage, there have been attempts to modify, improve, and extend the indications for liposuction by surgeons in a variety of specialties. The addition of tumescent local anesthesia,3 an old concept, [4-9] has improved the safety of the procedure and increased the amount of fluid that can be removed. Today liposuction is one of the most frequent cosmetic procedures performed.

Physicians performing liposuction must be adequately trained and experienced in the potential and actual complications before attempting to perform liposuction. Patient safety is the most important aspect of all surgeries, but especially cosmetic surgery, which is an elective and not a medically necessary surgery. It is, however, a psychological necessary surgery where the patient wishes to be his/hers imagined perfect body image. What patients do not understand is that cosmetic surgery may not meet his/hers expectations. This requires the surgeon to be especially careful in explaining the surgery and possible risk and complications to the patient. New technology helps to improve results but experience, care, and skill of the cosmetic surgeon, thinking in three-dimensional terms, is necessary to obtain optimal results that satisfy the patient.

Liposuction alone may not be the answer to a patient's beautification. There may be other procedures necessary to meet the patient's expectations and these must be a thorough explanation by the surgeon to the patient.

Liposuction began as a contouring procedure but has evolved into the treatment of the obese patient, gynecomastia, ptosis, macromastia, and even patients who have complications from heart disease or diabetes. Other disorders such as axillary sweat hypersecretion, lipomas, and angiomas are also potential disorders that may be treated with liposuction.

The contributors to this book have spent time and effort to present to the cosmetic and plastic surgeon as much information as possible in the techniques and uses of liposuction for cosmetic and non-cosmetic surgery purposes. There is an attempt to present broad subjects that will peak the surgeon's interest in perhaps exploring other uses for liposuction. There are still more disorders that may be treated with liposuction that have not yet been explored.

The contributors are international so that techniques and applications of liposuction that may not be in common use in the certain countries can be presented.

Liposuction is a surgery that is international in origin, in concept, and in usage. There is a need to bring together the international community of physicians to examine, evaluate, and research this procedure. It is the editors' hope that all surgeons performing liposuction will benefit from this book.

Melvin A. Shiffman
Alberto Di Giuseppe

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Preface

Liposuction surgery is one of the commonest cosmetic procedures performed in the USA. Despite its popularity there have been some poor results and even fatalities from the operation. Not enough information has been distributed to physicians and the public on the non-cosmetic applications of liposuction. Breast reduction with the use of liposuction as well as the treatment of obesity and male gynecomastia are performed regularly. There has been an evolution in liposuction as physicians have found successful treatment of a variety of other medical and surgical problems.

This book brings together all of the present known non-cosmetic uses of liposuction and shows the specific methods utilized as well as the results. The future will introduce liposuction as a treatment of other medical and surgical problems as medical knowledge and experience progresses.

Melvin A. Shiffman

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Part I
General Information

The History of Liposuction

Timothy Corcoran Flynn

1.1 Introduction

The history of liposuction [1–3] documents new innovations combined with continuous advancements to assist people in improving their genetically programmed body shape. Within the past 20 years, the medical and scientific community has come to understand the large degree of genetic influence on both weight and body shape. Family photographs of several generations document that one's body shape is largely inherited. Numerous studies have detailed the role of genetics in obesity. We know that humans for thousands of years have desired an improved appearance by noting the extensive use of cosmetics throughout time. But as time has proven, diet or exercise programs cannot address issues of localized areas of adiposity. Tumescent liposuction is needed to correct these genetic aspects of body shape.

The roots of liposuction go back to the 1920s [1]. A French surgeon, Charles Dujarrier, attempted to improve a ballet dancer's large calves and knees by using an intrauterine curette to remove the fat. An unfortunate result occurred. Other surgeons through the 1960s attempted to improve body shape by removing subcutaneous fat. Both curettage and en bloc removal were attempted but without good aesthetic results.

1.2 Initial Work

Modern liposuction was initiated with the pioneering work of two American surgeons working in Rome, Arpad and Giorgio Fischer [4, 5]. They developed the concept of the use of suction using a blunt, hollow cannula to aspirate subcutaneous fat. Some of their cannulas contained cutting abilities, and they reported good results obtained with these new instruments. The results were initially published in 1976 [6]. The Fischers can be credited with other developments such as the use of the cross-tunneling technique in which the fat is aspirated from multiple entry sites.

Pierre Fournier has done much to develop and promote modern liposuction [3]. Fournier showed an early interest in the Fischers' liposculpture technique and helped promote modern liposuction techniques to physicians all over the world. Illouz, also in Paris, favored a "wet technique" in which hypotonic saline combined with hyaluronidase was infiltrated into the adipose tissue and prior to suction removal. He felt this would reduce trauma and decrease bleeding. His techniques also included the use of blunt cannulas. He, along with Fournier, taught and promoted their techniques to physicians in multiple specialties internationally.

1.3 Dissemination of Liposuction Techniques

In 1977, while attending a meeting in Paris, dermatologic surgeon Larry Field observed the Fischers and Fournier perform liposuction using the Fischers' machine [7]. Other Americans subsequently developed an interest in the technique. A group of physicians from differing specialties received instruction from Illouz and Fournier in mid 1982. Claude Caver and Arthur Sumrall learned the technique in mid 1982 [1]. Rhoda Narins also visited Paris in 1982 and received instruction by Illouz, Fournier, and Fischer. She learned the wet technique, and she began performing small procedures after returning from Paris with instruments and a suction aspiration machine.

Interest in the field also came from plastic surgeons. The American Society of Plastic and Reconstructive Surgery sent a task force to Paris in 1982 to investigate the technique. They were interested in the potential and learned the technique from Fournier and Illouz as well. Americans Julius Newman and his associate Richard Dolsky learned the technique and taught the first American course in liposuction in Philadelphia in 1982. The first live surgery workshop was held in 1983 under the American Society of Cosmetic Surgeons and the American Society of Liposuction Surgery.

Other courses were given by Narins and by Field, particularly at the International Society for Dermatologic Surgery. Tromovitch, Stedman, and Glogau discussed liposuction in December 1983 at the American Academy of Dermatology. Liposuction presentations were also given at the American Society for Dermatologic Surgery and Plastic Surgery meetings.

Training in liposuction was available in some residency programs as early as 1984. Liposuction became a portion of the core surgical curriculum in dermatology in 1987. Several postgraduate courses were given around the country over subsequent years, being headed by Jeffrey Klein, Patrick Lillis, Rhoda Narins, and William Coleman III and Timothy Flynn.

Several societies continue to discuss, promote, and teach concepts of liposuction. Most notably the American Society for Dermatologic Surgery, the American Academy of Dermatology, and the International Society of Dermatologic Surgery discussed liposuction at their meetings beginning as early as 1984. Several special issues of journals have featured issues devoted to liposuction. *The Journal of Dermatologic Surgery* and *Oncology* featured a special issue in 1988. *Dermatology Clinics* featured several issues on liposuction in 1990 and again in 1999. *Dermatologic Surgery* featured a special issue on liposuction which was published in 1997.

Guidelines of care for liposuction were approved by the American Academy of Dermatology in 1989 and published in 1991, as were guidelines by the American Academy of Cosmetic Surgery. Additional guidelines of care for liposuction were published in *Dermatologic Surgery* in 2000 [8].

Several excellent textbooks have been published on liposuction. Narins has published a textbook entitled *Safe liposuction and fat transfer* with contributions from 32 authors [9]. Klein has published an excellent text solely authored by him entitled *Tumescent technique: tumescent anesthesia and microcannular liposuction* [10]. This textbook is up to date in its comprehensive coverage of many aspects of liposuction technique.

1.4 Key Developments

Certainly the first key development to occur was improvement in cannula design. Blunt-tip cannulas were appreciated for their ability to bypass vital structures such as nerves and blood vessels. This limited damage and decreased bleeding when liposuction was performed in the subcutaneous fat. Over time it was appreciated that cannulas could be made smaller in order to decrease trauma to the surrounding tissue. It was also found that these smaller cannulas could allow for a more complete harvest in that they were able to bypass fibrovascular structures without damaging them and increase the completeness of fat removal. This trend culminated in the development of some very small cannulas, some of which were as small as 20 gauge in size, such as those developed by Klein. These small cannulas were found to have advantages allowing greater finesse, allowing more complete fat removal, and allowing easier penetration with less pain [10].

Individual liposuction surgeons have different preferences for different cannula designs. Some liposuction surgeons prefer an aggressive, more open-tip design, which can be helpful when large-volume liposuction is performed. Other surgeons prefer to harvest the fat in a slower, more delicate manner using the smaller cannulas. Most liposuction surgeons appreciate the decreased trauma that the smaller blunt-tipped cannulas provide.

The most significant development in modern liposuction is the use of tumescent anesthesia [11]. This technique has revolutionized the field of liposuction for all specialties. Klein [12] reported on his development of tumescent anesthesia and published his work in 1987. His discovery showed that the infiltration of very dilute solutions of lidocaine containing epinephrine could allow for more extensive liposuction totally by local anesthesia with significantly reduced bleeding [13]. Klein demonstrated that very little blood was to be found within the aspirate. Using his technique of tumescent liposuction, there was a very low incidence of hematoma and seroma formation. This was found to be an extremely safe method of performing liposuction, and general anesthesia or heavy sedation was not necessary.

Klein further demonstrated the safety of the tumescent anesthesia by demonstrating that when lidocaine is used as a dilute solution of 0.05% lidocaine containing 1:1,000,000 epinephrine, does of up to 35 mg of lidocaine per kilogram of body weight were safe and effective [14]. This technique allowed increased amounts of fat to be safely and comfortably removed using only this local anesthetic technique.

Studies by other liposuction surgeons detail that the maximum tumescent safe lidocaine dose is greater than 35 mg of lidocaine per kilogram of body weight. Ostad [15] proposed that the maximum safe tumescent lidocaine dose was 55 mg/kg. Lilles felt that the maximum allowable dose was above 35 mg of lidocaine per kilogram of body weight. Butterwick [16] showed that the rate of infusion of the tumescent anesthesia was independent of plasma lidocaine levels.

There have been several studies that have demonstrated that modern tumescent liposuction, using only dilute solutions of local anesthesia, is an extremely safe procedure. There have been numerous reports documenting the safety of this technique. Studies directed by Hanke [17] and Bernstein [18] have shown very few complications when tumescent liposuction is performed correctly. A recent study by Housman [19] has clearly documented the safety of tumescent liposuction. In this study, 505 dermatologic surgeons were surveyed, asking for their incidence of serious adverse events (SAEs). A total of 66,570 procedures were reported upon, and there was an SAE rate of 0.68/100 cases. No deaths were reported. This study clearly demonstrates that the procedure is safe and without risk if tumescent liposuction is performed properly.

There have been several reports of the dangers of liposuction and several reports reporting on fatalities from the technique. These cases very often were carried out under general anesthesia or when large volumes of fluid were used. It is the opinion of many liposuction surgeons that the dangers of liposuction are minimal when proper technique is used using only dilute solutions of local anesthesia. Complications may occur with heavy sedation or general anesthesia, large volumes of liposuction, large volumes of fluid, or when extensive liposuction (megaliposuction) is performed. When intravenous fluids or general anesthesia is used, patients may experience fluid overload with the possibility of pulmonary edema. Unconscious patients can experience pulmonary embolism and thrombophlebitis. Furthermore, tumescent liposuction performed in the outpatient setting appears to be safer than those procedures performed in the hospital environment [20].

1.5 Refinements

Two variations in instrumentation have been developed. Ultrasonic liposuction was developed in Europe in the early 1990s, having been introduced by Zocchi [21]. The concept was that adipose cells could be treated with ultrasound energy, presumably breaking up their cell walls and facilitating fat aspiration. The American Society of Plastic and Reconstructive Surgery quickly adopted ultrasonic liposuction; however, over time, problems were found with this technique. Internal ultrasound (ultrasound tips contained within cannulas) increased the risk of cutaneous burns and seroma formation. Many dermatologic surgeons have not found any additional benefit over standard liposuction. External ultrasound devices when used before or during a liposuction procedure have not been found to be of any benefit to the patient or the surgeon. It is the feeling of the author that unnecessary complications without benefit can result from the use of ultrasound in liposuction [22, 23, 24].

Newer powered liposuction devices have been developed [24]. These are devices that use reciprocating cannulas, which facilitates the fat removal and decreases the work of the surgeon. Standard small cannulas are designed to be attached to a motor which moves the cannula in a to-and-fro motion anywhere from 2 to 7 mm forward and backward. This forward-and-backward motion helps the cannula move through the fat while the fat is being aspirated. A study has demonstrated that most patients prefer the comforting vibrations of the powered liposuction equipment over traditional cannulas.

Powered liposuction devices are largely electrically operated but some air-driven devices are also available [25, 26]. The author favors the use of powered liposuction largely because of the demonstrated increase in the rate of fat harvesting and the ease of use. Powered liposuction is particularly useful for difficult fibrofatty areas such as male pseudogynecomastia or male love handles.

1.6 New Horizons

The field of liposuction continues to expand. New areas and indications for liposuction are being developed. Most recently the use of liposuction for breast reduction has been discussed. Tumescent liposuction can be used to decrease the physical size of the breast; however, techniques have not yet been developed to significantly alter breast shape and position. Tumescent liposuction of the breast can be very helpful for relief of symptoms for women with very large breasts, and patients should be advised that they can expect a reduced breast size but with the same shape of the breast. Tumescent liposuction on the breast has also been nicely shown to be used to equate unequal breast sizes.

The use of lasers combined with liposuction is currently under development. The laser will hopefully assist in fat dissolution with the laser light helping to break up the adipocytes. No studies to date have shown increased benefit using laser-assisted liposuction.

The liposuction field will continue to evolve. New techniques and instruments are constantly being developed. In the meantime, thousands of patients are currently benefiting from modern techniques which allow safe and effective use of tumescent liposuction for improvement in body shape.

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Pathologic Disorders of Subcutaneous Fat

2

Maurizio Podda, Marcella Kollmann, Roland Kaufmann

2.1 Introduction

The subcutaneous adipose tissue plays an important role as a reservoir for energy, as insulation, and as protection against physical injury such as heat, cold, or mechanical factors. Its major components are adipocytes, fibrous trabeculae, and blood vessels. Disorders of the subcutaneous fat can be subdivided into inflammatory, dystrophic, or neoplastic diseases. The difficultly to classify cellulite and lymphedema will be categorized under dystrophic diseases of the subcutaneous fat. The scope of this chapter is not to entirely cover all diseases of the subcutaneous tissue [1–3] but rather to give of an overview of the commonest and possibly most relevant diseases for physicians performing liposuction surgery.

2.2 Inflammatory Disorders of Subcutaneous Fat

The group of diseases in which inflammation is found mainly in the subcutaneous layer is called panniculitis. Panniculitis presents as erythematous or violaceous often painful subcutaneous nodules. Clinical findings are often of little help for the determination of the different inflammatory conditions involving the subcutis. Deep biopsies of skin plus subcutaneous fat and, ideally, fascia are therefore mandatory for an exact diagnosis. Ideally biopsies are taken by incision with a large scalpel from fresh lesions as late-stage lesions may only show unspecific findings. Histologic classification of panniculitis depends on the location of inflammation and the character of the inflammatory infiltrate. In principle two different patterns of inflammation have been described, septal and lobular panniculitis; however, usually a mixed panniculitis is found with the inflammatory infiltrate being more abundant in one of the two components. A distinction between a mostly septal or a mostly lobular panniculitis is more realistic and can be rendered without difficulty at scanning magnification. In a second step the presence of vasculitis has to be assessed and third identification of the inflammatory infiltrate allows a specific diagnosis.

2.3 Lobular Panniculitis Without Vasculitis

2.3.1 Idiopathic Lobular Panniculitis (Weber–Christian Disease/ Relapsing Febrile Nodular Panniculitis)

This describes a group of diseases with subcutaneous inflammatory nodules, which histopathologically show inflammation mainly in the fat lobules. The typical patient, a woman between 30 and 60 years of age, presents with erythematous, edematous subcutaneous nodules that are symmetrically distributed at the lower legs and sometimes also arms, trunk, and face. Systemic symptoms are fever, arthralgia, fatigue, and myalgia. Involvement of organ fat can lead to focal necrosis and in severe cases to death. In some cases involvement of the bone marrow has been observed. Rothmann–Makai syndrome is a localized idiopathic lobular panniculitis that occurs without systemic symptoms.

Histopathology shows degeneration and necrosis of lipocytes and an inflammatory infiltrate with polymorphonuclear leukocytes and lymphocytes in the lobular area. For treatment a high dose of corticosteroids or other anti-inflammatory drugs such as azathioprine, cyclophosphamide, non-steroidal anti-inflammatory drugs, or tetracycline has been described.

2.3.2 Histiocytic Cytophagic Panniculitis

This is a predominantly lobular panniculitis with a characteristic infiltrate of cytophagic histiocytes with unknown etiology. Patients show multiple large subcutaneous nodules frequently with overlying ecchymosis or ulceration located on the extremities and sometimes also on trunk and face. Fever, hepatosplenomegaly, pancytopenia, weight loss, or bone marrow involvement is frequently diagnosed.

Histopathological specimens are characterized by inflammation in the lobular with involvement of the septal area. The infiltrate consists of large histiocytes, termed "beanbag cells", displaying phagocytosis of lymphocytes, erythrocytes, and platelets. The activity of the disease may be monitored by in vitro determination of phagocytosis by peripheral blood monocytes [4].

The prognosis of the disease is difficult as often lethal complications due to systemic involvement occur. For therapy, polychemotherapy with various substances has been described.

2.3.3 Physical Panniculitis

Thermal, mechanical, or chemical trauma can result in panniculitis. After acute exposure to cold temperatures newborn babies and in rare cases also infants and adults develop lobular panniculitis with necrosis of lipocytes and cellular infiltrate of neutrophils, lymphocytes, and histiocytes. It occurs localized at the exposed sites and clinically presents as indurated erythematous nodules of subcutaneous tissue. Spontaneous resolution followed by transient postinflammatory hyperpigmentation is observed.

Traumatic fat necrosis as the only reason for panniculitis is a rare event. It has been observed in the breast of obese women. Biopsy is necessary for clear differentiation from breast cancer and nodular or cystic fibrosis of the breast [5].

Injection of foreign substances into subcutaneous tissue may lead to foreign-body reaction and lobular panniculitis. Not only mineral oils and silicon have been described as causative agents, but also factitial self-injections of paint, acids, mustard, milk, and feces [3].

2.4 Lobular Panniculitis with Vasculitis: Nodular Vasculitis (Erythema Induratum Bazin)

The panniculitis appears predominately in women and presents as chronic recurrent symmetric erythematous nodules on the calf area of the legs. Ulceration of lesions is a common phenomenon. Cold weather and overweight are precipitating factors. This type of lobular panniculitis was first described in 1861 by Bazin, who observed it in association with tuberculosis. The involvement of mycobacteria as a causative agent for the disease is discussed controversially; therefore the term nodular vasculitis is used to describe all types of this specific lobular panniculitis with and without associated tuberculosis. Biopsy specimens taken from typical lesions show tuberculoid granulomas, fat necrosis, giant cell reaction, and caseation necrosis in the fat lobules. In the septal area, vessel vasculitis of venules and sometimes arterioles with inflammatory infiltrate, endothelial swelling, and thrombosis is found in early stages of disease. In later stages fibrinoid necrosis and granulomatous and chronic inflammatory infiltrate may be found between adipocytes. The granulomas can be non-specific or tuberculous. Late stages are characterised by fibrosis.

Antituberculous treatment is indicated if panniculitis is associated with tuberculosis. Nodular vasculitis which is not associated with tuberculosis can be treated with systemic corticosteroids or non-steroidal anti-inflammatory drugs.

2.5 Septal Panniculitis Without Vasculitis: Erythema Nodosum

Erythema nodosum can occur at any age. It is more frequent in women than in men. The etiology of erythema nodosum is not completely clear. Immunologic pathogenesis has been suspected; however, direct proof is lacking. It can be triggered by a wide range of possible antigens, like drugs, infections, and a variety of systemic diseases; however, often the causative agent is not found. Patients present with tender nodular lesions predominantly on the extensor surfaces of the lower extremities. When new lesions appear, fever, chills, and leukocytosis are often observed. Spontaneous resolution is seen after 4–6 weeks. In more than 50% of patients suffering from erythema nodosum accompanying arthritis is found. If erythema nodosum is combined with arthritis and hilar adenopathy, the triad is called Löffgren syndrome.

Deep-skin biopsy shows septal panniculitis that mainly involves the subcutaneous fibrous septa. In addition inflammatory infiltrate and histiocytes around small vessels can be seen.

Usually spontaneous resolution is seen; therefore no specific treatment is needed. In severe cases systemic steroids or potassium iodide is indicated.

2.6 Lipodermatosclerosis

Indurated skin on the lower extremities in combination with chronic venous disease is called lipodermatosclerosis. In general ‚sclerosing panniculitis with dermal and subcutaneous fibrosis is found. However, it may be difficult to differentiate lipodermatosclerosis from eosinophilic fasciitis clinically and histopathologically. Surgical treatment of chronic venous disease or consequent compression therapy is recommended.

2.7 Septal Panniculitis with Vasculitis: Polyarteritis Nodosa

In about 25% of patients with polyarteritis nodosa, cutaneous involvement is seen. Along the courses of subcutaneous arteries small nodules can be seen. In skin biopsies necrotizing vasculitis in the arteries of the dermal-subcutaneous interface is seen. Predominately neutrophilic inflammation is found in the vascular wall and perivascular tissue.

The treatment of the systemic disease will lead to remission of all lesions.

2.8 Lobular Panniculitis Associated with Systemic Disease

The various forms include lobular tumors of the subcutaneous tissues, cellulite, and lymphedema

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3 Lipedema and Lymphatic Edema

Manuel E. Cornely

3.1 Introduction

The differential diagnosis (Fig. 3.1) of symmetrical leg swellings needs to distinguish clearly between lipedema and lymphatic edema. Both volume and form changes often lead to misdiagnosis. These changes occur symmetrically in lipedema of the upper extremities. This may be due to an underused technical means of diagnosis in favor of the clinician's subjective impression.

The most frequent misdiagnosis certainly is obesity followed by lipohypertrophy. However, adequate exploration of the patient's history and thorough clinical examination can regularly uncover whether the clinical changes are due to lipedema, lymphatic edema, lipohypertrophy, or obesity.

3.2 Anatomy and Pathophysiology

Primary lymphatic edema of the extremities, which mainly results from hypoplasia or aplasia of the lymphatic system, appears less frequently than secondary edema. Primary lymphatic edema rarely appears completely symmetrically: usually the left side is worse. In the lower extremity, secondary, i.e., after in-

Fig. 3.1. Differential diagnosis. **a** Lymphatic edema is asymmetrical, Stemmer test is positive, erysipelas can be present **b** Lipedema is symmetrical, Stemmer test is negative, no erysipelas.

fectious disease or after surgery, lymphatic edema is much more frequent than primary lymphatic edema.

Although both entities differ in origin, a relative asymmetry characterizes the clinical aspect of lymphatic edema. Furthermore, lymphatic edema is characterized by painlessness, and usually is not accompanied by hematoma. Dorsal pedal edema and erysipelas frequently accompany lymphatic edema. Ideally the Kaposi–Stemmer sign [1] is positive.

Lymphatic edema is rich in protein and arises from the reduced transport capacity of the lymphatic system despite normal protein load; therefore, it can be clearly distinguished from the phlebedema owing to its specific gravity. Phlebedema results from varicosis and is low in protein. Ninety percent of the arterial blood flow of the extremities forms the venous blood flow. The remaining 10% constitutes the liquid part of the lymph. If the valve-bearing drainage system called the "lymphatic system" works insufficiently or is constituted poorly, the result is the corresponding edema. The lack in return transport capacity leads to retention of the respective liquids. Liquid retention can also be a clinical sign of varicosis, if less than 90% of the liquid is transported back via the venous system, thus putting an additional strain on the lymphatic system. Phlebedema displays a lymphatic component additionally by increasing the load to be transported via lymph.

According to Földi and Földi [2] the load to be transported via lymph is called prelymph before entering the lymphatic vessels (Fig 3.2). The prelymph flows via the prelymphatic channels towards the lymph capillaries and the precollectors, which in their entirety are also called initial lymphatic vessels. The physiologic inflow towards the lymph collectors can be compared with a cascade, with the lymph collectors having a diameter of approximately 0.5 mm. The following lymphatic trunks are about 2 mm in diameter. Then the protein-rich lymph gets back to the venous vascular system via the thoracic duct.

Lymph transported from the periphery to the center in this semicircular system essentially consists of products which cannot be transported via the venous system. Among these products plasma proteins represent the main protein load. They are transported within the water load and are accompanied by immobile cells, foreign substances, and long-chained fatty acids. These loads are addressed as cell load and fat load. The normal transport capacity of the lymphatic systems is 2–4 l/day. If the lymph flows anatomically correctly, it floods the lymph nodes at filter points in which the lymph has direct contact with the immunocompetent cells. The differentiation of B and T lymphocytes also takes place in these lymph nodes, which are filter points of specific anatomic regions like guards, i.e., sentinels, of the immune system. The further milky and cloudy liquid follows the thoracic duct, venous angle, left subclavian vein, and the left internal jugular vein. The appearance of the lymph in these anatomical structures led the old anatomists to the term "lactiferous glandular duct."

Földi and Földi [2] distinguish four stages (0–III) of lymphatic edema (Table 3.1). Stage 0 is an incipient edema. In stage I the edema is present, but reversible, and the tissue is soft. In stage II there is a spontaneous reversibility with sclerosis of the tissue. Only stage III is described as an irreversible lymphatic edema characterized by fibrosclerosis. These congestion

Table 3.1. Földi's staging system

Stage 0	Incipient
Stage 1	Reversible, tissue is soft
Stage 2	Spontaneously reversible, tissue is harder
Stage 3	Irreversible, fibroscleroses

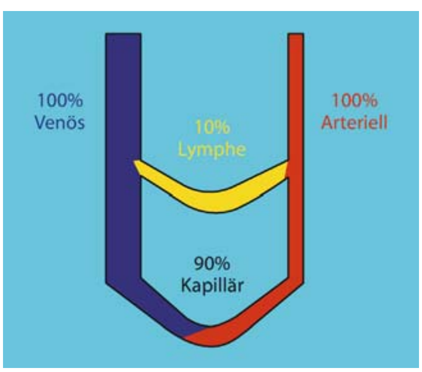

Fig 3.2. Lymphatic system. Differential diagnosis of lymphedema. Cardiologic: foot edema; nephrogenic: foot edema; phlebogenic: foot edema; lymphogenic: edema includes fingers and toes

Fig. 3.3. Feet with papillomatoses

Fig. 3.4. Crural ulcer due to lymphostasis in lipedema

Fig. 3.5. Kaposi–Stemmer sign

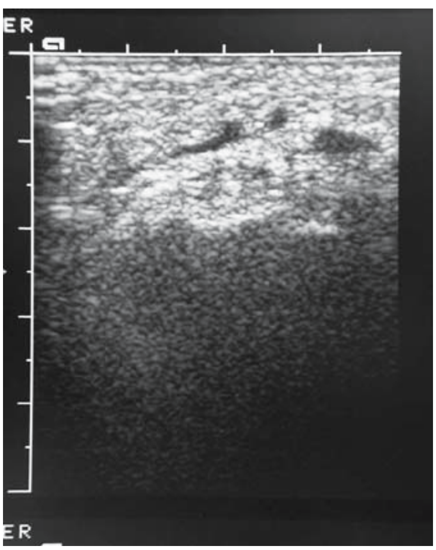

Fig. 3.6. Marshall clefts in duplex sonography

phenomena change the state of the skin in a serious and very impressive manner and result in papillomatosis (Fig. 3.3). These changes are strictly lymphostatic and need a therapeutic way corresponding to the pathophysiology. Lymphatic edema can also lead to deficiencies of the skin due to papillomatoses and congestion. Lymphostatic crural ulcers typically are refractory to treatment. In contrast to venostatic ulcers surgical intervention is not feasible for lymphostatic ulcers (Fig. 3.4).

Apart from the patient's, history the examiner will interpret clinical signs and symptoms. Thus, the palpation abilities are of utmost importance. Ideally, a Kaposi–Stemmer sign is present (Fig. 3.5). This means that on the back of the second toe a cutaneous fold cannot be elevated. This poor elevation can be a sign of edema or of the already fibrotically altered skin tissue. The cutaneous fold test can also be used in different anatomical regions, such as the side comparison of the thoracic wall in breast cancer patients with secondary lymphatic edema. A palpable difference in skin thickness clearly hints at the deposition of protein resulting in fibrosis.

Furthermore, imaging techniques provided by nuclear medicine help in establishing the diagnosis:

1. Functional lymph scintigraphy elucidates dynamics and transport capacity of the lymphatic vascular system.
2. Indirect lymphangiography displays the vascular situation.
3. In lymphedema, lymph vessels are made visible by duplex sonography using a 13-MHz probe, thus facilitating differential diagnosis, e.g., lipedema.

These sonographically documented vessels are called Marshall clefts (Fig. 3.6). This new technique may lead to a higher rate of correctly diagnosed lymphedema and lipedema. The correlation between the findings in 13-MHz duplex sonography and in histology is remarkable.

3.3 Clinical Categories of Lipedema

While the clinical findings in lymphatic edema have been known for decades, the findings in lipedema remained largely unknown. Allen and Hines [3] first described "lipedema of the legs" in 1940 and reported a clinical syndrome found in women. This clinical picture always comes with a symmetrical increase of the adipose tissue of the extremities, leading to a disproportion between extremities and trunk. Arms and legs appear symmetrically volume increased; trunk, hands and feet are not involved. Thus, lipedema differs clearly from Dercum's disease.

Lipedema is strictly accompanied by increased vascular fragility resulting in subcutaneous hematoma after minor bruising and an orthostatic tendency to lymphatic edema leading to tenderness.

Table 3.2. Clinical differentiation [4]

Lipohypertrophy: Painless malfunction of the distribution of fat at the extremities
Lipedema: Painful lipohypertrophy of the extremities

Herpertz [4] developed an easy and pragmatic clinical differentiation (Table 3.2). He differentiates a painless fat distribution of the extremities called “lipohypertrophy” from a painful one, which is then called “lipedema.” According to Herpertz, lipedema without pain does not exist. This corresponds to the clinical findings.

- Lipedema is an increase in leg fat volume which is always symmetrical, painful, and similar to saddlebags reaching from the iliac crest down to the ankles. It is always accompanied by a dynamic insufficiency of the lymphatic system.
- There is tenderness on pressure and an increased vascular fragility.
- The dorsal pedal pulses are slim; the Kaposi–Stemmer sign is negative.
- Similar symmetrical changes are to be found in the arms in up to 30% of patients.

3.4 Differential Diagnoses

The disproportion between extremities and trunk, the restriction of lipedema to the ankles and the wrists (30%), and the lack of involvement of the feet and hands clearly distinguish lipedema from adiposity. Lipedema is congenital, restricted to women, and finally formed, at the latest, by the end of the third decade.

This congenital maldistribution cannot be influenced nutritionally. “Adiposity” as the most frequent false diagnosis can be ruled out by the simple question whether the circumference of the legs and arms could be reduced by a diet or physical activities. A change of the genetically determined body shape cannot be achieved [8].

3.5 Pathophysiology

Pain in lipedema is due to the dynamic insufficiency of the lymph flow. The forming and coping of the edema in the fat tissue is structurally marked by a drainage weakness. Fatty lobules do not contain lymphatic vessels, but have a strong blood flow. This results in a large amount of lymph ultrafiltrate having to be transported via the septae in which lymphatic vessels run. The resulting higher blood ultrafiltrate is undercompensated by capillary drainage. This structural drainage weakness leads to the transport to the upper dermis and to the development of a dynamic insufficiency.

The microlymphangiographic studies by Amann-Vesti et al. [5] confirm the presence of microaneurysms in the skin of lipedema patients. The pathophysiology of the lipedema’s fat is supported by the data presented by Tiedjen and Schultz-Ehrenburg [6]. Using function scintigraphy, the uptake of lipedema patients in comparison with that of the normal population and of lipolymphatic edema patients was evaluated. In lipedema patients the lymphatic system tries to compensate for the huge amount of lymphatic ultrafiltrate by increasing the transport capacity to a high volume. Beyond the fifth decade the uptake values decrease under the lower limit of normal. This situation may result in lipolymphedema.

3.6 Pretherapeutic Diagnostics

Even if the clinical findings seem to be unequivocal, it is nevertheless necessary to exclude lymphedema and to confirm the presence of lipedema by indirect functional lymph scintigraphy, indirect lymphangiography, and the examination of the fatty tissue with 13-MHz duplex sonography. These instrumental methods allow an estimate of the progression of the disease and differentiation between lipophlebedema, lipolymphedema, and lipolymphatic phlebedema.

3.7 Therapeutic Options

It is uncontested that manual lymph drainage and complex therapy against congestion has a place in the treatment of lymphatic disease. Sufficient compression and skin care are always part of the manual lymph drainage concept.

3.8 Surgical Therapy

So far, surgical interventions have not produced truly positive results in lymphatic edema but the situation is different with lipedema. The development of dynamic insufficiency is just a question of time as the findings of Tiedjen and Schultz-Ehrenburg [6] and Amann-Vesti et al. [5] have shown. It appears reasonable to remove the fat tissue.

After the presurgical diagnostic testing and exclusion of further angiologic diseases, lipedema can be treated curatively by microcannular liposuction. Prerequisites are thorough clinical examination, complete vascular analysis of artery, vein, and lymphatic vessel systems, and duplex sonography. If varicosis is present it has to be operated on before any other treatment. Incisions should spare lymph vessels. This is followed by a microcannular liposuction under tumescence anaesthesia. For the success of the sufficient tumescence it is decisive that the action time lasts between 1 and 1.5 h. In the extremities long cannulas should be used for liposuction according to the axes. This procedure results in the maximum protection of the lymphatic vessels.

1. In Lipedema Lymphatic edema would represent a local contraindication to surgical intervention.
2. There is no surgical method for the restoration of primary or secondary lymphatic edema. The only exceptions are transplants with secondary lymphatic edema after breast cancer treatment. The size of the arm can be reduced by Liposuction [8].
3. Tumescence local anaesthesia allows a water dissection of cells and vessels by carefully dilating the tissue.
4. Injury of lymph and blood vessels does not happen.
5. Manual lymph drainage is useful and necessary in order to speed up the recovery after surgical treatment.
6. The presurgical procedure requires a clear picture about the complete vessel situation of the extremity, the dynamics of the lymph transport, and the situation of the fat. The clinical examination of a lipedema has to prove increased vessel fragility and painful tenderness.

3.9 Discussion

Perhaps early liposculpture will prevent the development of dynamic insufficiency and thus the progress of the lipedema. Today liposuction of lipedema seems to be a relieving therapy option. Lipedema is an unequivocal medical indication for the liposuction of the extremities.

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Biochemical Effects of Liposuction in Lipidosis

Lina Valero Pedroza

4.1 Introduction

How much fatty free acid is liberated into the blood during the life of an overweight or obese person? Owing to frequent comments and literature trying to associate liposuction with fat embolism and because of the lack of studies demonstrating the presence or absence of free fatty acids in the blood during liposuction, we decided to monitor all of our patients asking to have this surgical procedure.

4.2 Theories About the Causes of Fat Embolism

4.2.1 Mechanical

Fat cell and venous sinuses are disrupted following bone trauma and the liberated fat globules may enter the circulation by means of veins located in the traumatized area. Fat droplets may pass through the capillaries and enter the systemic circulation.

4.2.2 Biochemical

Embolic fat is derived from circulating blood lipids in a diverse series of non-traumatic conditions, including diabetes mellitus, chronic pancreatitis, alcoholism, sickle cell disease, and acute decompression syndrome during the metabolic response to stress. Chylomicrons, which are smaller than 1 mm, may coalesce to form fat globules up to 40 mm in diameter and these globules are capable of causing capillary occlusion.

In addition to mechanical obstruction of small vessels by neutral fat, hydrolysis of neutral fat tissue by lipase forms free fatty acids 1–2 days after injury. Free fatty acids have a direct toxic effect on the endothelial cells and pneumatocytes. The result is capillary leakage, loss of surfactant, and formation of hyaline membrane.

4.3 The Study Protocol

There were 673 patients who had liposuction to improve their self-image by loss of weight from April 1, 1997 to June 30, 2002 (Table 4.1). High triglycerides were present in 29 patients.

The laboratory tests were performed in the same laboratory before, during, and after the operation and included hemoglobin (Hgb), hematocrit (HCT), total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides, and blood glucose. Tests were performed 3–5 days before surgery, during surgery after removal of 1,000ml of fat, immediately postoperatively, 24 h postoperatively, and 7 days postoperatively.

Ultrasound-assisted liposuction was performed under general anesthesia using propofol and alfentanile and the tumescent solution did not contain lidocaine. The amounts of fat removed ranged from 1,000 to 18,000 ml with an average of 4,000–6,000 ml.

4.4 Discussion

There was very little change in Hgb and HCT following liposuction (Fig 4.1).

For those patients with preoperative hyperlipidemia who underwent liposuction, the effect of lipo-

Table 4.1. Patients (673) who had liposuction to improve their self-image by loss of weight from April 1, 1997 to June 30, 2002

Age group	Women	Men	20% overweight	Obese individuals	Lipodystrophy	Hypercholesterolemia
17–55	449	224	130	37	506	112

suction was studied with 1,000 ml of fat removal. An average of 20 32 mg% of total cholesterol was lowered from the beginning to the end of liposuction. Normal levels of cholesterol were reached 24 h after surgery and were maintained up to 7 days after surgery. Triglycerides, LDL cholesterol, and HDL cholesterol had identical results. (Figs 4.2, 4.3)

Twenty-two hypercholesterolemic patients were followed for 5 years following liposuction and showed normal levels of cholesterol. Those patients were maintained on low-fat diets and physical exercises, 2 or 3 days a week following surgery.

Hyperglycemia started to reach high levels at the very beginning of the surgical procedure and persisted for 1 week with a tendency to lower after that period of time. Blood glucose showed levels from 120 to 230 mg.

The mechanical theory of fat embolism should be improbable, because no fat droplets are sent into the blood, despite the biochemical theory, since there is no liberation of free fatty acids into the blood during liposuction and even 1 week after the surgical procedure.

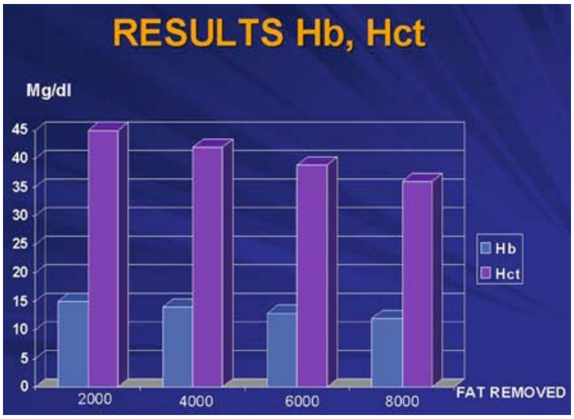

Fig. 4.1. Hemoglobin (*Hb*) and hematocrit (*HCT*) following liposuction

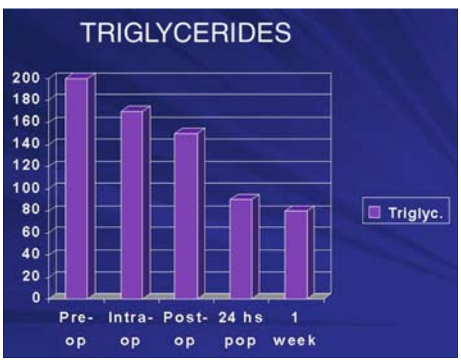

Fig. 4.2. Triglycerides

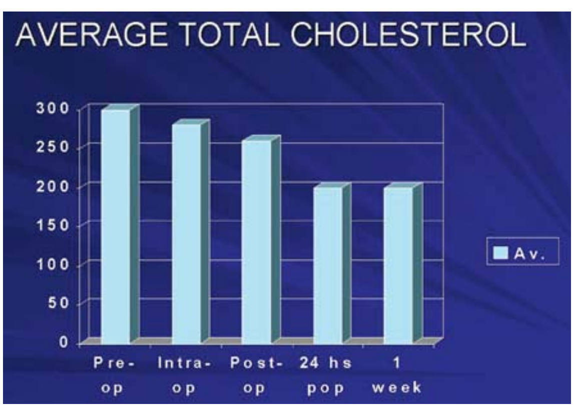

Fig. 4.3. Total cholesterol

4.5 Conclusions

Now at least, after almost 6 years of study, our purpose is to continue testing every patient with the examinations proposed for this clinical research. Patients can be more confident about their surgery now that we know the cholesterol and triglycerides are decreased for 1 week after liposuction and do not pose a danger even in the patient with hypercholesterolemia.

The Anatomy and Physiology Metabolism/Nutrition of Subcutaneous Fat

Mitchell V. Kaminski, Rose M. Lopez de Vaughan

5.1 Introduction

This chapter presents three aspects of subcutaneous fat: anatomy, physiology, and metabolism/nutrition. The goal is for the reader to gain familiarity with the interrelationship between these three aspects of subcutaneous fat as they relate to adipocyte mass, appearance, and liposculpture. With this knowledge, the surgeon should gain a deeper understanding of the impact of the surgical procedure, which should lead to improved results following liposuction.

An appreciation for the importance of interstitial soluble protein is crucial because Klein's solution dramatically dilutes its content and, predictably, causes a temporarily pseudo-leaky membrane in that region. Using excess Klein's solution can produce symptoms of acute congestive heart failure [1]. The liposuction guidelines of the American Academy of Cosmetic Surgery, therefore, need to be closely adhered to for this reason: when administered properly Klein's solution is safe in that the total body's soluble protein reserve will re-equilibrate over a relatively short period of time.

The section "Nutrition and Metabolism" presents the cellular dynamics involved in weight gain and simple principles that facilitate postoperative weight reduction. Continued weight loss following the procedure guarantees a happy patient who attributes the overall success to the surgeon. Weight gain following liposuction results in reaccumulation of fat that can never be as symmetrical as the preoperative anatomy, and it is safe to say that the fat will return in a hideous fashion. The chapter concludes with proven and easy to comply with dietary recommendations, comments on the science behind them, and a brief comment on fat's future as a subject of diverse scientific study.

Until recently, the study of the lowly lipocyte was considered boring and was therefore limited. Fat was viewed as an adynamic tissue which stored energy, improved insulation, and functioned as a shock absorber. Of course the differences in fat distribution between the sexes are well recognized and are the subject of discussion as well as artful renderings. Removal of fat by liposuction was thought the end of the line, producing a localized permanent reduction in lipocyte number; however, nothing could be further from the truth. Adult stem cells are abundant within the fat mass, and in the face of excess calorie consumption these stem cells are recruited to form new lipocytes as necessary. It is clear that fat is also an endocrine and exocrine organ. It reacts to, and is the source of, proinflammatory cytokines and has a role in immunity, as well as a dynamic role in metabolic activity and response to injury. As detailed at the end of this chapter, fat represents one of the most exciting tissues of the body.

5.2 Histology

Fibroblast-appearing preadipocytes are noted in the embryo as well as in adult subcutaneous fat tissue. The ultimate shape of a fat-laden mature adipocyte is that of a cygnet ring as the central lipid accumulation pushes the nucleolus to the periphery (Fig. 5.1).

The fibroblast-appearing preadipocyte is pluripotential. During calorie deprivation fat cells can also dedifferentiate back into the fibroblast appearance. The adult stem cell within fat tissue has been stimulated to form muscle and bone. This topic is detailed in the section "Fat's Future."

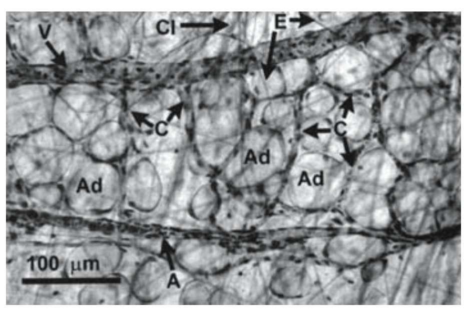

Fig. 5.1. A spread preparation using Fankels combined orcein connective tissue stain, which reveals rich microvasculature and adipocytes packed against each other. *Ad* adipocyte, *C* collagen *E* elastin

As can be seen in Fig. 5.1, every lipocyte is surrounded by or touching a capillary. These capillaries are highly sensitive to epinephrine, which causes vasoconstriction. This is a phenomenon associated with Kline's tumescent anesthesia that has made office-based liposuction a relatively non-bloody procedure, and safe outside of the hospital setting; no other additive in Klein's formula is as important. And this author uses 2 mg epinephrine per 1,000 ml crystalloid, rather than the recommended 1 mg. The total amount of tumescent solution with 2 mg epinephrine per liter should be limited to 3 l or less per procedure.

5.3 The Interstitium

The connective tissue of the interstitium is host to myriad cell types, including fibroblasts, adipocytes, macrophages (histiocytes), neutrophils, eosinophils, lymphocytes, plasma cells, mast cells, monocytes, and undifferentiated mesenchymal cells. These cells, either fixed or transient, interact with each other and the extracellular matrix components (i.e., collagen, elastic fibers, adhesion glycoproteins) and, as mentioned, substantial amounts of soluble protein [2, 3]. Within this integrated gel–sol assemblage are the vital components of the vasculature, initial lymphatics, and nervous system (lightly myelinated fibers to free nerve endings, myelinated fibers to encapsulated neural structures). The importance of the vasculature and lymphatics in maintaining homeostasis of protein and fluid concentration of the blood and interstitium is well documented and cannot be overstated. The neural components at a single anatomic site, although perhaps not vital, provide for the general sense of well-being. The presence of these constituents within the interstitium, however, cannot be overlooked and may represent a seed medium for the growth of normal adipose tissue.

Klein's [4] pioneering work using a crystalloid solution, epinephrine, and lidocaine has been a significant advance in lipoplasty. Considering the cell biology of the anatomic site, liposuction procedures are traumatic, albeit transient, events. Even with the most careful technique, the architecture and physiology are altered dramatically, which sets in motion a cascade of systemic and cytokine-mediated cellular responses.

The individual components of this integrated unit have been studied extensively and the literature is replete with thousands of reports. Providing a unified concept on the restructuring of this anatomic site after traumatic events is a challenge that needs to be met. The inventory of the components of the interstitium and how they interact is far from complete.

As expected, current techniques yield a heterogeneous material composed of liberated fat, locules of adipose cells, collagen fibers and septa, vessels and nerves, clots, ruptured cells, hemoglobin, inflammatory proteins, proteases, lipogenic enzymes, and electrolytes, including calcium [5].

Weber et al. [6] developed a concept of extracellular homeostasis. This concept is one of self-regulation of cellular composition and structure based on fibroblast-derived angiotensin that regulates the elaboration of transforming growth factor-1. This is a fibrogenic cytokine responsible for connective tissue formation at normal and pathologic sites. Biologic responses are found in various connective tissues, including adipose tissue. Given that the three-dimensional architecture is altered profoundly, it is astonishing that it can be reconstituted to normalcy in a relatively short period of time.

The bottom line of the previous discussion is that lipocytes are not islands unto themselves. They are surrounded by a sea of supportive cells, proteins, growth factors, and electrolytes.

5.4 Physiology

Note that for the most part the adipocytes are not rounded, bloated spheres; they have one or more flattened sides and are better described as polygonal, and appear packed between the vasculature. This is because they are compressed by colloid osmotic pressure, which is generated by soluble protein in the interstitial space. Under these conditions, the cells are like peanuts sealed by vacuum in a bag. The interstitial proteins that surround cells create –7-mmHg pressure [7]. Interstitial protein is reported as total protein when measured by a laboratory. Its three components are albumin, globulin, and fibrinogen. Albumin is the principle soluble protein and makes up at least 60% of total protein [8]. Because albumin is the smallest molecule that cannot pass easily through the semipermeable membrane of the capillary, it contributes most of the oncotic force, squeezing cells together. The number of particles in solution on one side of a semipermeable membrane—not their size–creates an oncotic force. To be specific, the molecular mass of albumin is 70,000Da, whereas that of globulin is 150,000 Da, and that of fibrinogen is 560,000 Da. Thus, 1 g of albumin has twice as many molecules as 1 g of globulin, and 8 times as many as of 1 g of fibrinogen.

To understand that this is oncotic pressure and not osmotic pressure, one should recall that if the particle in solution can pass back and forth across the semipermeable membrane, it cannot create an oncotic force. For example, if a glass funnel is covered with a semipermeable membrane whose pore size allows water, sodium, and chloride to pass but not sucrose, and if that funnel is then partially filled with a sugar and salt water solution and placed upside down in a beaker of fresh water, after a period of time the sugar molecules on the funnel side of the membrane will be responsible for drawing fluid into it. Because sodium and chloride easily traverse the membrane, they cannot create an oncotic force and will distribute equally on both sides of the membrane.

Unlike this example, in vivo soluble proteins that surround adipocytes are dynamic. Albeit slow, albumin molecules make a circuit from the heart, across the capillary membrane, through the interstitial space, and then return to the heart by way of lymphatic flow within 24–48 h.

5.5 Gross Anatomy

There are thee layers of subcutaneous fat: apical, mantle, and deep layers.

5.5.1 Apical Layer

This layer, just beneath the reticular dermis (Fig. 5.2), is also called the thecal or periadnexal layer in that it surrounds sweat glands and hair follicles.

Slightly deeper, the apical layer also surrounds vascular and lymphatic channels. Depending on the quantity and depth of color of fruits and vegetables in the diet this layer is rich in carotenoids and tends to be yellow in appearance. Because of the neural, vascular, and lymphatic potential for damage, this layer should be avoided during liposuction. Extensive disruption of these anatomical elements can lead to seroma, erythemia, hyperpigmentation, and even full thickness dermal necrosis. This was more of a problem in the past when larger-diameter 8 and 10-mm cannulas were directed at the deep fat layer, but these complications have become rare in this era of 2- and 3-mm cannulas.

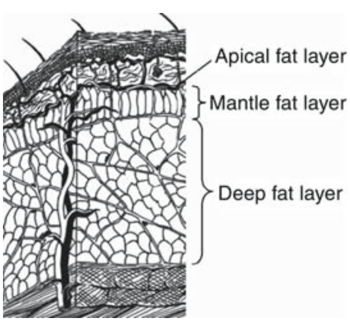

Fig. 5.2. The general lipocyte distribution from the dermis to the muscular fascia. The apical and mantle layers represent the “no man’s zone” of liposuction. Damage to these layers may compromise the blood supply to the skin and predispose to postoperative complications such as seroma or dermal necrosis. (After Klein [4])

5.5.2 Mantle Layer

Just beneath the adipocytes investing dermal structures is another anatomically organized layer of fat cells which is part of the superficial fat layer. It is called the mantle layer and is composed of more columnar-shaped lipocytes. It is separated from the deep layer of fat by a fascia-like layer of fibrous tissue. The mantle is absent from the eyelids, nail beds, bridge of the nose, and penis.

This layer significantly contributes to the skin’s ability to resist trauma. It causes external pressure to be distributed across a larger field; much like a box-spring mattress absorbs sitting pressure.

5.5.3 The Deep Layer

This layer extends from the undersurface of the mantle layer to the muscle fascia below. Its shape and thickness depend on the sex, genes, and diet of the individual. This is the layer best suited for liposculpture. Here, fat cells are arranged in pearls, and the pearls are gathered into globules. These globules are then packaged like eggs in an egg crate between fibrous septa, and arranged between tangential and oblique fibrous planes.

Histologically tangential planes are thicker and run parallel to the underlying muscle fascia, but they are of little consequence when performing liposuction.

Oblique planes are thinner and interconnect the tangential fibrous layers. They hold fat globules in their relative positions. Though thinner, they are of cosmetic consequence because the vertical arrangement of subcutaneous fat from skin to muscle fascia is the cause of cellulite.

5.6 Deep Fat of the Neck

A wattle is produced by accumulation of excess fat between plathysma and the superficial layer of the deep cervical fascia, which is superficial to the anterior bellies of the digastric muscles (Fig. 5.3). The fat immediately beneath the plathysma is amenable to liposuction. However, the fat between the digastric muscles and beneath the superficial layer of the deep, or investing, fascia of the neck should not be removed. Doing so may result in a permanent depression.

The buccal fat pad accounts for the chipmunk fascial features noted in some families. It extends anterior to the mandibular ramus into the cheek, deep into the subcutaneous musculoaponeurotic system buccinators. The buccal branch of C7 courses over and just lateral to the buccal fat pad.

5.7 Upper Arm Fat

Liposuction without brachioplasty is suitable for younger patients with minimal to moderate fat excess, who exhibit taut skin. It is generally limited to the posterior flap. This flap in layman's terms produces a "kimono arm" deformity (Fig. 5.4).

For the patient who is middle-aged and has loose skin, liposuction may have to be accompanied by a brachioplasty. Loose skin of the posterior arm shrinks poorly. The patient who chooses liposuction without resection should understand that an excision may be required later.

A middle-aged to older individual who complains of loose skin following weight loss or owing to senile laxity will always require an excision of the redundant tissue. Preoperative notes should make clear the fact that these considerations were discussed in detail with the patient.

5.8 Abdomen

The subcutaneous fat of the abdominal wall is divided by two easily identifiable fascial layers: the superficial campers fascia and the deeper scarpis fascia. These layers are most easily observed in the lower abdomen. The deep fascia overlays the muscolaponeurosis and is continuous with the fascia lata of the thigh. It also covers the small arteries and veins along the surface of the anterior rectus sheath. Liposuction using small cannulas of 2–3.7 mm in diameter can be artfully performed between these fascial layers in the abdomen with impunity. However, care must be taken not to injure the vascular and lymphatic complexes within the mantle layer of fat just beneath the skin (Fig. 5.5).

5.9 Hips and Flanks

In the area of the hips and flanks the subcutaneous fat is divided into two well-defined layers: the superficial

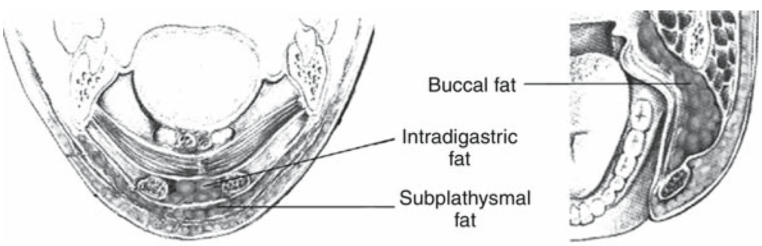

Fig. 5.3. Submantle fat is amenable to the standard liposuction technique using very small cannulas. Removal of the buccal fat requires an intraoral incision just lateral to the second molar tooth. Removal of the intradigastric fat also requires an incision but is usually not advised unless it is excessive. However, a partial removal may be indicated. (After Pitman [9])

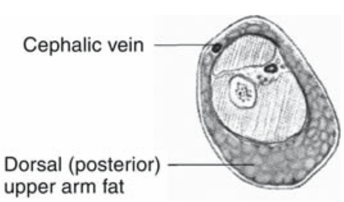

Fig. 5.4. The majority of upper-arm liposuction alone procedures are performed in younger patients with good skin contractility. For older patient or patients with excess skin due to recent weight loss a brachioplasty is usually indicated as a combined one- or two-stage procedure. (After Pitman [9])

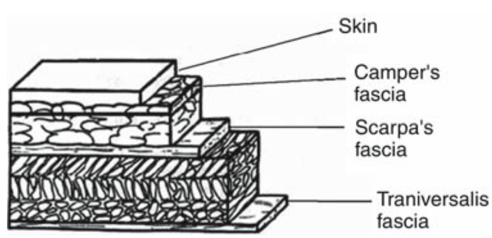

Fig. 5.5. The relationship of Camper's fascia to Scarpa's fascia. Scarpa's fascia is the membranous layer of the subcutaneous tissue of the abdomen

and the deep. The superficial fascial system encases the superficial fat. This fat is light yellow and dense, whereas the deeper fat is usually darker and less well structured. Zones of adherence are formed where the superficial fascial system connects to the underlying muscle fascia. The zones of adherence differ between men and women (Fig. 5.6).

In men, the attachment runs along the iliac crest; it confines the deep fat to the mid abdomen. The zone of adherence in women is more inferior, thus localizing the deep fat over the iliac crest. This difference is largely responsible for the android vs. gynoid appearance of the hip region. Popular Western culture appreciates the visible iliac bones in women. Following liposuction, women like to feel and see these anatomic features.

5.10 Thighs and Buttocks

The muscle mass of the hamstrings largely determines the contour of the upper posterior thigh. Laterally, the zones of adherence represent an area that should not be violated with a liposuction cannula. The gluteal crease represents another zone of adherence. Note that anteriorly, the quad underlies the bulk of the upper anterior thigh (Fig. 5.7).

5.11 Lower Leg

A subtle tapering from the thighs to the ankle is considered attractive. Thus, although a degree of fullness at the knee is normal it is usually identified as an area to be reduced during liposuction of the legs. The lateral knee should never be liposuctioned. It is also an area of insertion of thigh musculature (Fig. 5.8). No major arteries or nerves run within the subcutaneous fat. Rather, they run along or beneath the investing fascia of the superficial fat of the legs.

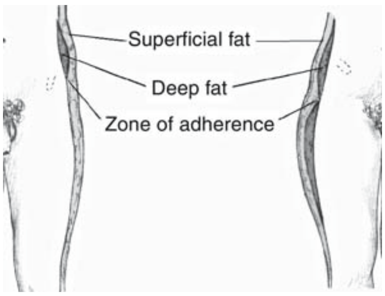

Fig. 5.6. The hip and flank region are distinctly male or female; specifically, the zones of adherence differ. Care should be taken to preserve these attachments during liposuction. (After Pitman [9])

5.12 Nutrition and Metabolism

More often than not, a patient will present with unwanted fatty deposits that are secondary to the overconsumption of food. Stored fat is mobilized during calorie restriction through the activation of triglyceride lipase. Triglyceride lipase is a cyclic AMP dependent mobilizing enzyme. The hormonal signal to activate triglyceride lipase is glucagon and to some extent epinephrine. When the insulin–glucagon ratio

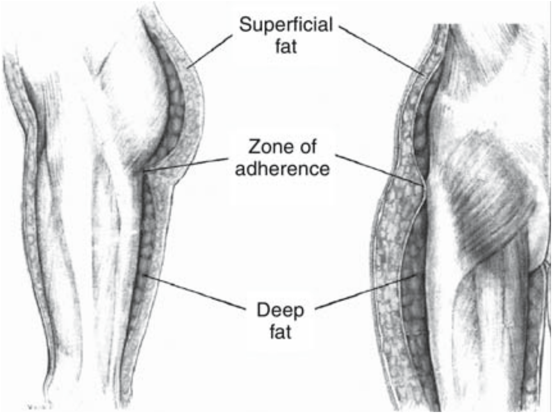

Fig. 5.7. The fat anatomy in the hip and buttock region is to be conceptualized as a three-dimensional wrap-around regarding the gluteal zone of adherence. Note the distribution of the superficial and deep fat above and below the zone of adherence. (After Pitman [9])

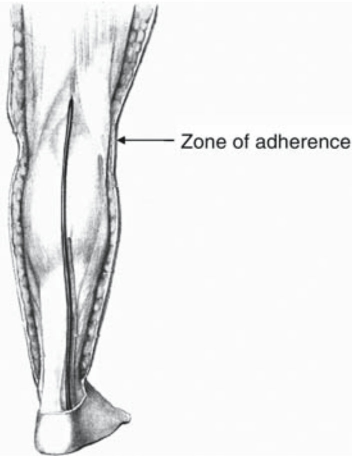

Fig. 5.8. The deep fat does not extend into the lower leg. Note the zone of adherence located at the lateral knee, which essentially has no fat. (After Pitman [9])

is in favor of insulin, fat cannot be mobilized. Insulin is secreted in response to circulating glucose levels (Table 5.1). Thus, a meal that raises glucose will cause insulin secretion, the magnitude of which depends on the carbohydrate load and the refined vs. complex composition of the food consumed (Fig. 5.9).

Eating either fat or protein will not raise insulin levels. All fruits and vegetables are predominantly complex carbohydrates, which, because they are tightly configured, require more time to digest and absorb. The tighter the carbohydrates are configured the slower the digestion and absorption, and the lower the level of maximum postparandial glucose. Flour and sugar products, on the other hand, are refined carbohydrates, which will dramatically elevate blood glucose and insulin. It is therefore conceivable that someone who is eating what she or he believes is a calorie-restricted diet will never catabolize stored fat over a 24-h period. Such a diet might be a bagel and coffee for breakfast, a sweet roll at 10 a.m. on coffee break, a can of pop with a cheese sandwich for lunch, a pasta dinner, a soda pop with cake for dessert, and fat-free cookies while watching TV. Even if small portions are chosen, the refined carbohydrate represented by these choices will guarantee an elevated insulin level throughout the day. The average soft drink contains more than nine packs of table sugar per can.

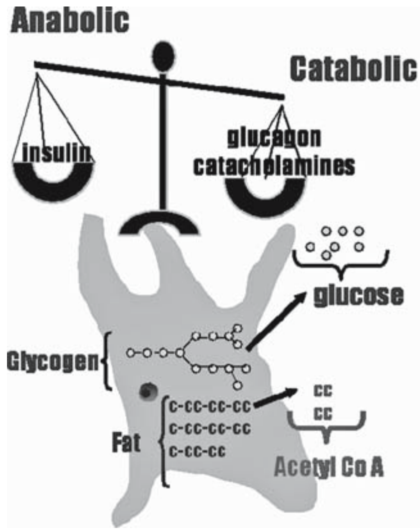

Fig. 5.9. Stored calories are expressed in two forms: (1) dextrose, which forms a large starch molecule called glycogen; (2) triglycerides, which are composed of even-numbered carbon atom fatty acids attached to a glycerol base. Both respond to insulin and glucagon. Insulin promotes uptake of dextrose and fatty acids, while glucagon stimulates mobilization. Both moieties enter the Kreb's cycle to generate ATP

Table 5.1. Representative factors secreted by adipocytes and their presumed functions. (After Halvorsen et al. [10])

Secreted molecules and their targets	Adipocyte-specific	Reference
Energy homeostasis		
Agouti	No	[11]
Leptin	Yes	[12]
Lipoprotein lipase	No	[13]
Insulin-like growth factor	No	[14]
Insulin-like growth factor binding protein	No	[15]
Acylation stimulating protein	No	[16]
TNF-α	No	[17]
apM-1	Yes	[18]
Cardiovascular		
Angiotensinogen	No	[19]
ApoE	No	[20]
Cholesterol ester transfer protein	No	[21]
Plaminogen activator inhibitor-1 (PEI-1)	No	[22, 23]
Adiponectin	Yes	[24]
Complement factors		
Adipsin	Yes	[25]
Adipo Q/Acrp30	Yes	[26]
Complement factor B		[27]
Other		
VEGF angiogenesis	No	[28]
IL-6	No	[29]
Preadipocyte factor-1 (pref-1)	No	[30]
Colony-stimulating factor	No	[31]

Patients on this diet are perplexed by their inability to lose weight. When a physician tries to get refined carbohydrates out of their diet it is not unusual for patients to vigorously object because they claim that they suffer from hypoglycemia. They report that unless they are frequently treating themselves with refined carbohydrates they become severely symptomatic. They will complain of brain fog, tremor, and severe hunger pains which are quickly ameliorated by consumption of another form of a refined carbohydrate. Thus, they are convinced that they are hypoglycemic or that refined carbohydrates would not treat their symptoms.

The fact is that the blood sugar level rises rapidly with this diet, and then within 90 120 min begins to decline secondary to the insulin response. It is the downward slope of the serum glucose that triggers what the dieter calls a hypoglycemic episode. In fact the blood sugar level remains above normal at all times [32] (Fig. 5.10).

The potential for any given complex carbohydrate or refined carbohydrate to raise blood glucose in comparison with that of a 50-g dextrose meal is called the glycemic index (GI). All vegetables and fruits are complex carbohydrates, but some have a higher GI than others. It is recommended to keep the GI below 55 for any given meal. The GI of anything made from flour or sugar is near 90; thus, all baked goods and pasta should be avoided.

Gelatinization is a process that occurs during boiling where a complex carbohydrate vegetable with a low GI can be converted to a high GI food. During boiling, gaps appear in the tight molecular structure and these are quickly filled by water molecules. This new configuration reduces the time of digestion, increasing the rate of absorption, and therefore increasing the GI. Overheating, especially overboiling, is another consideration to be avoided in food preparation.

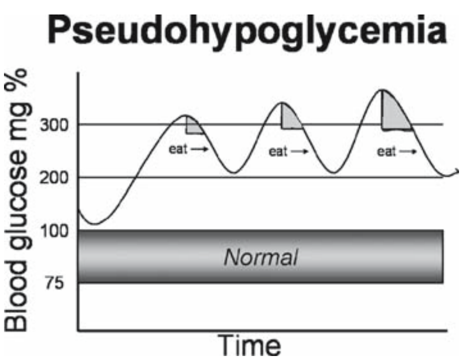

Fig. 5.10. The yo-yo hyperglycemia experienced by refined carbohydrate carboholics. It is the downward slope of the hyperglycemia curve that initiates the symptoms described as hypoglycemia by the patient. Note that the blood sugar level is never normal

Glycosolation refers to the combination of glucose and protein. This occurs naturally by simple contact. Neither heat nor an enzyme is necessary to create this new molecule. Glycosolation irreparably damages the protein just as oxygen changes iron into rust. When the damaged glycosolated protein is replaced during a healing process as it floats free, it is called an advanced glycosolation end product (AGE). An AGE is recognized by the immune system as a foreign microorganism such as a virus or pathogenic bacterium. The AGE binds to a receptor on white blood cells called receptors for AGE (RAGE) which upregulates the immune response. This upregulation increases free-radical production. Free radicals then promote all AGE-related disease processes. Inflammation is now known to be a major faction in Alzheimer's disease, osteoarthritis and rheumatoid arthritis, coronary artery disease, and renal disease, and the list goes on. Understanding this deepens the reason for advising those patients who are obese, refined carbohydrate carboholics who present for liposuction to get refined carbohydrates out of their diet. Details of these nutritional concepts and other lifestyle guidance have recently be summarized by the authors [32].

5.13 Fat's Future

The traditional concept of the adipocyte as a simple calorie storage cell has been shattered over the past few years. Fat is an exocrine, endocrine, and apocrine organ and plays a role in immunity.

For almost 2 decades leptin was pursued as the holy grail in the control of obesity. It was considered the adipostat mediator. A specific adipostat may never be found because there are many factors that contribute to energy homeostasis. Since the introduction of fat-free and low-fat food the average American's weight for any given age has increased 10 lb.

Adipocyte number is not as stagnant as previously thought. Decrease occurs via a process called apoptosis of both preadipocytes and adipocytes. Adipocytes may also dedifferentiate into preadipocytes. Adipocyte differentiation is the in vitro process by which differentiated fat cells revert morphologically and functionally to less differentiated cells [33, 34]. The process has been observed in vitro. These adipocytes lost their cytoplasmic liquid and acquired a fibroblast morphology [35, 36]. These dedifferentiated cells also display the gene expression patterns of preadipocytes [34, 37].

This is intriguing behavior in that preadipocytes exhibit stem-cell-like qualities. Zuk [38] reported isolation of a population of stem cells from human adipocyte tissue, where the cells were obtained from liposuction aspirate, and were then determined to be mesodermal and mesenchymal in origin. In vitro these cells could differentiate into adipogenic, chondrogenic, osteogenic, and myogenic cells in the presence of proper induction factors.

Researchers from Duke University Medical Center have enthusiastically reported that adipocytes can become true stem cells [39]. Their research exposed cells taken from human liposuction procedures to different cocktails of nutrients and vitamins. They successfully reprogrammed 62% of them to grow into bone, cartilage, fat, or nerve cells. Since nerve tissue is ectodermal, and not mesodermal in embryonic origin, these experiments confirm true stem cell potential.

5.14 Conclusions

Both the microscopic and the gross anatomy of the fat mass should be appreciated by the liposuction surgeon. With this appreciation a better result can be expected, especially in understanding the caveat to not injure the dermis during a procedure.

The physiology depends on an appreciation for colloid osmotic pressure, which is significantly reduced by Klein's tumescent solution. This wash-down of interstitial protein would enhance flow of the solution into the vascular space if it were not for the effect of epinephrine. Nevertheless using a massive amount of tumescent solution can overwhelm the right side of heart and cause congestive heart failure.

The fat mass is dynamic. The fact that adipocytes can differentiate and dedifferentiate is exciting in their application to redifferentiation into other cell types. Stem cells from lipoaspirate make more sense than bone marrow or embryonic sources.

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6 Liposuction Technique and Lymphatics in Liposuction

Andreas Frick, Rüdiger G.H. Baumeister, Johannes N. Hoffmann

6.1 Dry Liposuction Procedure

Closed liposuction was first performed by conventional uterine curettes. Besides variable results with skin excess and uneven contours, severe complications such as lymphorrhea occurred. Lymphorrhea persisted in the cavity despite drainage for a long period of time. The cavities epithelialize in many cases.

Fischer and Fischer [1], in 1977, and Kesselring [2], in 1978, introduced suction to curettage. Kesselring created an epifascial continuous, regular cavity by a layerwise suction procedure. High-volume liposuction was associated with perioperative bleeding and postoperative swelling of the extremities [3, 4]. Lymphatic lesions can cause edema. The lymph and lymphatics were, therefore, in focus at the beginning of the development of the liposuction procedure. Knowledge of lymphatic anatomy, especially the course of the collectors, as well as possible ways to protect them, is important.

We studied different interactions between liposuction and lymphatics. One study demonstrated that patent blue, a dye of 583 Da, is transported even postmortally by lymphatics of the lower limbs [5].

Liposuction was performed thereafter using a blunt 4-mm cannula with the dry technique without precedent fluid instillation. In ten lower extremities, sequential regions were defined in which either longitudinal or transvers suction was performed.

Lymphatics can tolerate longitudinal tension up to a certain limit in contrast to low transverse tension. If suction is performed in the axes (0–10°) of the extremities and the lymphatics, there was no, or only small, damage to the lymphatics in the cadaver study. There was no, or only moderate, extravasation of patent blue into the surrounding tissues. The lesions were significantly increased in regions where liposuction was performed vertical (80–90°) to the direction of the lymphatics.

6.2 Tumescent Liposuction

Illouz [6] introcluced the third generation of suction-assisted lipectomy. He injected saline solution to cause fat-cell swelling and rupture. The whole procedure was be performed under local anesthesia without the risks of general anesthesia and narcotic analgesics. The main advantage of the tumescent technique is a decrease in bleeding complications with high-volume liposuction.

To study the interactions between liposuction and lymphatic vessels in the tumescent technique we performed a second experimental study [7]. Liposuction parallel to the extremity axes and lymphatics produced no, or only slight, lymphatic damage with perivascular extravasation of patent blue. The vertical suction procedure caused no, or some more moderate, lesions.

The tumescent procedure in the lower extremities was unlikely to cause major injury to epifascial lymph vessels in the second cadaver study. In clinical practice suction procedures, even liposuction vertical to the extremity axes may be possible, for example, in the transition zone of non-edematous lower legs [8]. Liposuction parallel to the axis of the extremity and the direction of the lymphatics caused. However, the least injury to lymphatics with any technique.

The subcutaneous connective tissues, which serve for skin suspension, may be the reason for the protective effect by the tumescent technique. The small connective fibers are guidelines for surrounding small vessels. The integrity of this framework seems to be protected by the tumescent technique [6, 9].

6.3 Anatomy of Lymphatics in the Lower Limb

The initial lymph vessels form a polygonal network at the border of the papillary stratum. In the reticular stratum initial precollectors with valves transport the lymph through the corium and the subcutaneous tissue into the prefascial collectors. Valves protect the initial network against retrograde filling.

In the lymph vessel bundles of the extremities, long and short main collectors, collaterals, and anastomotic branches can be differentiated. In the lower extremities, long main collectors ascend from the feet to the inguinal lymph nodes (Fig. 6.1). Short main collectors ramify from the long ones and are found especially in the lower and upper thigh regions.

Collaterals connect the distal part of the main collector to the proximal one and can replace the bridged part of the collector. Anastomotic branches connect similar and different neighboring vessel parts. By this way the lymph can be directed into sideways-situated collectors. The anastomotic branches have the same diameter as the collectors but they occur only in an oblique ascending direction.

Segmental, vertically orientated precollectors join the deep cutaneous stratum to the subcutaneous collectors. The vertical precollectors drain round skin regions with a diameter of 1.5 cm at the sole and 3–4 cm in the other regions. Each skin region can be drained in several directions because their borderlines overlap with neighboring fields. The drainage is directed into the vertical precollectors. A lower resistance facilitates this. The precollectors of some skin areas drain mostly with a common trunk in the superficial collectors. That is the reason why in valve insufficiency irregular bordered skin areas are punctiformly filled in a retrograde way.

Fig. 6.1. Lymphatics and lymphatic territories of the lower extremity in ventral and dorsal views

The ventro-medial bundle at the lower leg can be formed in two types. The mixed type has main collectors, many collaterals, and anastomotic branches. The so-called collector type consists mainly of principal collectors. The number diminishes at the knee region and increases upwards again. Brunner [10] called the narrow part of the knee a physiological bottleneck. A smaller narrowing is situated between the malleoli. The vessel-rich parts ahead of the narrow ones and the regional nodes, which decrease the lymphatic flow, serve as a reservoir.

Four to six main collectors have to be intact for sufficient drainage. At the knee region, compensation is only possible if no more than two vessels break down.

The breakdown of the ventro-medial bundle is equivalent to an inguinal lymphadenectomy. It is naturally drained through the division of the extremities' roots in the lower region of the trunk.

Depending upon the direction of drainage (precollectors, collectors, and lymphatic bundle), we can define areas, zones, and territories. The skin regions, which are connected to one collector, form a skin area in stripes. The skin areas of all collectors of one lymph vessel bundle form a territory.

In the lower extremities, four drainage territories are differentiated: the territories of the ventro-medial and ventro-lateral bundles, and the dorso-medial and the dorso-lateral upper thigh territories (Fig. 6.1). Vessel breakdown in the latter territories is not of significance.

The skin areas anastomose with one another by the cutaneous lymph-vessel network, especially by numerous connections of neighboring collectors. In contrast, only some anastomotic branches connect the borderline collectors of neighboring territories. The interterritorial zone with a low number of vessels is called the lymphatic water division [11, 12]. From one territory to another the lymph can only flow through the divide. The drainage is facilitated if the position of the valves allows it to pass or if in extended vessels, the valves become insufficient and enable a retrograde flow. The number of interterritorial anastomosing branches varies individually and territorially. The water divide is a well-recognizable border between an edematous and a cutaneous territory without stasis [13].

6.4 Lymphatics of the Upper Limb

The collectors of the dorsum of the hand are connected to the radial and ulnar bundles (Fig. 6.2). The pursuit of the lower arm bundles is the medial upper arm bundle in the stripelike middle upper arm territory. The eight to ten collectors ascend along the medial bicipital sulcus to the axillary lymph nodes. One or two vessels ascend through the basilic hiatus. The collectors of the dorsal lateral territory form a lateral upper arm bundle in 60% of cases. One or two collectors ascend along the cephalic vein and terminate in part in the infra-clavicular and supra-clavicular nodes.

A long lateral bundle is found in 14% of cases. It can drain the lymph of the lower arm and compensate a loss of the medial bundle [14]. At the lower arm the middle territory lies between the radial and the ulnar territories, at the upper arm the stripelike, middle territory is between the dorso-medial and dorso-lateral ones (Fig. 6.2).

6.5 Lymphatics of the Trunk

At the trunk the collectors are radially orientated towards the regional nodes of each quadrant. Consequently two upper and two lower territories exist. The ventral vertical separates them and the horizontal water divide.

The drainage of extremity edema over the water divide is possible especially through integeral normal lymphatics, accessory collectors, newly formed lymphatics, widening of dermal lymphatics, and over the water divide to the contra-lateral side or the homolateral territory.

Fig. 6.2. Lymphatics and lymphatic territories of the upper limb in ventral and dorsal views

6.6 Lymph Liposuction

In persistent lymphedema, reconstructive and resection procedures have been established for operative treatment of lymphedemas with the dry technique. Autogenous lymph vessel transplantation was developed to bridge local blockades by a bypass [15]. The grafts are harvested from the ventro-medial bundle of the medial upper thigh. Under ×40 magnification of an operating microscope they are anastomosed to ascending lymphatics of the affected arms or legs. In an arm edema an overall circumferential reduction of one third can be achieved [16].

A surplus of fat and fibrotic tissue can persist. In an experimental study with the dry technique we could demonstrate that the risk of lymphatic lesions is decreased by longitudinal liposuction and increased by transversale liposuction [5]. In a second anatomical study with the tumescent technique we found a reduced risk even by transverse liposuction compared with the dry technique [7]. In clinical practice liposuction has already been employed to treat arm edemas [17, 18].

For the therapeutic strategy, possibilities of lymphatic reconstructive procedures are first to be clarified. In these patients an autogenous lymphatic transplantation is performed. A resting surplus of tissue in arms and especially in legs may be treated by lymph liposuction later on. Conventional blunt, straight cannulas (Rasp, Polytech Europe, Dieburg, Germany) and a conventional vacuum pump (Lipectom, Aesculap, Tuttlingen, Germany) are used, which produces a negative atmospheric pressure of 750 mmHg (1 bar). The direction of the suction cannula is mainly longitudinal to the axes of the extremities and lymphatics or at an angle of 10°. Transverse liposuction is omitted as far as possible.

6.7 Conclusions

Knowledge of the anatomic direction of the lymphatics of the extremities and the trunk reduces the risk of injury. Longitudinal liposuction in the axes of the extremities and lymphatics seems to have the lowest risk of lymphatic lesions.

Despite the preference of liposuction in the longitudinal direction, the tumescent technique diminishes, at least experimentally, the risk of lymphatic damage even in the transverse direction compared with the dry technique.

Lymph liposuction can serve for minimal invasive resection therapy in a lymphedema adjunct after autogenous lymph-vessel transplantation. Especially in patients with lymphatic diseases, the suction cannula should be directed longitudinally to the lymphatics in any case.

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7 Proposed Safety Guidelines for the Maximum Volume Fat Removal by Tumescent Liposuction

Warwick L. Greville

7.1 Introduction

With increasing scrutiny of liposuction procedures and personnel by regulatory authorities and the public, it is imperative that we have a safe and reasonable set of guidelines for cosmetic surgeons. The American Academy of Cosmetic Surgery and others have excellent safety recommendations [1–6] for performing liposuction. Elaboration of recommendations pertaining to the safe maximum volume fat removal is an important addendum that requires further delineation.

Some regulatory bodies in America and Australia have made or are in the process of making guidelines and surgeons performing this procedure on a daily basis are qualified to have input into formulating these guidelines. For example, it has been regulated in California that for safety reasons 5 l shall be the maximum volume extracted at any one time. In Florida lesser volumes have been proposed depending whether the surgery is carried out in a registered or non-registered facility. However, no account has been taken of other very important parameters. The designation of 5 l seems not to be based on scientific data. The regulatory authorities certainly have real concerns about public safety.

Common sense indicates, and, in fact, all surgeons routinely performing liposuction would attest that while 5 l of fat extracted from a healthy person of 100 kg is inherently very safe, 5 l extracted from a thin, elderly person of 50 kg could be potentially dangerous. Needless to say, all the factors that influence the safety of the procedure must be properly addressed in formulating guidelines to protect the public.

7.2 Guidelines

The weight of the patient, the total surface areas that are to be liposuctioned, and an estimation of a maximum safe dose of and concentration of lidocaine should all be utilized in the determination of the total volume of fat that can be safely removed. The safe concentration of lidocaine is influenced by the age, health, concomitant medications, supplements, and foods that the patient is ingesting.

7.2.1 Considerations of the Patient's Weight

The weight of the patient is probably a more important determinant in considering the maximum volume of fat that can be extracted safely. Traditionally, among conservative experienced surgeons, the volume of actual supranatant fat in liters to be safely removed for an average patient has been considered to be around 4–5% of that person's body weight in kilograms [7]. When the total volume of fat plus infranatant or any other fluid present is included, this equates to approximately 5%. However, this percentage, while a good approximation, is influenced by several variables and can be, for example, increased by the enthusiastic infusion of excess tumescent fluid, or near the end of the procedure by non-fat aspirate. Nevertheless, for an obese patient, conservative surgeons would consider that up to 6% of the body weight would be an appropriate safe volume of the total aspirate. For the grossly obese some would possibly consider more than 6%.

In continental Europe, where liposuction originated and was popularized, a more aggressive approach is taken and for the grossly obese removal of up to 10% of the body weight has commonly been carried out apparently without any published serious complications [7].

Consequently, using these facts an initial simple formula can be developed for a 60-kg patient:

$$60 \text{ (weight in kilograms)} \times 5/100 = 3.0 \text{ l.}$$

7.2.2 Consideration of Total Lidocaine Infused and the Resultant Concentration Using Klein's Tumescent Solution

The second main limitation for liposuction using the tumescent local anesthesia is the total amount in milligrams of lidocaine infused, the weight of the patient, and the resultant concentration. Leibaschoff (G.H. Leibaschoff, personal communication, 20 January 1999) states that a lidocaine concentration of 35 mg/kg is exceptionally safe, and allows variation depending upon individual circumstances. Klein [8] has advocated that for a healthy young woman (ASA status 1) of average weight the total amount of lidocaine infused should not exceed 45 mg/kg. The American Academy of Cosmetic Surgery recommends up to 55 mg/kg for these guidelines [9]. A middle-of-the-road approach of 45 mg/kg is to be used, while other modifying factors must also be taken into consideration.

Thus, for a patient with some mild liver dysfunction as evidenced by elevation of liver enzymes using the more conservative guidelines of 45 mg/kg, the guideline of 45 mg/kg would be reduced to 35 mg/kg.

For a thin patient (judged by appearance, body mass index, BMI, or reference to insurance tables), the concentration would be reduced from 45 to 40 mg/kg. The formula would include this modification:

$$60 \times 5/100 \times 40/45 = 2.66 \text{ l}.$$

Similarly for an elderly patient (over age 60), the reduced concentration of 40 mg/kg would be used. However, if we have a thin and elderly patient with such confounding variables, the problem is compounded and the next example shows how this is calculated:

$$60 \times 5/100 \times 40/45 \times 40/45 = 2.37 \text{ l}.$$

This is a more correct way to calculate, albeit with a more conservative outcome. However, for simplicity the following calculation would also suffice:

$$60 \times 5/100 \times 35/45 = 2.33 \text{ l aspirate (maximum safety volume)}.$$

For an overweight patient this would be increased to 47 mg/kg (BMI greater than 25, fat percentage greater than 30). For an obese patient this would be increased to 50 mg/kg (BMI greater than 30, fat percentage greater than 35). These must be clearly documented and made part of the patient's record.

It is critical that the surgeon supervises and double-checks not only these calculations but also the timely and meticulous production of the tumescent solutions. Taking all these actions can be instrumental in preventing drug errors, and if any adverse outcome should eventuate, the all-important documentation is charted and substantiates what has been done.

7.2.3 Considerations of the Surface Areas to Be Treated

The larger the surface area treated with liposuction the greater the trauma and this entails a greater risk to the patient [6–9]; therefore, surface area should be part of the equation in determining limiting safety factors. The determination of the areas involved parallels that for a burn patient although the pathophysiology may differ significantly. It would be more appropriate to define the specific areas of liposuction and attribute a unitary amount to the individual area.

A guideline for determining units of involvement is:

1. Both arms including the areas of the lateral chest above the bra line: 1 unit.
2. Both breasts in women: 2 units. Both breasts in men: 1 unit.
3. Upper abdomen from the inframammary line to the umbilicus and extending to the anterior axillary line: 1°unit.
4. Lower abdomen from the umbilicus inferiorly to and including the pubic area and extending laterally to the anterior axillary line: 1–2 units.
5. Both hips; 1 unit.
6. Waist that includes the area to the anterior axillary line of the lateral chest below the bra line and extending to the superior margin of the iliac crest: 1 unit.
7. Outer thighs (saddlebags) including the lateral gluteal region: 1–2 units.
8. Inner thighs extending to above the inner knees: 1 unit.
9. Anterior thighs from below the inguinal crease inferiorly to include the suprapatellar areas of the knees: 1 unit.
10. Calves and ankles: 1 unit.
11. Buttocks: 0.5 unit. With prominent steatopygia: 1 unit.
12. Inner knees: 0.5 unit.
13. Other areas can be allocated units in a similar fashion.

Estimation of the surface area treated is not precise and may be adjusted to the physiognomy of the individual. The safe volume formula for a patient of average weight is predicated on the basis of 5% as being the maximum acceptable percentage of aspirate at any one time. Both empirically and by experience, 4 units is the average area of liposuction presently accepted. However, the relative importance of surface areas is less than the ratio of the volume of aspirate to the weight of the patient. Any increased deviation from 4 units total can be decreased by a factor of 0.5.

The formula for a healthy 60-kg patient with 4 units for liposuction would be:

$$60 \times 5/100 \times 4/4 = 3.0\ \text{l}.$$

If there is more (A_1) or less (A_2) than 4 units to be treated then the formula would be:

Weight (kilograms) × $A_1/(A_1 + 0.5 \times$ difference between A_1 and A_2 or between A_2 and $A_1) \times 5/100$ = volume (liters).

For example, in a 60-kg healthy young patient with 6 units to be treated:

$$60 \times 4/5 \times 5/100 = 2.4\ \text{l}.$$

If the estimated volume of liposuction planned exceeds the maximum safety volume (large-volume liposuction), then staged procedures are recommended as the safest option. These can be performed 3–4 weeks apart. Removal of 10% above the maximum safety volume of fat would be considered megaliposuction, which would require surgery in a hospital with appropriate consultations, appropriate anesthesia, continuous monitoring, overnight hospital care, and immediate access to all emergency facilities [10, 11]. The patient should be informed of the less than acceptable risks that this might entail [12].

7.3 Discussion

Those patients who are on medications that utilize the same mixed function oxidase, cytochrome P450 3A4 (which is more abundant and important) and cytochrome P450 1A2, as lidocaine in their hepatic detoxification would only tolerate a much lower concentration of lidocaine. When these pathways are inhibited, any further infusion of fluid containing lidocaine is potentially very dangerous as there is no longer a 70% detoxification in the first-pass metabolism by the liver. The resultant rising concentration of lidocaine would be proportional to any decremental catabolism.

Such medications include most of the groups of medications that include the macrolide antibiotics, selective serotonin uptake inhibitors, calcium blockers (which probably also inhibit hepatic blood flow), benzodiazepines, HIV protease inhibitors, the antifungals, and H_2 blockers and in foods such as grapefruit (and its juice), which has narengenin, which is an inhibitor of the intestinal cytochrome P450 3A4. To prevent this type of competitive inhibition, the time interval between the cessation of taking cytochrome P450 3A4 inhibitors and any surgical procedure varies from 1 to 10 days [13, 14].

Lidocaine is also metabolised by cytochrome P450 1A2, which is more inducible than cytochrome P450 3A4. It is polymorphic and one of the variant genotype factors such as the homozygous 1A2 IF/IF allele that is strongly upregulated by lifestyle factors such as smoking and some naturopathic herbal products like St. John's wort. Genetic testing can be performed to detect abnormalities but there is increased cost and controversy in its use [15].

Versed (midazolam) used for conscious sedation competes for detoxification through the cytochrome P450 3A4 pathway and elderly patients are highly susceptible to this agent's respiratory depressant effects. Any occult infection or inflammation that increases tumor necrosis factor α and the interleukins 1 and 6 also decreases hepatic detoxification of lidocaine. Evaluation of the erythrocyte sedimentation rate and the C-reactive protein can be used as surrogate markers for the cytokines.

The safe concentration of lidocaine depends on genetic inheritance and its phenotype expression. There are over 50 cytochrome P450 isoforms with their polymorphisms and with many confounding variables and, therefore, safe lidocaine concentrations can only be estimated.

7.4 Conclusions

The guidelines are simple to use with four variable or modifying factors:

Weight of patient × percentage fat removal × (appropriate concentration of lidocaine)/45× (4 units/4 ± 0.5 × difference in the number of units).

While these guidelines are more encompassing than other formats presently in use, they are only guidelines as such. However, it is important that there is an ongoing dialogue with regulatory authorities and those surgeons performing liposuction so that their experience and knowledge is accessed, thus resulting in practical relevant standards that ensure safety for patients and protect the public interest.

In Figs. 7.1 and 7.2 are two cases of staged procedures which would have otherwise required megaliposuction, with the first case having 8.5 l of fat extracted and the second case having 10 l of fat extracted. Serial staging of the procedures under a local anesthetic with conscious sedation allows the surgeon to evaluate the results with the patient standing up. The surgeon can then mark any areas of irregularities and the lay the patient down again and treat any of these contour imperfections. At subsequent procedures this process can be repeated, and even other areas from any previous procedure can be touched up so with this blending the best silhouette can be achieved. A few patients

a b

Fig. 7.1. A 30-year-old woman: **a** preoperatively; **b** postoperatively. Weight 66.5 kg, height 1.51 m, body mass index (*BMI*) 25.66, body fat 32% (impedance measurement). In the first procedure, the areas treated were the upper and lower abdomen, hips, and waist, and the total aspirate was 3.3 l. In the second procedure (1 month later), the inner and outer thighs and the inner knees were treated, and the total aspirate was 2.9 l. In the third procedure (3 months later), the arms above and below the bra line were treated, and the total aspirate was 2.3 l. The total aspirate from the three procedures was 8.5 l

Fig. 7.2. A 48-year-old woman: **a** preoperatively; **b** postoperatively. Weight 89 kg, height 1.68m, BMI 31.5. In the first procedure, the areas treated were the inner and outer thighs and the knees, and the total aspirate was 4.3 l. In the second procedure (2 months later), the upper and lower abdomen and the waist and the inner knees were treated, and the total aspirate was 3.5 l. In the third procedure (1 month later), the arms and breast (to correct asymmetry from previous surgery) were treated, and the total aspirate was 2.2 l. The total aspirate from the three procedures was 10 l

do ask if all areas of the body can be treated in one procedure. However, when the possible safety concerns and the outcomes are addressed most patients accept the concept of several staged procedures. In fact they tolerate the staged procedure far better than the trauma of one large procedure. In addition, as in the illustrated cases, most patients were keen to adhere to dietary recommendations and are successful with a continued weight-loss program.

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Part II
Anesthesia

Anesthesia for Liposuction

Gary Dean Bennett

8.1 Introduction

An estimated 70% of all elective surgery is performed in an outpatient setting [1], and more than 50% of aesthetic plastic surgeons perform most of their procedures in an office setting [2]. Economic considerations play a major role in the shift to ambulatory surgery. Because of greater efficiency, these outpatient surgical units have greater cost-effectiveness [3]. Advances of monitoring capabilities and the adoption of monitoring standards of the American Society of Anesthesiologists (ASA) are credited for a reduction of perioperative morbidity and mortality [4]. Advances in pharmacology have resulted in a greater diversity of anesthetic agents with rapid onset, shorter duration of action, and reduced morbidity [5]. The advent of minimally invasive procedures has further reduced the need for hospital-based surgeries. Regulatory agencies such as the American Association of Accreditation of Ambulatory Surgery (AAAASF) and the Accreditation Association for Ambulatory Health Care (AAAHC) have helped establish minimum standards of care for surgical locations where anesthesia is administered.

As a consequence of the shift away from hospital-based surgery, the surgeon has adopted a more important role in the medical decision-making with respect to anesthesia. Frequently, the surgeon decides on the location of surgery, the extent of the preoperative evaluation, the type of anesthesia to be administered, the personnel to be involved in the care and monitoring of the patient, the postoperative pain management, and the discharge criteria used. Therefore, it is incumbent on the surgeon to understand current standards of anesthesia practice. If the surgeon chooses to assume the role of the anesthesiologist, then he or she must adhere to the same standards that are applied to the anesthesiologist. While the morbidity and mortality of anesthesia has decreased [6, 7], risk awareness of anesthesia and surgery must not be relaxed.

If the intended surgical procedure requires general anesthesia or enough sedative–analgesic medication (SAM) to increase the probability of loss of the patient's life-preserving protective reflexes (LPPRs), then, according to the law in some states, the surgical facility must be accredited by one of the regulatory agencies (AAAASF, Institute for Medical Quality, Joint Commission on Accreditation, or AAAHC) [8, 9].

Regardless of which type of facility is selected or the type of anesthesia planned, the operating room must be equipped with the type of monitors required to fulfill monitoring standards established by the ASA [10], as well as proper resuscitative equipment and resuscitative medications [11, 12]. The facility should be staffed by individuals with the training and expertise required to assist in the care of the patient [12, 13]. Emergency protocols must be established and rehearsed [14]. Optimally, the surgical facility should have ready access to a laboratory in the event a stat laboratory analysis is required. Finally, a transfer agreement with a hospital must be established, in some states, in the event that an unplanned admission is required [11, 12].

An anesthesiologist or a certified nurse anesthetist (CRNA) may administer anesthesia. The surgeon may prefer to perform the surgery using exclusively local tumescent anesthesia without parenteral sedation, especially in limited liposuction [15]. However, many surgeons add parenteral sedative or analgesic medications with the local anesthetic. If the surgeon chooses to administer parenteral SAMs, then another designated, licensed, preferably experienced individual should monitor the patient throughout the perioperative period [16]. Use of unlicensed, untrained personnel to administer parenteral SAM and monitor patients may increase the risk to the patient. It is also not acceptable for the nurse monitoring the patient to double as a circulating nurse [17]. Evidence suggests that anesthesia-related deaths more than double if the surgeon also administers the anesthesia [18]. Regardless of who delivers the anesthesia, the surgeon should preferably maintain current advanced cardiac life support (ACLS) certification and all personnel assisting in the operating room and recovery areas must maintain basic life support certification [19]. At least one ACLS-certified health provider must remain in the facility until the patient has been discharged [20].

8.2 Preoperative Evaluation

The time and energy devoted to the preoperative preparation of the surgical patient should be commensurate to the efforts expended on the evaluation and preparation for anesthesia. The temptation to leave preoperative anesthesia preparation of the patient as an afterthought must be resisted. Even if an anesthesiologist or a CRNA is to be involved later, the surgeon bears responsibility for the initial evaluation and preparation of the patient. Thorough preoperative evaluation and preparation by the surgeon increases the patients confidence, reduces costly and inconvenient last-minute delays, and reduces overall perioperative risk to the patient [21]. If possible, the preoperative evaluation should be performed with the assistance of a spouse, parent, or significant other so that elements of the health history or recent symptoms may be more readily recalled.

A comprehensive preoperative evaluation form is a useful tool to begin the initial assessment. Information contained in the history alone may determine the diagnosis of the medical condition in nearly 90% of patients [22]. While a variety of forms are available in the literature, a check-list format to facilitate the patient's recall is probably the most effective [23]. Regardless of which format is selected, information regarding all prior medical conditions, prior surgeries and types of anesthetics, current and prior medications, adverse outcomes to previous anesthetics or other medications, eating disorders, prior use of anti-obesity medication, and use of dietary supplements, which could contain ephedra, should be disclosed by the patient.

A family history of unexpected or early health conditions such as heart disease, or unexpected reactions, such as malignant hyperthermia, to anesthetics or other medications should not be overlooked. Finally, a complete review of systems is vital to identifying undiagnosed, untreated, or unstable medical conditions that could increase the risk of surgery or anesthesia. Last-minute revelations of previously undisclosed symptoms, such as chest pain, should be avoided.

Indiscriminately ordered or routinely obtained preoperative laboratory testing is now considered to have limited value in the perioperative prediction of morbidity and mortality [23–26]. In fact, one study showed no difference in morbidity in healthy patients without preoperative screening tests versus morbidity in a control group with the standard preoperative tests [27]. Multiple investigations have confirmed that the preoperative history and physical examination is superior to laboratory analysis in determining the clinical course of surgery and anesthesia [28, 29]. Newer guidelines for the judicious use of laboratory screening are now widely accepted (Table 8.1). Additional preoperative tests may be indicated for patients with prior medical conditions or risk factors for anesthesia and surgery (Table 8.2).

Consultation from other medical specialists should be obtained for patients with complicated or unstable medical conditions. Patients with ASA III risk designation should be referred to the appropriate medical specialist prior to elective surgery. The consultant's role is to determine if the patient has received optimal treatment and if the medical condition is stable. Additional preoperative testing may be considered necessary by the consultant. The medical consultant should also assist with stabilization of the medical condition in the perioperative period if indicated. If the surgeon has concerns about a patient's ability to tolerate anesthesia, a telephone discussion with an anesthesiologist or even a formal preoperative anesthesia consultation may be indicated.

Certain risk factors, such as previously undiagnosed hypertension, cardiac arrhythmias, and bronchial asthma, may be identified by a careful physical examination. Preliminary assessment of head and neck anatomy to predict possible challenges in the event endotracheal intubation is required may serve as an early warning to the anesthesiologist or CRNA even if a general anesthetic is not planned. For most ambulatory surgeries, the anesthesiologist or CRNA evaluates the patient on the morning of surgery.

8.3 Preoperative Risk Assessment

The ultimate goals of establishing a patient's level of risk are to reduce the probability of perioperative morbidity and mortality. The preoperative evaluation is the crucial component of determining the patient's preoperative risk level. There is compelling evidence to suggest that the more coexisting medical conditions a patient has, the greater the risk for periopera-

Table 8.1. Guidelines for preoperative testing in health patients (ASA 1-11) (Adapted from Roizen et al. [30])

Age	Risk
12–40[a]	CBC
40–60	CBD, EKG
>60	CBC, BUN, glucose, EGG, CXR

[a]Pregnancy test for potentially childbearing women is suggested

Table 8.2. Common indications for additional risk specific testing (Adapted from Roizen et al. [31])

Electrocardiogram	
History	Coronary artery disease, congestive heart failure, prior myocardial infarction, hypertension, hyperthyroidism, hypothyroidism, obesity, compulsive eating disorders, deep venous thrombosis, pulmonary embolism, smoking, chemical dependency on chemotherapeutic agents, chronic liver disease
Symptoms	Chest pain, shortness of breath, dizziness
Signs	Abnormal heart rate or rhythm, hypertension, cyanosis, peripheral edema, wheezing, rales, rhonchi
Chest X-ray	
History	Bronchial asthma, congestive heart failure, chronic obstructive pulmonary disease, pulmonary embolism
Symptoms	Chest pain, shortness of breath, wheezing, unexplained weight loss, hemoptysis
Signs	Cyanosis, wheezes, rales, rhonchi, decreased breath sounds, peripheral edema, abnormal heart rate or rhythm
Electrolytes, glucose, liver function tests, BUN, creatinine	
History	Diabetes mellitus, chronic renal failure, chronic liver disease, adrenal insufficiency, hypothyroidism, hyperthyroidism, diuretic use, compulsive eating disorders, diarrhea
Symptoms	Dizziness, generalized fatigue or weakness
Signs	Abnormal heart rate or rhythm, peripheral edema, jaundice
Urinalysis	
History	Diabetes mellitus, chronic renal disease, recent urinary tract infection
Symptoms	Dysuria, urgent, frequent, and bloody urination

tive morbidity and mortality [16, 32]. Identification of preoperative medical conditions helps reduce perioperative mortality.

A variety of indexing systems have been proposed to help stratify patients according to risk factors, but the system finally adopted by the ASA in 1984 (Table 8.3) [33] has emerged as the most widely accepted method of preoperative risk assessment. Numerous studies have confirmed the value of the ASA system in predicting which patients are at a higher risk for morbidity [34] and mortality [35]. Goldman et al. [36] established a multifactorial index based on cardiac risk factors that has repeatedly demonstrated its usefulness in predicting perioperative mortality. Physicians should incorporate one of the acceptable risk classification systems as an integral part of the preoperative evaluation.

While studies correlating the amount of fat aspirate during liposuction with perioperative morbidity and mortality have not been performed, it would not be unreasonable to extrapolate conclusions from previous studies and apply them to liposuction. Liposuction surgeries with less than 1,500 ml fat aspirate are generally considered less invasive procedures, while liposuctions aspirating more than 3,000 ml are considered major surgical procedures. As blood loss exceeds 500 ml [37], or the duration of surgery exceeds 2 h, morbidity and mortality increases [34, 38]. The recognition of preoperative risk factors and improved perioperative medical management of patients with coexisting disease has reduced the morbidity and mortality of surgery. The surgeon should maintain a current working understanding of the evaluation and treatment of those medical conditions that may increase complications during anesthesia. These conditions include cardiac disease [39, 40], obesity [41–43], hypertension [44, 45], diabetes mellitus [46], pulmonary disease [47], obstructive sleep apnea [48, 49], and malignant hyperthermia susceptibility [50, 51].

Table 8.3. The American Society of Anesthesiologists' (ASA) physical status classification

ASA class I	A healthy patient without systemic medical or psychiatric illness
ASA class II	A patient with mild, treated and stable systemic medical or psychiatric illness
ASA class III	A patient with severe systemic disease that is not considered incapacitating
ASA class IV	A patient with severe systemic, incapacitating, and life-threatening disease not necessarily correctable by medication or surgery
ASA class V	A patient considered moribund and not expected to live more than 24 h

8.4 Anesthesia for Liposuction

Anesthesia may be divided into four broad categories: local anesthesia, local anesthesia combined with sedation, regional anesthesia, and general anesthesia. The ultimate decision to select the type of anesthesia depends on the type and extent of the surgery planned, the patient's underlying health condition, and the psychological disposition of the patient. For example, a limited liposuction of less than 500 ml of fat from a small area in a healthy patient, with limited anxiety, could certainly be performed using strictly local anesthesia without sedation. As the scope of the surgery broadens, or the patient's anxiety level increases, the local anesthesia may be supplemented with oral or parenteral analgesic or anxiolytic medication.

8.4.1 Local Anesthesia

A variety of local anesthetics are available for infiltrative anesthesia. The selection of the local anesthetic depends on the duration of anesthesia required and the volume of anesthetic needed. The traditionally accepted, pharmacological profiles of common anesthetics used for infiltrative anesthesia for adults are summarized in Table 8.4.

The maximum doses may vary widely depending on the type of tissue injected, the rate of administration, the age, underlying health, and body habitus of the patient, the degree of competitive protein binding, and possible cytochrome (cytochrome oxidase P450 3A4) inhibition of concomitantly administered medications (Table 8.5). The maximum tolerable limits of local anesthetics have been redefined with the development of the tumescent anesthetic technique. Lidocaine doses up to 35 mg/kg were found to be safe, if administered in conjunction with dilute epinephrine during liposuction with the tumescent technique; peak plasma levels occur 6–24 h after administration [54]. More recently, doses up to 55 mg/kg have been found to be within the therapeutic safety margin [55]. However, recent guidelines by the American Academy of Cosmetic Surgery recommend a maximum dose of 45–50 mg/kg [20].

Since lidocaine is predominantly eliminated by hepatic metabolism, specifically, cytochrome oxidase P450 3A4, drugs that inhibit this microsomal enzyme may increase the potential of lidocaine toxicity. Propofol and Versed, commonly used medications for sedation and hypnosis during liposuction are also known to be cytochrome P450 inhibitors. However, since the duration of action of these drugs is only 1–4 h, the potential inhibition should not interfere with lidocaine at the peak serum level 6–12 h later. Lorazepam is a sedative which does not interfere with cytochrome oxidase and is preferred by some physicians.

Significant toxicity has been associated with high doses of lidocaine as a result of tumescent anesthesia during liposuction [56]. The systemic toxicity of local anesthetic has been directly related to the serum concentration. Early signs of toxicity, usually occurring at serum levels of about 3–4 μg/ml for lidocaine, include circumoral numbness, lightheadedness, and tinnitus. As the serum concentration increases toward 8 μg/ml, tachycardia, tachypnea, confusion, disorientation, visual disturbance, muscular twitching, and cardiac depression may occur. At still higher serum levels, above 8 μg/ml, unconsciousness and seizures may ensue. Complete cardiorespiratory arrest may occur between 10 and 20 μg/ml. However, the toxicity of lidocaine may not always correlate exactly with the plasma level of lidocaine, presumably because of the variable extent of protein binding in each patient and the presence of active metabolites and other factors, including the age, ethnicity, health, and body habitus of the patient, and additional medications.

During administration of infiltrative lidocaine anesthesia, rapid anesthetic injection into a highly vascular area or accidental intravascular injection leading to sudden toxic levels of anesthetic results in sudden onset of seizures or even cardiac arrest or cardiovascular collapse. Patients who report previous allergies to anesthetics may present a challenge to surgeons performing liposuction. Although local anesthetics of the aminoester class such as procaine are associated with allergic reactions, true allergic reactions to local anesthetics of the aminoamide class, such as lidocaine, are extremely rare. Allergic

Table 8.4. Clincial pharmacolgy of common local anesthetics for infiltrative anesthesia (Adapted from Covino and Wildsmith [52])

Agent	Concentration (%)	Duration of action (without epinephrine)	Maximum dose (without epinephrine)			Duration of action (with epinephrine)	Maximum dose (with epinephrine)		
		min	mg/kg	Total mg	Total ml	min	mg/kg	Total mg	Total ml
Lidocaine	1.0	30–60	4	300	30	120	7	500	50
Mepivacaine	1.0	45–90	4	300	30	120	7	500	50
Etidocaine	0.5	120–180	4	300	60	180	5.5	400	80
Bupivacaine	0.25	120–240	2.5	185	75	180	3	225	90
Ropivacaine	0.2	120–360	2.7	200	80	120–360	2.7	200	80

Table 8.5. Medications inhibiting cytochrome oxidase P450 3A4 (From Shiffman [53])

Amiodarone	Itraconazole	Pentoxifylline
Atenolol	Isoniazide	Pindolol
Carbamazepine	Labetolol	Propofol
Cimetidine	Ketoconazole	Propranolol
Clarithromycin	Methadone	Quinidine
Chloramphenicol	Methyprednisolone	Sertraline
Cyclosporin	Metoprolol	Tetracyline
Danazol	Miconazole	Terfenidine
Dexamethasone	Midazolam	Thyroxine
Diltiazam	Nadolol	Trimolol
Erythromycin	Nefazodone	Triazolam
Fluconazole	Nicardipine	Verapamil
Flurazepam	Nifedipine	
Fluoxetine	Paroxetine	

reactions may occur to the preservative in the multidose vials. Tachycardia and generalized flushing may occur with rapid absorption of the epinephrine contained in some standard local anesthetic preparations.

The development of vasovagal reactions after injections of any kind may cause hypotension, bradycardia, diaphoresis, pallor, nausea, and loss of consciousness. These adverse reactions may be misinterpreted by the patient and even the physician as allergic reactions. A careful history from the patient describing the apparent reaction usually clarifies the cause. If there is still concern about the possibility of true allergy to local anesthetic, then the patient should be referred to an allergist for skin testing.

In the event of a seizure following a toxic dose of local anesthetic, proper airway management and maintaining oxygenation is critical. Seizure activity may be aborted with intravenous diazepam (10–20 mg), midazolam (5–10 mg), or thiopental (100–200 mg).

Although the ventricular arrhythmias associated with bupivacaine toxicity are notoriously intractable, treatment is still possible using large doses of atropine, epinephrine and bretylium [57, 58]. Some studies indicate that bupivacaine should not be used [59]. Pain associated with local anesthetic administration is due to the pH of the solution and may be reduced by the addition of 1 mEq of sodium bicarbonate to 10 ml of anesthetic.

8.4.2 Sedative–Analgesic Medication

Most liposuctions are performed with a combination of local tumescent anesthesia and supplemental sedative-analgesic medications (SAMs) administered orally (p.o.), intramuscularly (i.m.), or intravenously (i.v.). The goals of administering supplemental medications are to reduce anxiety (anxiolysis), the level of consciousness (sedation), unanticipated pain (analgesia), and, in some cases, to eliminate recall of the surgery (amnesia).

Sedation may be defined as the reduction of the level of consciousness usually resulting from pharmacological intervention. The level of sedation may be further divided into three broad categories: conscious sedation, deep sedation, and general anesthesia. The term conscious sedation has evolved to distinguish a lighter state of anesthesia with a higher level of mental functioning whereby the life-preserving protective reflexes are independently and continuously maintained. Furthermore, the patient is able to respond appropriately to physical and verbal stimulation.

LPPRs may be defined as the involuntary physical and physiological responses that maintain the patient's life which, if interrupted, result in inevitable and catastrophic physiological consequences. The most obvious examples of LPPRs are the ability to maintain an open airway, swallowing, coughing, gagging, and spontaneous breathing. Some involuntary physical movements such as head turning or attempts to assume an erect posture may be considered LPPRs if these reflex actions occur in an attempt to improve airway patency such as expelling oropharyngeal contents. The myriad of homeostatic mechanisms to maintain blood pressure, heart function, and body temperature may even be considered LPPRs.

As the level of consciousness is further depressed to the point that the patient is not able to respond purposefully to verbal commands or physical stimulation, the patient enters into a state referred to as deep sedation. In this state, there is a significant probability of loss of LPPRs. Ultimately, as total loss of consciousness occurs and the patient no longer responds to verbal command or painful stimuli: the patient enters a state of general anesthesia. During general anesthesia the patient most likely loses the LPPRs.

In actual practice, the delineation between the levels of sedation becomes challenging at best. The loss of consciousness occurs as a continuum. With each incremental change in the level of consciousness, the likelihood of loss of LPPRs increases. Since the definition of conscious sedation is vague, current ASA guidelines consider the term sedation–analgesia a more relevant term than conscious sedation [16]. The term SAM has been adopted by some facilities. Monitored anesthesia care (MAC) has been generally defined as the medical management of patients receiving local anesthesia during surgery with or without the use of supplemental medications. MAC usually refers to services provided by the anesthesiologist or the CRNA. The term "local standby" is no longer used because it mischaracterizes the purpose and activity of the anesthesiologist or CRNA.

Surgical procedures performed using a combination of local anesthetic and SAM usually have a shorter recovery time than similar procedures performed under regional or general anesthesia. Use of local anesthesia alone, without the benefit of supplemental medication, is associated with a greater risk of cardiovascular and hemodynamic perturbations such as tachycardia, arrhythmias, and hypertension particularly in patients with preexisting cardiac disease or hypertension. Patients usually prefer sedation while undergoing surgery with local anesthetics [60]. While the addition of sedatives and analgesics during surgery using local anesthesia seems to have some advantages, use of SAM during local anesthesia is certainly not free of risk. A study by the Federated Ambulatory Surgical Association concluded that local anesthesia, with supplemental medications, was associated with more than twice the number of complications than local anesthesia alone. Furthermore, local anesthesia with SAM was associated with greater risks than general anesthesia [40]. Significant respiratory depression as determined by the development of hypoxemia, hyperbaric, and respiratory acidosis often occurs in patients after receiving minimal doses of medications. This respiratory depression persists even in the recovery period.

One explanation for the frequency of these complications is the wide variability of patients' responses to these medications. Up to 20-fold differences in the dose requirements for some medications such as diazepam, and up to fivefold variations for some narcotics such as fentanyl have been documented in some patients [61]. Small doses of fentanyl, as low as 2 μg/kg, are considered by many physicians as subclinical, and produce respiratory depression for more than 1 h in some patients. Combinations of even small doses of sedatives, such as midazolam, and narcotics, such as fentanyl, may act synergistically (effects greater than an additive effect) in producing adverse side effects such as respiratory depression and hemodynamic instability. The clearance of many medications may vary depending on the amount and duration of administration, a phenomenon known as context-sensitive half-life. The net result is increased sensitivity and duration of action to medication for longer surgical procedures [62]. Because of these variations and interactions, predicting any given patient's dose-response is a daunting task. Patients appearing awake and responsive may, in an instant, slip into unintended levels of deep sedation with greater potential of loss of LPPRs. Careful titration of these medications to the desired effect combined with vigilant monitoring are the critical elements in avoiding complications associated with the use of SAM.

Supplemental medication may be administered via multiple routes, including oral, nasal, transmucosal, transcutaneous, intravenous, intramuscular, and rectal. While intermittent bolus has been the traditional method to administer medication, continuous infusion and patient-controlled delivery result in comparable safety and patient satisfaction.

Benzodiazepines such as diazepam, midazolam, and lorazepam remain popular for sedation and anxiolysis. Patients and physicians especially appreciate the potent amnestic effects of this class of medications, especially midazolam. The disadvantages of diazepam include the higher incidence of pain on intravenous administration, the possibility of phlebitis, and the prolonged half-life of up to 20–50 h. Moreover, diazepam has active metabolites which may prolong the effects of the medication even into the postoperative recovery time. Midazolam, however, is more rapidly metabolized, allowing for a quicker and more complete recovery for outpatient surgery. Because the sedative, anxiolytic, and amnestic effects of midazolam are more profound than those of other benzodiazepines and the recovery is rapider, patient acceptance is usually higher [63]. Since lorazepam is less effected by medications altering cytochrome P459 metabolism, it has been recommended as the sedative of choice for liposuctions which require a large-dose lidocaine tumescent anesthesia [56]. The disadvantage of lorazepam is the slower onset of action and the 11–22-h elimination half-life making titration cumbersome and postoperative recovery prolonged.

Generally, physicians who use SAM titrate a combination of medications from different classes to tailor the medications to the desired level of sedation and analgesia for each patient (Table 8.6). Use of prepackaged combinations of medications defeats the purpose of the selective control of each medication. Typically, sedatives such as the benzodiazepines are combined with narcotic analgesics such as fentanyl, meperidine, or morphine during local anesthesia to decrease pain associated with local anesthetic injection or unanticipated breakthrough pain. Fentanyl has the advantage of rapid onset and duration of action of less than 60 min. However, because of synergistic action with sedative agents, even doses of 25–50 μg can result in respiratory depression. Other medications with sedative and hypnotic effects such as a barbiturate, ketamine, or propofol are often added. Adjunctive analgesics such as ketorolac may be administered for additional analgesic activity. As long as the patient is carefully monitored, several medications may be titrated together to achieve the effects required for the patient characteristics and the complexity of the surgery. Fixed combinations of medications are not advised.

More potent narcotic analgesics with rapid onset of action and even shorter duration of action than fentanyl include sufenanil, alfenanil, and remifenanil

Table 8.6. Common medications and doses used for sedative analgesia. These doses may vary depending on age, gender, underlying health status, and other concomitantly administered medications (Adapted from Philip [63], Sa Rego et al. [64], and Fragen [65])

Medication	Bolus dose	Average adult dose	Continuous infusion rate (ug/kg/min)
Narcotic analgesics			
Alfentanil	5–7 μg/kg	30–50 μg	0.2–0.5
Fentanyl	0.3–0.7 μg/kg	25–50 μg	0.01
Meperidine	0.2 mg	10–20 mg i.v., 50–100 mg i.m.	NA
Morphine	0.02 mg	1–2 mg i.v., 5–10 mg i.m.	NA
Remifentanil	0.5–1.0 μg/kg	10–25 μg	0.025–0.05
Sufentanil	0.1–0.2 μg/kg	10 μg	0.001–0.002
Opiate agonist–antagonist analgesics			
Buprenorphene	4–6 μg/kg	0.3 mg	NA
Butorphanol	2–7 μg/kg	0.1–0.2 mg	NA
Nalbupnine	0.03–0.1 mg/kg	10 mg	NA
Sedative-hypnotics			
Diazepam	0.05–0.1 mg/kg	5–7.5 mg	NA
Methohexital	0.2–0.5 mg/kg	10–20 mg	10–50
Midazolam	30–75 μg/kg	2.5–5.0 mg	0.25–0.5
Propofol	0.2–0.5 mg/kg	10–20 mg	10–50
Thiopental	0.5–1.0 mg/kg	25–50 mg	50–100
Dissociative anesthetics			
Ketamine	0.2–0.5 mg/kg	10–20 mg	10

and may be administered using intermittent boluses or continuous infusion in combination with other sedative or hypnotic agents. However, extreme caution and scrupulous monitoring is required when these potent narcotics are used because of the risk of respiratory arrest. Use of these medications should be restricted to the anesthesiologist or CRNA. A major disadvantage of narcotic medication is the perioperative nausea and vomiting [66].

Many surgeons feel comfortable administering SAM to patients. Others prefer to use the services of an anesthesiologist or CNRA. Prudence dictates that for prolonged or complicated surgeries or for patients with significant risk factors, the participation of the anesthesiologist or CRNA during MAC anesthesia is preferable. Regardless of who administers the anesthetic medications, the monitoring must have the same level of vigilance.

Propofol, a member of the alkylphenol family, has demonstrated its versatility as a supplemental sedative–hypnotic agent for local anesthesia and of regional anesthesia. Propofol may be used alone or in combination with a variety of other medications. Rapid metabolism and clearance results in faster and more complete recovery with less postoperative hangover than other sedative–hypnotic medications such as midazolam and methohexital. The documented antiemetic properties of propofol yield added benefits of this medication [67]. The disadvantages of propofol include pain on intravenous injection and the lack of amnestic effect. However, the addition of 3 ml of 2% lidocaine to 20 ml propofol virtually eliminates the pain on injection with no added risk. If an amnestic response is desired, a small dose of a benzodiazepine, such as midazolam (5 mg i.v.), given in combination with propofol, provides the adequate amnesia. Rapid administration of propofol may be associated with significant hypotension, decreased cardiac output, and respiratory depression. Continuous infusion with propofol results in a rapider recovery than similar infusions with midazolam. Patient-controlled sedation with propofol has also been shown to be safe and effective.

Barbiturate sedative–hypnotic agents such as thiopental and methohexital, while older, still play a role in many clinical settings. In particular, methohexital, with controlled boluses (10–20 mg i.v.) or limited infusions remains a safe and effective sedative–hypnotic alternative with rapid recovery; however, with prolonged administration, recovery from methohexitial may be delayed compared with propofol.

Ketamine, a phencyclidine derivative, is a unique agent because of its combined sedative and analgesic effects and the absence of cardiovascular depression in healthy patients [68]. Because the CNS effects of ketamine result in a state similar to catatonia, the resulting anesthesia is often described as dissociative anesthesia. Although gag and cough reflexes are more predictably maintained with ketamine, emesis and pulmonary aspiration of gastric contents is still possible. Unfortunately, a significant number of patients suffer distressing postoperative psychomimetic reactions. While concomitant administration of benzodiazepines attenuates these reactions, the postoperative psychological sequelae limit the usefulness of ketamine for most elective outpatient surgeries.

Droperidol, a butyrophenone and a derivative of haloperidol, acts as a sedative, hypnotic, and antiemetic medication. Rather than causing global CNS depression like barbiturates, droperidol causes more specific CNS changes similar to phenothiazines. For this reason, the cataleptic state caused by droperidol is referred to as neuroleptic anesthesia [69]. Droperidol has been used effectively in combination with various narcotic medications. Innovar is a combination of droperidol and fentanyl. While droperidol has minimal effect on respiratory function if used as a single agent, when combined with narcotic medication, a predictable dose-dependent respiratory depression may be anticipated. Psychomimetic reactions such as dysphoria or hallucinations are frequent unpleasant side effects of droperidol. Benzodiazepines or narcotics reduce the incidence of these unpleasant side effects. Extrapyramidal reactions such as dyskinesias, torticollis, or oculogyric spasms may also occur, even with small doses of droperidol. Dimenhydrinate usually reverses these complications. Hypotension may occur as a consequence of droperidol's α-adrenergic blocking characteristics. One rare complication of droperidol is the neurolept malignant syndrome (NMS), a condition very similar to malignant hyperthermia, characterized by extreme temperature elevations and rhabdomyolysis. The treatment of NMS and malignant hyperthermia is essentially the same. While droperidol has been used for years without appreciable myocardial depression, a surprising announcement from the Federal Drug Administration warned of sudden cardiac death resulting after the administration of standard, clinically useful doses [70]. Unfortunately, this potential complication makes the routine use of this once very useful medication difficult to justify given the presence of other alternative medications.

Butorphanol, buprenorphine, and nalbuphine are three synthetically derived opiates which share the properties of being mixed agonist-antagonist at the opiate receptors. These medications are sometimes preferred as supplemental analgesics during local, regional, or general anesthesia, because they partially reverse the analgesic and respiratory depressant effects of other narcotics. While these medications result in respiratory depression at lower doses, a ceiling effect occurs at higher dose, thereby limiting the respiratory depression. Still, respiratory arrest is possible, especially if these medications are combined with other medications with respiratory depressant properties. While the duration of action of butorphanol is 2–3 h, nalbuphine has a duration of action of about 3–6 h and buprenorphine has a duration of action of up to 10 h, making these medications less suitable for surgeries of shorter duration.

8.4.3 General Anesthesia

While some authors attribute the majority of complications occurring during and after liposuction to the administration of systemic anesthesia, others consider sedation and general anesthesia safe and appropriate alternatives in indicated cases. Most of the complications attributed to midazolam and narcotic combinations occur as a result of inadequate monitoring. Although significant advances have been made in the administration of local anesthetics and supplemental medications, the use of general anesthesia may still be the anesthesia technique of choice for many patients. General anesthesia is especially appropriate when working with patients suffering extreme anxiety, high tolerance to narcotic or sedative medications, or if the surgery is particularly complex. The goals of a general anesthetic are a smooth induction, a prompt recovery, and minimal side effects, such as nausea, vomiting, or sore throat. The inhalation anesthetic agents halothane, isoflurane, and enflurane remain widely popular because of the safety, reliability, and convenience of use. The newer inhalation agents sevoflurane and desflurane share the added benefit of prompt emergence [71, 72]. Nitrous oxide, a long-time favorite inhalation anesthetic agent, may be associated with postoperative nausea and vomiting (PONV). Patients receiving nitrous oxide also have a greater risk of perioperative hypoxemia.

The development of potent, short-acting sedative, opiate analgesics and muscle-relaxant medications has resulted in newer medication regimens that permit the use of intravenous agents exclusively. The same medications that have been discussed for SAM can also be used during general anesthesia as sole agents or in combination with the inhalation agents. The anesthesiologist or CRNA should preferentially be responsible for the administration and monitoring of general anesthesia.

Airway control is a key element in the management of the patient under general anesthesia. Maintaining a patent airway, ensuring adequate ventilation, and preventing aspiration of gastric contents are the goals of successful airway management. For shorter cases, the airway may be supported by an oropharyngeal airway and gas mixtures delivered by an occlusive mask. For longer or more complex cases, or if additional facial surgery is planned requiring surgical field avoidance, then the airway may be secured using laryngeal mask anesthesia (LMA) or endotracheal intubation.

8.5 Preoperative Preparation

Generally, medications which may have been required to stabilize the patient's medical conditions should be continued up to the time of surgery. Notable exceptions include anticoagulant medications, monoaomine oxidase (MAO) inhibitors, and possibly the angiotensin converting enzyme (ACE) inhibitor medications. It is generally accepted that MAO inhibitors, carboxazial (Marplan), deprenyl (Eldepryl), paragyline (Eutonyl), phenelzine (Nardil), tranylcypromine (Parnate), be discontinued 2–3 weeks prior to surgery, especially for elective cases, because of the interactions with narcotic medication, specifically, hyperpyrexia, and certain vasopressor agents, specifically, ephedrine. Patients taking ACE inhibitors (captopril, enalapril, and lisinopril) may have a greater risk for hypotension during general anesthesia. As previously discussed, diabetics may require a reduction in the dose of their medication. However, if the risks of discontinuing any of these medications outweigh the benefits of the proposed elective surgery, the patient and physician may decide to postpone, modify, or cancel the proposed surgery.

Previous requirements of complete preoperative fasting for 10 16 h are considered unnecessary by many anethesiologists [73, 74]. More recent investigations have demonstrated that gastric volume may be less 2 h after oral intake of 8 oz of clear liquid than after more prolonged fasting [73]. Furthermore, prolonged fasting may increase the risk of hypoglycemia [74]. Many patients appreciate an 8-oz feeding of their favorite caffeinated elixir 2 h prior to surgery. Preoperative sedative medications may also be taken with a small amount of water or juice. Abstinence from solid food ingestion for 10–12 h prior to surgery is still recommended. Liquids taken prior to surgery must be clear, for example, coffee without cream or juice without pulp.

Healthy outpatients are no longer considered higher risk for gastric acid aspiration and, therefore, routine use of antacids, histamine type-2 (H2) antagonists, or gastrokinetic medications is not indicated. However, patients with marked obesity, hiatal hernia, or diabetes mellitus have higher risks for aspiration. These patients may benefit from selected prophylactic treatment [75]. Sodium citrate, an orally administered, non-particulate antacid, rapidly increases gastric pH. However, its unpleasant taste and short duration of action limits its usefulness in elective surgery. Gastric volume and pH may be effectively reduced by H2 receptor antagonists. Cimetidine (300 mg p.o., 1 2 h prior to surgery) reduces gastric volume and pH.; however, cimetidine is also a potent cytochrome oxidase inhibitor and may increase the risk of reactions to lidocaine during tumescent anesthesia [76]. Ranitidine (150–300 mg 90–120 min prior to surgery) and famotidine (20 mg p.o. 60 min prior to surgery) are equally effective but have a better safety profile than cimetidine.

Omeprazole, which decreases gastric acid secretion by inhibiting the proton-pump mechanism of the gastric mucosa, may prove to be a safe and effective alternative to the H2 receptor antagonists. Metaclopramide (10–20 mg p.o. or i.v.), a gastrokinetic agent, which increases gastric motility and lowers esophageal sphincter tone, may be effective in patients with reduced gastric motility, such as diabetics or patients receiving opiates. However, extrapyramidal side effects limit the routine use of the medication.

PONV remains one of the more vexing complications of anesthesia and surgery [77]. In fact, patients dread PONV more than any other complication, even postoperative pain. PONV is the commonest postoperative complication, and the common cause of postoperative patient dissatisfaction. Use of prophylactic antiemetic medication will reduce the incidence of PONV. Even though many patients do not suffer PONV in the recovery period after ambulatory anesthesia, more than 35% of patients develop PONV after discharge.

Droperidol, 0.625–1.25 mg i.v., is an extremely cost effective antiemetic. However, troublesome side effects such as sedation, dysphoria, extrapyramidal reactions, and cardiac arrest may occur. These complications may preclude the widespread use of droperidol altogether. Ondansetron, a serotonin antagonist (4–8 mg i.v.), is one of the most effective antiemetic medications available without sedative, dysphoric, or extrapyramidal sequelae [78]. The antiemetic effects of ondansetron may reduce PONV for up to 24 h postoperatively. The effects of ondansetron may be augmented by the addition of dexamethasone (4–8 mg) or droperidol (1.25 mg i.v.). Despite its efficacy, cost remains a prohibitive factor in the routine prophylactic use of ondansetron, especially in the office setting. Ondansetron is available in a parenteral preparation and as orally disintegrating tablets and oral solution.

Promethazine (12.5–25 mg p.o., per rectum, p.r., or i.m.) and chlorpromazine (5–10 mg p.o., or i.m. and 25 mg p.r.) are two older phenothiazines which are still used by many physicians as prophylaxis, especially in combination with narcotic analgesics. Once again, sedation and extrapyramidal effects may complicate the routine prophylactic use of these medications.

Preoperative atropine (0.4 mg i.m.), glycopyrrolate (0.2 mg i.m.), and scopolamine (0.2 mg i.m.) anticholinergic agents, once considered standard preoperative medication because of their vagolytic and antisialogic effects, are no longer popular because of side effects such as dry mouth, dizziness, tachycardia, and dissorientation. Transdermal scopolamine, applied 90 min prior to surgery, effectively reduces PONV. However, the incidence of dry mouth and drowsiness is high, and toxic psychosis is a rare complication. Antihistamines, such as dimenhydrinate (25–50 mg p.o., i.m., or i.v.) and hydroxyzine (50 mg p.o. or i.m.) may also be used to treat and prevent PONV with few side effects except for possible postoperative sedation.

The selection of anesthetic agents may also play a major role in PONV. The direct antiemetic actions of propofol have been clearly demonstrated [79]. Anesthetic regimens utilizing propofol alone or in combination with other medications are associated with significantly less PONV. Although still controversial, nitrous oxide is considered by some a prime suspect among possible causes of PONV [80]. Opiates are also considered culprits in the development of PONV and the delay of discharge after outpatient surgery [81]. Adequate fluid hydration has been shown to reduce PONV.

One goal of preoperative preparation is to reduce patients' anxiety. Many simple, non-pharmacological techniques may be extremely effective in reassuring both patients and families, starting with a relaxed, friendly atmosphere and a professional, caring, and attentive office staff. With proper preoperative preparation, pharmacological interventions may not even be necessary. However, a variety of oral and parenteral anxiolytic–sedative medications are frequently called upon to provide a smooth transition to the operating room. Diazepam (5–10 mg p.o.) given 1–2 h preoperatively is a very effective medication which usually does not prolong recovery time. Parenteral diazepam (5–10 mg i.v. or i.m.) may also be given immediately preoperatively. However, because of a long elimination half-life of 24–48 h, and active metabolites with an elimination half-life of 50–120 h, caution must be exercised when using diazepam, especially in shorter procedures, so that recovery is not delayed. Pain and phlebitis with intravenous or intramuscular administration reduces the popularity of diazepam.

Lorazepam (1–2 mg p.o. or s.l., sub lingua, 1–2 h preoperatively) is also an effective choice for sedation or anxiolysis. However, the prolonged duration of action may prolong recovery time after shorter procedures. Midazolam (5–7.5 mg i.m., 30 min preoperatively, or 2 mg i.v. minutes prior to surgery) is a more potent anxiolytic–sedative medication with rapider onset and shorter elimination half-life, compared with diazepam. Unfortunately, oral midazolam has unpredictable results and is not considered a useful alternative for preoperative medication. Oral narcotics, such as oxycodone (5–10 mg p.o.), may help relieve the patient's intraoperative breakthrough pain during procedures involving more limited liposuction with minimal potential perioperative sequelae. Parenteral opioids, such as morphine (5–10 mg i.m., or 1–2 mg i.v.), demerol (50–100 mg i.m., or 10–20 mg i.v.), fentanyl (10–20 μg i.v.), or sufentanil (1–2 μg i.v.), may produce sedation and euphoria and may decrease the requirements for other sedative medication. The level of anxiolysis and sedation is still greater with the benzodiazepines than with the opioids. Premedication with narcotics has been shown to have minimal effects on postoperative recovery time. However, opioid premedication may increase PONV [82].

Antihistamine medications, such as hydroxyzine (50–100 mg i.m., or 50–100 mg p.o.) and dimenhydrinate (50 mg p.o., i.m., or 25 mg i.v.), are still used safely in combination with other premedications, especially the opioids, to add sedation and to reduce nausea and pruritis. However, the anxiolytic and amnestic effects are not as potent as those of the benzodiazepines. Barbiturates, such as secobarbital and pentobarbital, once a standard premedication have largely been replaced by the benzodiazepines.

Postoperative pulmonary embolism (PE) is an unpredictable and devastating complication with an estimated incidence of 0.1–5%, depending on the type of surgical case, and has a mortality rate of about 15%. Risk factors for thromboembolism include prior history or family history of deep venous thrombosis (DVT) or PE, obesity, smoking, hypertension, use of oral contraceptives and hormone replacement therapy, and patients over 60 years of age. Estimates for the incidence of postoperative DVT vary between 0.8% for outpatients undergoing herniorrhaphies to up to 80% for patients undergoing total hip replacement. Estimates of fatal PE also vary from 0.1% for patients undergoing general surgeries to up to 1–5% for patients undergoing major joint replacement. While a recent national survey of physicians performing tumescent liposuction, in a total of 15,336 patients, indicated that no patient suffered DVT or PE [83], only 66 physicians who perform liposuction responded out of 1,778 questionnaires sent, which is a mere 3.7% response rate. A review of 26,591 abdominoplasties revealed nine cases of fatal PE, or 0.03%, but gave no information regarding the incidence of non-fatal PE [84]. Other reports suggest that the incidence of PE after tumescent liposuction and abdominoplasty may be commoner than reported [85–87]. One study revealed that unsuspected PE may actually occur in up to 40% of patients who develop DVT [88].

Prevention of DVT and PE should be considered an essential component of the perioperative management. Although unfractionated heparin reduces the rate of fatal PE [89], many surgeons are reluctant to use this prophylaxis because of concerns of perioperative hemorrhage. The low molecular weight heparins enoxaparin, dalteparin, and ardeparin and danaparoid, a heparinoid, are available for prophylactic indications. Graduated compression stockings and intermittent pneumatic lower extremity compression devices applied throughout the perioperative period, until the patient has become ambulatory, are considered very effective and safe alternatives in the prevention of postoperative DVT and PE [90, 91]. Even with prophylactic therapy, PE may still occur up to 30 days after surgery. Physicians should be suspicious of PE if patients present postoperatively with dyspnea, chest pain, cough, hemoptysis, pleuritic pain, dizziness, syncope, tachycardia, cyanosis, shortness of breath, or wheezing.

8.6 Perioperative Monitoring

The adoption of a standardized perioperative monitoring protocol has resulted in a quantum leap in perioperative patient safety. The standards for basic perioperative monitoring were approved by the ASA in 1986 and amended in 1995 [10]. These monitoring standards are now considered applicable to all types of anesthetics, including local with or without sedation, regional, or general anesthesia, regardless of the duration or complexity of the surgical procedure and regardless of whether the surgeon or anesthesiologist is responsible for the anesthesia. Vigilant and continuous monitoring and compulsive documentation facilitates early recognition of deleterious physiological events and trends, which, if not recognized promptly, could lead to irreversible pathological spirals, ultimately endangering a patient's life.

During the course of any anesthetic, the patient's oxygenation, ventilation, circulation, and temperature should be continuously evaluated. The concentration of the inspired oxygen must be measured by an oxygen analyzer. Assessment of the perioperative oxygenation of the patient using pulse oximetry, now considered mandatory in every case, has been a significant advancement in monitoring. This monitor is so critical to the safety of the patient that it has earned the nickname "the monitor of life." Evaluation of ventilation includes observation of skin color, chest wall motion, and frequent auscultation of breath sounds. During general anesthesia with or without mechanical ventilation, a disconnect alarm on the anesthesia circuit is crucial. Capnography, a measurement of respiratory end-tidal CO_2, is required, especially when the patient is under heavy sedation or general anesthesia. Capnography provides the first alert in the event of airway obstruction, hypoventilation, or accidental anesthesia circuit disconnect, even before the oxygen saturation has begun to fall. All patients must have continuous monitoring of the electrocardiogram (ECG), and intermittent determination of blood pressure and heart rate at a minimum of 5-min intervals. Superficial or core body temperature should be monitored. Of course, all electronic monitors must have preset alarm limits to alert physicians prior to the development of critical changes.

While the availability of electronic monitoring equipment has improved perioperative safety, there is no substitute for visual monitoring by a qualified, experienced practitioner, usually a CRNA or an anesthesiologist. During surgeries using local anesthesia with SAM, if a surgeon elects not to use a CRNA or an anesthesiologist, a separate, designated, certified individual must perform these monitoring functions [18]. Visual observation of the patient's position is also important in order to avoid untoward outcomes such as peripheral nerve or ocular injuries.

Documentation of perioperative events, interventions, and observations must be contemporaneously performed and should include blood pressure and heart rate every 5 min and oximetry, capnography, ECG pattern, and temperature at 15-min intervals. Intravenous fluids, medication doses in milligrams, patient position, and other intraoperative events must also be recorded. Documentation may alert the physician to unrecognized physiological trends that may require treatment. Preparation for subsequent anesthetics may require information contained in the patient's prior records, especially if the patient suffered an unsatisfactory outcome due to the anesthetic regimen that was used. Treatment of subsequent complications by other physicians may require information contained in the records, such as the types of medications used, blood loss, or fluid totals. Finally, compulsive documentation may help exonerate a physician in many medical legal situations.

When local anesthesia with SAM is used, monitoring must include an assessment of the patient's level of consciousness as previously described. For patients under general anesthesia, the level of consciousness may be determined using the bispectral index, a measurement derived from computerized analysis of the electroencephalogram. When used with patients receiving general anesthesia, the bispectral index improves control of the level of consciousness, the rate of emergence and recovery, and cost-control of medication usage.

8.7 Fluid Repalcement

Management of perioperative fluids probably generates more controversy than any other anesthesia-related topics. Generally, the typical, healthy, 60-kg patient requires about 100 ml of water per hour to replace metabolic, sensible, and insensible water losses. After a 12-h period of fasting, a 60-kg patient may be expected to have a 1-l volume deficit on the morning of surgery. This deficit should be replaced over the first few hours of surgery. The patient's usual maintenance fluid needs may be met with a crystalloid solution such as lactated Ringer's solution.

Replacement fluids may be divided into crystalloid solutions, such as normal saline or balance salt solution, colloids, such as fresh frozen plasma, 5% albumin, plasma protein fraction, or hetastarch, and blood products containing red blood cells, such as packed red blood cells. Generally, balanced salt solutions may be used to replace small amounts of blood loss. For every milliliter of blood loss, 3 ml of fluid replacement is usually required. However, as larger volumes of blood are lost, attempts to replace these losses with crystalloid reduce the serum oncotic pressure, one of the main forces supporting intravascular volume. Subsequently, crystalloid rapidly moves into the extracellular space and the intravascular volume cannot be adequately sustained with further crystalloid infusion. At this point, many authors suggest that a colloid solution may be more effective in maintaining intravascular volume and hemodynamic stability [92, 93]. Given the ongoing crystalloid–colloid controversy in the literature, the most practical approach to fluid management is a compromise. Crystalloid replacement should be used for estimated blood losses (EBLs) less than 500 mls, while colloids, such as hetastarch, may be used for EBLs greater than 500 ml. One milliliter of colloid should be used to replace 1 ml of EBL. However, not all authors agree on the benefits of colloid resuscitation. Moss and Gould [93] suggested isotonic crystalloid replacement, even for large EBLs, to restore plasma volume as well as colloid replacement.

For patients with less than 1,500 ml of fat extraction using the tumescent technique, studies have determined that postoperative serum hemoglobin remains essentially unchanged [94]; therefore, intravenous fluids beyond the deficit replacement and the usual maintenance amounts are generally not required [95]. As the volume of fat removed approaches or exceeds 3,000 ml, judicious intravenous fluid replacement including colloid may be considered, depending on the patients hemodynamic status [12]. Fluid overload with the possibility of pulmonary edema and congestive heart failure following aggressive administration of infusate and intravenous crystalloid solutions has become a legitimate concern. Using the tumescent technique during which there are subcutaneous infusion ratios of 2–3 ml for 1 ml of fat aspirated, significant intravascular hemodilution has been observed [96]. A 5-l tumescent infusion may result in a hemodilution of 10%. Plasma lidocaine near toxic levels, combined with an increased intravascular volume, may increase the risk of cardiogenic pulmonary edema, even in healthy patients.

While the crystalloid replacement regimen may vary, Pitman et. al. [97] advocate limiting intravenous replacement to the difference between twice the volume of total aspirate and the sum of intravenous fluid already administered i.v. and as tumescent infusate. This replacement formula presumes a ratio of infusate to aspirate of greater than 2:1. If the ratio is less than 1, more generous replacement fluids may be required since hypovolemia may occur. The determination of fluid replacement is still not an exact science, by any means. Because of the unpredictable fluid requirements in patients, careful monitoring is required, including possible laboratory analyses such as complete blood count and blood urea nitrogen.

The estimation of perioperative blood and fluid loss during liposuction and abdominoplasty surgeries is not a trivial task. Observers in the same room frequently have wide discrepancies in the EBL. In the case of the abdominoplasty, unrecognized blood loss occurs. Substantial amounts of blood typically seep around and under the patient, unnoticed by the surgeon, only to be discovered later as the nurses apply the dressing. Because of subcutaneous hematoma formation and the difficulty of measuring the blood content in the aspirate, estimating the EBL during liposuction may be a particularly daunting task. Fortunately, the development of the tumescent technique has dramatically reduced perioperative blood loss during liposuction surgeries [98].

The blood content in the aspirate after tumescent liposuction has varied between less than 1 and 8% [98, 99]. Samdal et. al. [98] admitted that the mean fall of postoperative hemoglobin of 5.2% (±4.9%) was higher than anticipated. The author suggested that previous estimates of continued postoperative blood extravasation into the surgical dead space may be too low and may be greater than the EBL identified in the aspirate. Mandel [99] concluded that unappreciated blood loss continues for several days after surgery, presumably owing to soft-tissue extravasation, and that serial postoperative hematocrit determinations should be used, especially for large-volume liposuctions.

The decision to transfuse a patient involves multiple considerations. Certainly, the EBL, the health, age, and estimated preoperative blood volume of the patient, and the hemodynamic stability of the patient are the primary concerns. The potential risks of transfusions, such as infection, allergic reaction, errors in cross matching, and blood contamination should be considered. Finally, the patient's personal or religious preferences may play a pivotal role in the decision to transfuse. Cell-saving devices and autologous blood transfusions may alleviate many of these concerns. Healthy, normovolemic patients, with hemodynamic and physiologic stability, should tolerate hemoglobin levels down to 7.5 g/dl [100]. Even for large-volume liposuction using the tumescent technique, transfusions are rarely necessary. Once the decision to transfuse is made, 1 ml of red blood cells should be used to replace every 2 ml of EBL. Serial hematocrit determination although sometimes misleading in cases of fluid overload and hemodilution is still considered an important diagnostic tool in the perioperative period to assist with decisions regarding transfusion.

During large-volume liposuction, a useful guide to the patient's volume status is monitoring the urine output using an indwelling urinary catheter. Urinary output should be maintained at greater than 0.5 ml/kg/h. However, urinary output is not a precise method of determining the patient's volume status since other factors, including surgical stress, hypothermia, and the medications used during anesthesia, are known to alter urinary output [101]. Therapeutic determinations based on a decreased urinary output must also consider other factors, since oliguria may be a result of either hypovolemia or fluid overload and congestive heart failure. In general, use of loop diuretics, such as furosemide, to accelerate urinary output makes everyone in the room feel better, but does little to elucidate the cause of the reduced urinary output, and in cases of hypovolemia may worsen the patient's clinical situation. However, a diuretic may be indicated if oliguria develops in the course of large-volume liposuction where the total infusate and intravenous fluids is several liters more than the amount of aspirate.

8.8 Recovery and Discharge

The same intensive monitoring and treatment which occurs in the operating room must be continued in the recovery room under the care of a designated, licensed, and experienced person for as long as is necessary to ensure the stability and safety of the patient, regardless of whether the facility is a hospital, an outpatient surgical center, or a physician's office. During the initial stages of recovery, the patient should not be left alone while hospital or office personnel attend to other duties. Vigilant monitoring including visual observation, continuous oximetry, continuous ECG, and intermittent blood pressure and temperature determinations must be continued. Because the patient is still vulnerable to airway obstruction and respiratory arrest in the recovery period, continuous visual observation is still the best method of monitoring for this complication. Supplemental oxygenation should be continued during the initial stages of recovery and until the patient is able to maintain an oxygen saturation above 90% on room air.

The commonest postoperative complication is nausea and vomiting. The antiemetic medications previously discussed, with the same consideration of potential risks, may be used in the postoperative period. Because of potential cardiac complications, droperidol, one of the most commonly used antiemetics, is now considered unsafe unless the patient has no cardiac risk factors and a recent 12-lead ECG was normal. Ondansetron (4–8 mg i.v. or s.l.) is probably the most effective and safest antiemetic; however, the cost of this medication is often prohibitive, especially in an office setting. Postoperative surgical pain may be managed with judiciously titrated intravenous narcotic medication such as demerol (10–20 mg i.v. every 5–10 min), morphine (1–2 mg i.v. every 5–10 min), or butorphanol (0.1–0.2 mg i.v. every 10 min).

Following large-volume liposuction, extracellular fluid extravasation or third spacing may continue for hours postoperatively, leading to the risk of hypotension, particularly if the ratio of tumescent infusate to aspirate is less than 1:1. For large-volume liposuction, blood loss may continue for 3–4 days. Crystalloid or colloid replacement may be required in the event of hemodynamic instability.

The number of complications that occur after discharge may be more than twice the number of complications occurring intraoperatively and during recovery combined. Accredited ambulatory surgical centers generally have established discharge criteria. While these criteria may vary, the common goal is to ensure the patient's level of consciousness and physiological stability (Table 8.7).

Medication intended to reverse the effects of anesthesia should be used only in the event of suspected overdose of medications. Naloxone (0.1–0.2 mg i.v.), a pure opiate receptor antagonist, with a therapeutic half-life of less than 2 h, may be used to reverse the respiratory depressant effects of narcotic medications, such as morphine, demerol, fentanyl, and butorphanol. Because potential adverse effects of rapid opiate reversal of narcotics include severe pain, seizures, pulmonary edema, hypertension, congestive heart failure, and cardiac arrest, naloxone must be administered by careful titration. Naloxone has no effect on the actions of medications, such as the benzodiazepines, the barbiturates, propofol, or ketamine.

Table 8.7. Ambulatory discharge criteria (Modified from Mecca [102])

1.	All life-preserving protective reflexes, i.e., airway, cough, and gag, must be returned to normal
2.	The vital signs must be stable without orthostatic changes
3.	There must be no evidence of hypoxemia 20 min after the discontinuation of supplemental oxygen
4.	Patients must be oriented to person, place, time, and situation (times 4)
5.	Nausea and vomiting must be controlled and patients should tolerate p.o. fluids
6.	There must be no evidence of postoperative hemorrhage or expanding ecchymosis
7.	Incisional pain should be reasonably controlled
8.	The patient should be able to sit up without support and walk with assistance

Flumazenil (0.1–0.2 mg i.v.), a specific competitive antagonist of the benzodiazepines, such as diazepam, midazolam, and lorazepam, may be used to reverse excessive or prolonged sedation and respiratory depression resulting from these medications [103]. The effective half-life of flumazenil is 1 h or less.

The effective half-lives of many narcotics exceed the half-life of naloxone. The benzodiazepines have effective half-lives greater than 2 h and, in the case of diazepam, up to 50 h. Many active metabolites unpredictably extend the putative effects of the narcotics and benzodiazepines. A major risk associated with the use of naloxone and flumazenil is the recurrence of the effects of the narcotic or benzodiazepine after 1–2 h. If the patient has already been discharged to home after these effects recur, the patient may be at risk for oversedation or respiratory arrest [104, 105]; therefore, routine use of reversal agents, without specific indication, prior to discharge is ill advised. Patients should be monitored for at least 2 h prior to discharge if these reversal agents are administered [18].

Physostigmine (1.25 mg i.v.), a centrally acting anticholinesterase inhibitor, functions as a non-specific reversal agent which may be used to counteract the agitation, sedation, and psychomotor effects caused by a variety of sedative, analgesic, and inhalation anesthetic agents [106, 107]. The effects of neuromuscular blocking drugs, if required during general anesthesia, are usually reversed by the anesthesiologist or CRNA prior to emergence in the operating room with anticholinesterase inhibitors such as neostigmine or edrophonium. Occasionally, a second dose may be required when the patient is in the recovery room.

In the event a patient fails to regain consciousness during recovery, reversal agents should be administered. If no response occurs, the patient should be evaluated for other possible causes of unconsciousness, including hypoglycemia, hyperglycemia, cerebral vascular accidents, or cerebral hypoxia. If hemodynamic instability occurs in the recovery period, causes such as occult hemorrhage, hypovolemia, pulmonary edema, congestive heart failure, or myocardial infarction must be considered. Access to laboratory analysis to assist with the evaluation of the patient is crucial. Unfortunately, stat laboratory analysis is usually not available if the surgery is performed in an office-based setting.

8.9 Conclusions

This information is meant to serve as an overview of the extremely complex subject of anesthesia. It is the intent of this chapter to serve as an introduction to the physician who participates in the perioperative management of patients and should not be considered a comprehensive presentation. The physician is encouraged to seek additional information on this broad topic through the other suggested readings. At least one authoritative text on anesthesia should be considered a mandatory addition to the physician's resources.

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9 Pharmacokinetics of Tumescent Anesthesia

Timothy D. Parish

9.1 Introduction

Tumescent anesthesia may be defined as a subcutaneous, periadipose, hyperhydrostatic pressurized, megadosed, ultradilute, epinephrinized, local anesthetic field block [1]. The procedure was first popularized by the dermatologic surgeon Jeffrey Klein in the late 1980s [2, 3]. The majority of the literature revolves around the use of lidocaine as the local anesthetic, although bupivacaine, ropivacaine, and prilocaine have also been utilized [4–9].

9.2 Pharmacokinetics

Currently, two standards of care for the safe dose of lidocaine should now be utilized [10, 11]. First, for commercially available formulations (0.5–2% lidocaine with epinephrine) a 7-mg/kg maximum safe dose limit. Second, for tumescent anesthesia using ultradilute lidocaine (500–1,500 mg/l, 0.05–0.15%) with epinephrine (0.5–1.5 mg/l) [12–14]. The diluent is normal saline with the addition of 10–15 mEq sodium bicarbonate per liter. Lactated Ringer's solution may be used and has been documented to prolong the stability of epinephrine secondary to a more acidic pH of 6.3 [13]. A dose of 35 mg/kg lidocaine can be considered the optimal therapeutic threshold, with doses up to 55 mg/kg approaching the margins of the safe therapeutic window [14–16]. These latter dose recommendations are based on the clinical experience of large numbers of physicians performing this procedure on a large patient population, together with studies utilizing supplementary anesthetic techniques, including oral (p.o.), intravenous (i.v.), and general anesthesia in a total of 163 patients [3, 7, 9, 13, 14, 16, 18–24].

Traditional lidocaine pharmacokinetics utilizing commercial preparations by i.v., subcostal, epidural, etc., administration follows the two-compartment model. However, with subcutaneous injection, there is a slower rate of absorption and lower peak serum C_{max} compared with equal doses used at other sites of administration [15–24]. The two-compartment model is biphasic and follows the rapid attainment of C_{max} in the highly vascular central compartment preceding an accelerated distribution phase until equilibrium with less vascular peripheral tissue is reached. From the point of equilibrium, there is a slow plasma decline secondary to metabolism and excretion [16]. Less than 5% of lidocaine is excreted by the kidneys. In the healthy state, lidocaine clearance approximates plasma flow to the liver equal to 10 ml/kg/min. Lidocaine has a hepatic extraction ratio of 0.7 (i.e., 70% of lidocaine entering the liver is metabolized and 30% remains unchanged). If there is a 50% reduction in the rate of lidocaine metabolism, there will be a corresponding doubling of the C_{max} plasma lidocaine [17].

Tumescent anesthesia, with highly diluted lidocaine with epinephrine, exhibits the properties of a one-compartment pharmacokinetics model similar to a slow-release tablet (Figs. 9.1–9.3). In a one-compartment model, the body is imagined as a single homogeneous compartment in which drug distribution after delivery is presumed to be instantaneous, so that no concentration gradients exist within the compartment, resulting in decreased concentration solely by elimination of the drug from the system. The rate of change of the concentration is proportional to the concentration. This is an essential premise of a first-order process. In a one-compartment model, the location of the drug pool for systemic release is kinetically insulated from the central compartment [18].

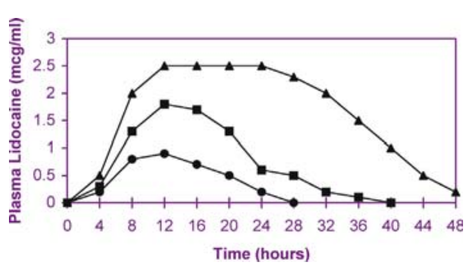

Fig. 9.1. Plasma lidocaine levels over time. (Modified from Klein [18]. Reprinted with permission of Mosby Inc.)

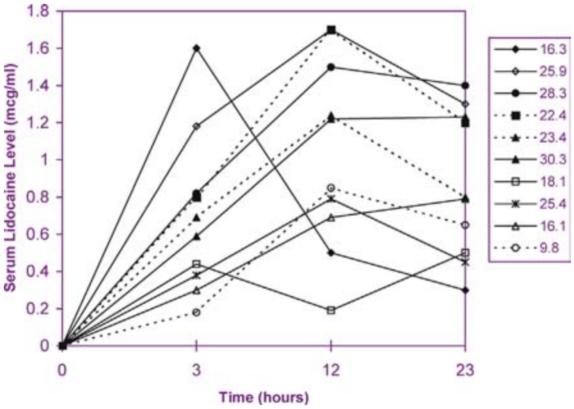

Fig. 9.2. Serum lidocaine levels in patients undergoing tumescent liposuction alone. The total dose of lidocaine (mg/kg) is listed to the *right*. The patient with the peak lidocaine level at 3 ho received 50 mg lidocaine intravenously. (From Burk et al. [34]. Reprinted with permission of Lippincott, Williams & Wilkins)

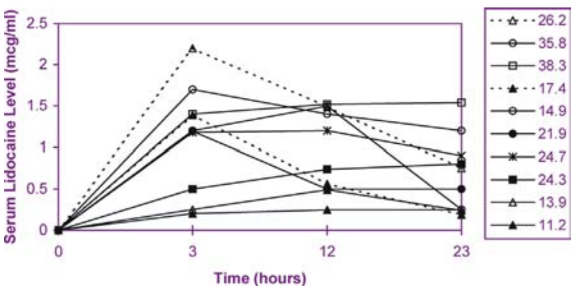

Fig. 9.3. Serum lidocaine levels in patients undergoing tumescent liposuction combined with other aesthetic surgery. The total dose of lidocaine (mg/kg) is listed to the *right*. (From Burk et al. [34]. Reprinted with permission of Lippincott, Williams & Wilkins)

The reason that tumescent anesthesia behaves as a one-compartment model is related to the delayed absorption rate into the plasma from the subcutaneous adipose tissue [25]. This is theorized to occur for a number of reasons (Figs. 9.1–9.3): (1) decreased blood flow related to vasoconstriction or vessel collapse proportional to increasing interstitial hydrostatic pressure; (2) formation of an ultradilute interstitial lake with a low concentration gradient relative to plasma and increased diffusion distance from the microcirculation; and (3) the high lipophilic nature of lidocaine leads to subcutaneous adipose tissue absorption, acting for a 1,000 mg/l lidocaine formulation (0.1%), as a large 1 mg of lidocaine to 1,000 mg of adipose tissue buffer [10, 19]. This buffering effect is aided by the threefold greater partition coefficient of adipose tissue compared with muscle, enabling lidocaine to bind tightly to fat [20].

At equilibrium, the fat–blood concentration ratio of lidocaine is between 1:1 and 2:1. With increased dosing of lidocaine from 15 mg/kg, there is a well-defined peak C_{max} that occurs 4–14 h after infiltration. With doses up to 60 mg/kg there is progressive flattening of the peak and a plateau effect that may persist for up to 16 h [21]. The flattening of the curve denotes saturation of the system and then elimination of a constant amount, as opposed to a fraction of the drug per unit time, which signifies zero-order elimination. Although lidocaine levels appear to be below serum concentrations associated with toxicity, it is known that concentrations of 4–6 μg/ml have been found in deaths caused by lidocaine toxicity [22, 23]. However, there are no documented data concerning lidocaine stability in postmortem blood and tissues and none related to the fate or physiologic impact of the active metabolites of lidocaine, lidocaine monoethylglycinexylidide, or glycinexylidide [24]. At the same time, because of the slow-release phenomenon, toxicity will be present for longer with increased dosing on a milligram per kilogram basis of lidocaine. It is this slow-release process that makes the use of longer-acting local anesthetics irrelevant [13, 14, 26, 27]. According to Klein [14, 28], liposuction reduces the bioavailability of lidocaine by 20%. This is further facilitated by open drainage from wounds.

It is the non-protein-bound portion of lidocaine that exhibits toxicity. With increasing total plasma lidocaine levels, there is an increasing proportion of unbound to bound plasma lidocaine as the α_1-acid glycoprotein buffer becomes saturated. In the therapeutic range of 1–4 μg/ml lidocaine, up to 40% of lidocaine is unbound. Surgery and smoking increase serum α_1-acid glycoprotein, and oral hormones decrease it. Therefore, increased serum levels of α_1-acid glycoprotein result in increased lidocaine binding, decreased free lidocaine, and a buffering of potentially toxic manifestations (Fig. 9.4) [28–32].

In a study of 18 patients by Butterwick et al. [33] (Fig. 9.5) using 0.05–0.1% lidocaine with 0.65–0.75 mg/l epinephrine at infusion rates of 27–200 mg/min over 5 min to 2 h using doses between 7.4 and 57.7 mg/kg, there was no correlation between the maximum dose of lidocaine (milligrams per kilogram) or the rate of lidocaine delivered (milligrams per milliliter) with plasma levels of lidocaine. Increased rates of infiltration are associated with increased pain and need for increased sedation [30].

The pharmacokinetics of epinephrine (0.5–1 mg/l) is felt to mimic the one-compartment model of lidocaine. In one study on 20 patients by Burk et al. [34] (Figs. 9.6, 9.7) using epinephrine doses up to 5 mg, the C_{max} of 5 times the upper normal limit of epinephrine was reached at 3 h, returning to normal at 12 h.

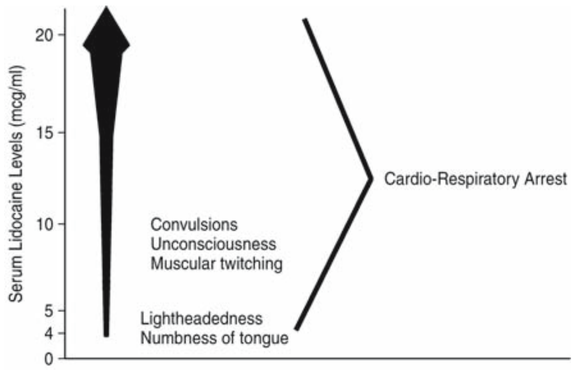

Fig. 9.4. Continuum of toxic effects produced by increasing lidocaine plasma concentrations. (Modified from Barash et al. [51]. Reprinted with permission of Lippincott, Williams, & Wilkins)

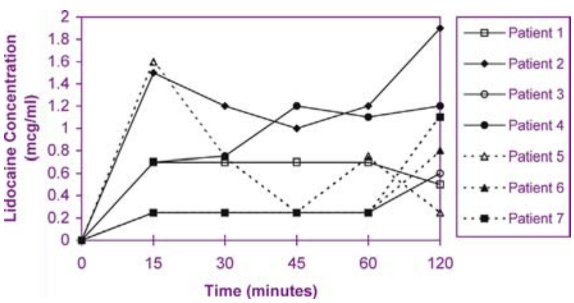

Fig 9.5. Lidocaine levels over 2 h. (From Butterwick et al. [33]. Reprinted with permission of Blackwell Science, Inc.)

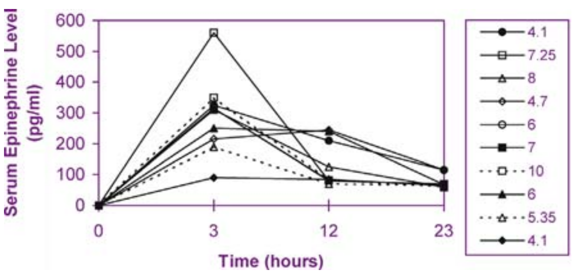

Fig. 9.6. Serum epinephrine levels in patients undergoing tumescent liposuction alone. The total dose of epinephrine (mg) is listed to the *right*. (From Burk et al. [34]. Reprinted with permission of Lippincott, Williams & Wilkins)

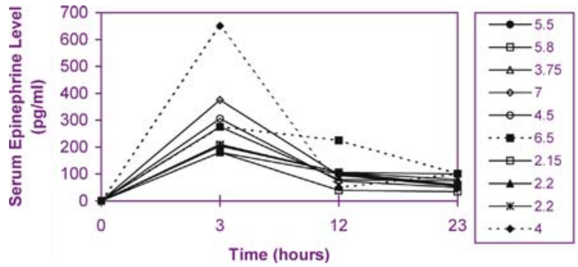

Fig. 9.7. Serum epinephrine levels in patients undergoing tumescent liposuction combined with other aesthetic surgery. The total dose of epinephrine (mg) is listed to the *right*. (From Burk et al. [34]. Reprinted with permission of Lippincott, Williams & Wilkins)

9.3 Important Caveats

9.3.1 Drug Interactions

All enzyme systems have the possibility of saturation [31, 35] and once the subcutaneous adipose tissue reservoir is saturated, any free drug has the potential to be absorbed rapidly following the two-compartment pharmacokinetics model with an accelerated rise and decline in the blood lidocaine level; therefore, the prudent favor the currently held safest therapeutic margins and do not stray to the boundaries [10, 36]. All patients taking drugs interfering with the cytochrome P450 3A4 system should optimally have these medications withheld before surgery. The time of preoperative withdrawal depends upon each drug's kinetic elimination profile [37–39] (Table 9.1). The withholding of some of these medications for more than 2 weeks may be the optimal plan. Patients should, therefore, have relevant medical clearance for such an action, according to the basic standards of preanesthetic care (Table 9.2) [40]. Klein suggests that if it is not feasible to discontinue a medication that is metabolized by the cytochrome P450 system, then the total dose of lidocaine should be decreased. It is not clear how much the dose should be reduced. In the case of thyroid dysfunction, the patient should be euthyroid at the time of surgery. This is an anesthetic truism.

In the author's opinion, all patients should have complete preoperative liver function studies, as well as a screen for hepatitis A, B, and C. However, the free fractions of basic drugs, such as lidocaine, are not increased in patients with acute viral hepatitis; this implies that drug binding to α_1-acid glycoprotein is minimally affected in patients with liver disease [40]. The physician should also inquire about over-the-counter herbal remedies and recommend withholding those for 2 weeks before surgery. The cocaine addict's surgery should be canceled, and the nasal-adrenergic addict should be guided into withdrawal from this medication.

All systemic anesthetics, particularly general anesthesia, have the potential to decrease hepatic blood flow. However, general anesthesia has the greatest potential, although the potpourri approach probably increases this likelihood. General anesthesia decreases hepatic blood flow, resulting in decreased lidocaine metabolism. Inhalational anesthetics, hypoxia, and hypercarbia are potentially arrythmagenic, and the interface of this with mega doses of ultradilute epinephrine perhaps increases this potential. The counterbalance of the increased dose of lidocaine is poorly understood, and in animal studies, lidocaine toxicity may present as marked hypotension and bradycardia in lethal doses that occurs without

Table 9.1. Drugs which inhibit cytochrome P450. (Modified from Shiffman [39], McEvory [52] and Gelman et al. [53])

Drug	Plasma half-life
Acebutolol	Biphasic: α phase 3 h, β phase 11 h
Amiodarone (Cordarone)	Biphasic: α phase 2.5–10 days, β phase 26–107 days (average 53 days)
Atenolol	7 h
Carbamazepine (Tegretol, Atretol)	25–65 h
Cimetidine (Tagamet)	2 h
Chloramphenicol (Chloromycetin)	68–99% excretion in 72 h
Clarithromycin (Biaxin)	3–7 h
Cyclosporin (Neoral, Sandimmune)	10–27 h (average 19 h)
Danazol (Danocrine)	4–5 h
Dexamethasone (Decadron)	1.8–2.2 h
Diltiazam (Cardizem)	3–4.5 h
Erythromycin	1–3 h
Esmolol (Brevibloc)	Biphasic: α phase 2 min, β phase 5–23 min (average 9 min)
Flucanazole (Diflucan)	20–50 h
Fluoxetine (Prozac)	1–3 days after acute administration, 4–6 days after chronic administration
Norfluoxetine (active metabolite)	4–16 days
Flurazepam (Dalmane)	47–100 h
Isoniazid (Nydrazid, Rifanate, Rifater)	Excreted within 24 h
Itracanazole (Sporanox)	24 h after single dose, 64 h at steady state
Ketoconazole (Nizoral)	Biphasic: α phase 2 h, β phase 8 h
Labetalol (Normodyne, Trandate)	6–8 h
Methadone (Dolophine)	25.0 h
Methylprednisolone (Medrol)	2–3 h
Metoprolol (Lopressor)	3–7 h
Metronidazole (Flagyl)	6–14 h (average 8 h)
Miconazole (Monistat)	Intravenous 24 h
Midazolam (Versed)	Biphasic: α phase 6–20min, β phase 1–4 h
Nadolol (Corgard, Corzide)	10–24 h
Nefazodone (Serzone)	1.9–5.3 h, active metabolite 4–9 h
Nicardipine (Cardene)	Average 8.6 h
Nifedipine (Procardia, Adalat)	2 h (extended release in 6–17 h, average 8 h)
Paroxetine (Paxil)	17–22 h
Pentoxifylline (Trental)	1–1.6 h
Pindolol (Visken)	3–4 h
Propranolol (Inderal)	4 h
Propofol (Diprivan)	1–3 days
Quinidine	6–12 h
Sertraline (Zoloft)	Average 26 h, active metabolite 62–104 h
Tetracycline	6–12 h
Terfenadine (Seldane)	Mean 6 h
Thyroxine (Levothyoxine)	5–9 days
Timolol (Timolide, Timoptic)	3–4 h
Triazolam (Halcion)	1.5–5.5 h
Valporic acid (Depakene)	6–16 h
Verapamil (Calan, Isoptin, Verelan)	4–12 h
Zileuton (Zyflo)	2.1–2.5 h

Table 9.2. Basic standard for preanesthesia care. (Modified from American Society of Anesthesiologists [40])

The development of an appropriate plan of anesthesia care is based on:
1. Reviewing the medical record
2. Interviewing and examining the patient to:
   (a) Discuss the medical history, previous anesthetic experiences, and drug therapy
   (b) Assess those aspects of the physical condition that might affect decisions regarding perioperative risk and management
3. Obtaining or reviewing tests and consultations necessary to the conduct of anesthesia
4. Determining the appropriate prescription of preoperative medications as necessary to the conduct of anesthesia

arrhythmias [32]. The ideal preoperative anesthetic, says Klein, is 0.1 mg clonidine (p.o.) and 1 mg lorazepam (p.o.). These can be taken 1 h before surgery, although lorazepam can be taken the night before surgery. This preoperative regimen is administered to patients who have a blood pressure greater than 105/60 mmHg and a pulse greater than 70 beats/min. Lorazepam does not interfere with the cytochrome P450 3A4 hepatic enzyme system [25].

9.3.1.1 Volume of Distribution

Thin patients have a smaller volume of distribution, and therefore, potentially, a greater C_{max} than an obese patient, given an identical dosage of lidocaine [41, 42]. Similarly, men have a smaller volume of distribution for lidocaine, secondary to increased lean body mass. In these two situations, the maximum allowable dose should be decreased by up to 20% with a maximum dose of 45 mg/kg being a reasonable upper limit. Older patients have a relative decrease in cardiac output leading to decrease in hepatic perfusion, and therefore, maximum safe doses should be decreased approximately 20%. This 20% decrease has a greater margin of safety if applied to a 35-mg/kg maximum safe dose of lidocaine than it does if applied to a 50-mg/kg maximum safe dose of lidocaine.

9.3.1.2 Classifications of Patients

As an elective outpatient procedure, ideally only ASA I and ASA II patients should be selected. Morbid obesity may be classified as an ASA III type patient and significantly increases the risk of any form of anesthetic.

9.3.1.3 Two Sequential Procedures Are Better than One

The risk of perioperative morbidity and mortality increases with increasing time of the procedure and the size of the procedure. This includes separate procedures performed under the same anesthetic. This is an anesthetic truism. The AACS 2000 *Guidelines for Liposuction Surgery* state that the maximal volume extracted may rise to 5,000 ml of supernatant fat in the ideal patient with no comorbidities. The guidelines also state that the recommended volumes aspirated should be modified by the number of body areas operated on, the percentage of body surface area operated on, and the percentage of body weight removed. Currently held conservative guidelines limit the total volume of supernatant fat aspirate to less than or equal to 4 l in liposuction cases [37, 38]. The more fat removed, the greater the risk for injury and potential complications.

9.3.1.4 Intravenous Fluids

Tumescent anesthesia significantly decreases blood loss associated with liposuction [13, 44, 45]. Studies have shown that between 10 and 70 ml of blood per liter of aspirate is lost depending on the adequacy and the rate of tumescent infiltration [46–50]. Tissue tumescence is obtained by doubling the volume of subcutaneous adipose tissue in the area to be addressed. On average, the ideal ratio of tumescent anesthesia to aspirated fat is 2:1 to 3:1 [47].

Tumescent crystalloid infiltration follows the one-compartment kinetics model [47]. Without i.v. infusion, approximately 5 l of normal saline tumescence results in hemodilution of the hematocrit by approximately 10%, no change in the urine specific gravity, and maintenance of urine output greater than 70 ml/h [48]. According to Klein, if the extraction of supernatant fat is less than 4 l (representing 3–4% of total body weight), then there is no clinically detectable third-spacing injury and intravascular fluid administration is not required. Fluid overload remains as a potentially significant perioperative mishap [18, 49, 50], and therefore, bladder catheterization with larger cases should be considered [10].

9.3.2 Anesthetic Infiltration

The author's preferred technique is to utilize multiple entry points via 1.5–2.0-mm punch biopsy sites, starting with deep infiltration then working superficially until tumescence is obtained. Particular attention is paid to the periumbilical area as this area has increased sensitivity and fibrous tissue. Following

Table 9.3. Recommended Concentration for Effective Tumescent Anesthesia for Liposuction using Normal Saline As The Diluent (The dose utilized should be calculated on milligrams per kilogram basis) (Modified from Klein [54, 55])

Areas	Lidocaine (mg/L)	Epinephrine (mg/L)	Sodium Bicarbonate (mEq/L)
Basic/checking	500	0.5	10
Hips; lateral, medial, & anterior thighs; knees	700-500	0.65	10
Back; male flanks; arms	1000	0.65-1.0	10
Female abdomen	1000-1250	1.0	10
Male abdomen & breasts	1250	1.0	10
Female breasts; chin, cheek, & jowls	1500	1.5	10
Facial resurfacing (CO_2 laser)	600mg/250ml	1mg/250ml	5mEq/250ml

tumescence, it is advisable to allow for detumescence over a 20–30-min waiting period prior to beginning liposuction. Care must be taken preoperatively to identify any evidence of abdominal hernias or rectus diasthesis. In-office abdominal ultrasound nicely compliments clinical examination. The shorter the infiltration cannula, the greater the control, and the smaller the diameter of the cannula, the less the pain (Table 9.3).

9.3.3 Allergic Reactions

Case reports of allergic reactions to amide local anesthetics have been documented. Methylparaben, a preservative agent found in amide local anesthetic preparations, is metabolized to *p*-aminobenzoic acid, which is a highly antigenic substance. In addition, allergic reactions are rarely caused by antioxidants that are found in local anesthetics, such as sodium bisulfite and metabisulfite. Hypersensitivity reactions to preservative-free formulations of amide local anesthetics are rare, but have also been reported.

9.4 Conclusion

Tumescent anesthesia for liposuction is an effective and safe anesthetic providing the guidelines outlined here are followed.

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Liposuction with Local Tumescent Anesthesia and Microcannula Technique

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10.1 Background and History

Tumescent liposuction refers to the process of suction-assisted aspiration of subcutaneous fat after infiltration with a dilute crystalloid solution containing lidocaine and epinephrine. By definition, pure tumescent liposuction is performed entirely under local anesthesia and excludes the use of general anesthesia or intravenous sedation [1].

The concept of liposuction utilizing local tumescent anesthesia and microcannulas was reported by Klein [2] in 1987. Prior to this innovation, liposuction techniques employed larger-diameter cannulas under general anesthesia. The field of modern liposuction was first described by Fischer [3] in 1976 and further expanded by liposuction pioneers Pierre Fournier and Yves-Gerard Ilouz. Initially, the procedure was performed with larger-diameter cannulas under a dry technique until Ilouz of France introduced the wet technique utilizing an infiltrated hypotonic saline and hyaluronidase solution to facilitate the fat removal. While these early techniques were effective, they were associated with more trauma and potential complications including hemorrhage, fluid loss, and pain [4–6].

The invention of tumescent anesthesia by Klein revolutionized the field of liposuction. Klein described a technique for aspirating adipose tissue entirely under local anesthesia with a dilute solution of lidocaine and epinephrine. The technique provided excellent hemostasis, maintained fluid balance, and eliminated the need for general anesthesia and associated complications. In conjunction with the innovation of tumescent anesthesia, small microcannulas were developed to more gently and precisely remove layers of adipose tissue to achieve a sculpting effect. These cannulas have a diameter of 20–10 gauge (0.58–2.7-mm inner diameter) compared with the larger cannulas having a diameter from 3 to 6 mm or greater. With proper technique, liposuction utilizing microcannulas under local tumescent anesthesia is an exceedingly safe and effective procedure with a relatively comfortable postoperative recovery period for the patient [7].

10.2 Tumescent Anesthesia

10.2.1 Advantages of Tumescent Anesthesia

The concept of tumescent anesthesia relies on infiltrating a dilute solution of normal saline with lidocaine and epinephrine that is partially removed in the lipoaspirate (10–30%) but largely removed from the subcutaneous tissue over several hours after the procedure has been completed. This slow absorption allows for gradual intravascular volume replacement and elimination of the lidocaine over several hours without achieving toxic plasma lidocaine levels (over 5 μg/ml) [8]. This technique provides excellent anesthesia, obviating the need for general anesthesia and its associated complications, and provides excellent hemostasis provided by the vasoconstrictive effects of the epinephrine. The procedure can be done safely on an outpatient basis with rapid postoperative healing. Furthermore, owing to delayed lidocaine absorption, prolonged anesthesia can last up to 18 h, mitigating the need for postoperative analgesic medications [7].

In addition to its local anesthetic effects, an added benefit of tumescent solution with lidocaine appears to be an antibacterial effect. The antibacterial properties of lidocaine are known and have previously been reported [9, 10]. Contradictory studies, however, have questioned the antibacterial properties of lidocaine when very low concentrations are used as in tumescent fluid [11]. Nevertheless, although studies on this issue are not definitive, physicians experienced in the tumescent technique have noted a low rate of significant clinical infections, which may be attributed in part to the antibacterial properties of lidocaine [5, 12, 13]. Addition of bicarbonate to lidocaine appears to enhance the in vivo antibacterial effect [14].

10.2.2 Pharmacology of Tumescent Anesthesia

Tumescent anesthesia relies on the effects of lidocaine, which acts by blocking the sodium ion flux across nerve membranes and slowing the rate of depolarization such that threshold potentials are not reached and impulses are not propagated [15]. The tumescent concept works because lidocaine's aromatic structure renders it lipophilic in nature. Lidocaine is therefore highly soluble in fat and has a high affinity for the subcutaneous compartment. When skin is excised after infiltrating tumescent anesthesia, there is a marbled appearance and puddles of anesthetic solution are loculated within and between connective tissue septa. These lakes act as physical reservoirs of lidocaine. The lipophilic property of lidocaine is harnessed in the tumescent technique to delay the absorption of lidocaine into the systemic circulation. The lidocaine is slowly removed from the subcutaneous compartment over several hours owing to its affinity for the subcutaneous tissues, the relative hypovascular nature of the subcutaneous tissues, and the vasoconstrictive effects epinephrine, all of which minimize intravascular absorption of the lidocaine [15]. Compression of the vasculature by the infused fluid may also contribute to the slow absorption [8].

After infiltration, clinical observation has determined that optimal anesthesia and hemostasis occur after 15–30 min. Greater duration of time may allow additional anesthetic effect. Elimination of the lidocaine from the fat occurs over 48 h , with peak plasma concentrations occurring around 12 h. When utilizing a maximum dose of 35 mg/kg, lidocaine concentrations have been shown to peak 12–14 h after infiltration and were in the range 0.8–2.7 µg/ml [7].

With the tumescent anesthesia formulation, significantly higher doses of lidocaine can be used compared with the traditional upper limit of 7 mg/kg lidocaine with epinephrine. Early work by Klein and Lillis [16] dramatically altered the manner in which local anesthesia metabolism and safe dose determinations were viewed. Now it is firmly established that 35 mg/kg lidocaine as performed in liposuction is a safe level, and studies indicate that levels up to 55 mg/kg may be tolerated safely, presuming there are no contraindications such as potential drug interactions or underlying hepatic insufficiency [7, 8]. Caution must be exercised when using higher doses of lidocaine in the range 50–55 mg/kg as cases of mild nausea and vomiting have been reported, although the plasma lidocaine levels were below 3.5 µg/ml [17]. Doses exceeding 55 mg/kg were shown to be associated with a 2% incidence of mild toxicity of nausea and vomiting and the incidence is 10% or greater if dosages above 60 mg/ml are used. The cited threshold for lidocaine toxicity is 5 µg/ml, although deaths have been reported in the literature at lower levels. Those patients, however, did not have solely tumescent liposuction under local anesthesia [15].

Tumescent anesthesia is highly effective and has an extraordinary safety profile when appropriate dosing is used and strict guidelines are maintained. According to the textbook *Tumescent technique* by Klein [15], "tens of thousands of tumescent liposuction patients have received 35 to 50 mg/kg of lidocaine with no known reports of deleterious effect, which has proved the safety of tumescent local anesthesia for liposuction."

10.2.3 Tumescent Anesthesia Formulation

The tumescent fluid formulated for microcannula liposuction most often consists of a concentration of 0.05–0.1% lidocaine. A typical standard 0.1% solution contains a total of 1,000 mg lidocaine, 10 mEq sodium bicarbonate, and a concentration of 1:1,000,000–1:2,000,000 epinephrine in 1 liter of normal saline solution [15]. The full-strength 0.1% solution is useful when treating smaller areas (neck, jowls) or when treating those areas which tend to be more fibrous and tender (abdomen, back, breasts, female flanks). However, tumescent formulations vary depending on the clinical circumstance. Different concentrations of lidocaine are chosen depending on the area and volume required. For instance, a 0.05% lidocaine formulation may be used when treating more extensive areas where larger amounts of fluid are required but the maximum safe dosing is to be maintained. Alternatively, extremely sensitive areas such as the periumbilical region are often resistant to 0.05 and 0.1% solutions and a 0.15% mixture may be required. When infusing just a neck, higher lidocaine concentrations can be used since only smaller volumes of total fluid are required. This contrasts with the abdomen and flanks, where significantly larger volumes are required, making use of higher concentrations potentially problematic. Keeping in mind the 35–55-mg/kg upper limit and the volumes of infiltration needed, varying concentration levels can be utilized.

Epinephrine is a potent adrenergic agent that acts as a vasoconstrictor that enhances hemostasis and prevents rapid systemic absorption of lidocaine from the subcutaneous tissues. Epinephrine dosing was empirically derived, with experience showing that doses of 0.5–1 mg/l (which yields a final epinephrine concentration of 1:2,000,000–1:1,000,000) provided consistent vasoconstriction with a low incidence of tachycardia. The addition of epinephrine to the mixture results in prolonged local anesthetic effect and permits higher lidocaine doses by slowing its absorption. Furthermore, the epinephrine provides a dramatic hemostasis that substantially reduces blood loss. Although higher concentrations of epinephrine provide more effective hemostasis, patients should be monitored for tachycardia and hypertension. Thorough preoperative evaluations should be performed and lower concentrations of epinephrine should be considered in patients with underlying medical conditions such as thyroid or cardiovascular disease. Smaller areas over multiple sessions can be performed if required. Premedication with clonidine may also be helpful (see later) in patients who may be sensitive to epinephrine effects [15].

The solubility of lidocaine is enhanced in acidic solutions but these are often more painful to inject. Buffering of lidocaine solution with sodium bicarbonate has been shown to decrease pain [18]. Because non-acidic solutions cause the spontaneous degradation of epinephrine, it is recommended that anesthetic solutions be freshly mixed on the day of surgery (Table 10.1) [15].

10.2.4 Calculating the Maximum Lidocaine Dose

The maximum lidocaine dose must be calculated for each patient individually on the basis of the patient's weight, which should be obtained on the day of surgery. A dose of 35–55 mg/kg should not be exceeded. For a 160-lb man, the maximum lidocaine dose is calculated as follows: 160 lb/2.2=72.3 kg. The total dose range is from (35×72.3) to (55×72.3), i.e., from 2,530.5 to 3,976.5 mg.

The absolute upper limit of lidocaine is 3,976.5 mg in this example. Various concentrations and volumes of tumescent fluid can be used depending on the areas being treated but the total dose of lidocaine should not exceed 3,976.5 mg. Thus, with a 0.1% lidocaine solution, the total volume of fluid used should be less than 4 l.

10.3 Lidocaine Metabolism and Toxicity

Metabolism of lidocaine occurs through the hepatic cytochrome enzymes, which convert the lipophilic lidocaine to a hydrophilic molecule that can be more readily eliminated. Lidocaine is metabolized rapidly with 70% elimination with first pass through the liver, where the molecule undergoes oxidative N-dealkylation. Lidocaine is largely metabolized by the cytochrome P450 3A4 (CYP3A4) enzyme. Reduction in the cytochrome enzymes, either through downregulation or competitive inhibition by other medications, can reduce the clearance of lidocaine and augment the potential for lidocaine toxicity. Alternatively, parenchymal liver disease or decreased hepatic blood flow can also reduce the rate of lidocaine clearance [7, 19, 20].

Medications such as ketoconazole and erythromycin can impair lidocaine metabolism by inhibiting its cytochrome P450 mediated metabolism. A thorough understanding of lidocaine metabolism and drug interactions is essential prior to performing tumescent liposuction to avoid possible lidocaine toxicity. A report of medication-related lidocaine toxicity after tumescent liposuction was attributed to concomitant use of sertraline or flurazepam via their inhibitory effects on the cytochrome P450 enzymes [20]. Table 10.2 includes a list of some CYP3A4 inhibitors that are clinically relevant when evaluating a patient preoperatively for liposuction. It should be emphasized that many medications are metabolized by the CYP3A4 enzyme system and the table shown is only a partial list. Furthermore, some food ingredients such as naringenin and quercetin in grapefruit juice can also have inhibitory effects on the cytochrome system [19]; therefore, careful preoperative evaluation for all possible CYP3A4 interactions must be diligently performed. It is advised that each and every medication that the patient is taking be closely reviewed for possible cytochrome P450 interactions.

In patients on medications that affect the cytochrome enzyme system, the dose of lidocaine used during tumescent liposuction should be maintained below 35 mg/kg. If possible, medications with cytochrome P450 interactions should be discontinued prior to surgery. Because some medications which are cytochrome inhibitors have a prolonged half-life and are tightly bound to plasma proteins, at least 7 days should elapse between the time that the medication is discontinued and the surgery is performed. Patients with a history of liver disease or hepatic insufficiency should also be treated conservatively. Generally, these patients should be treated only if hepatic transaminases and liver enzymes are in the normal range and the total dose of lidocaine should be kept below

Table 10.1. Standard tumescent anesthesia formulation

	Lidocaine (mg)	Epinephrine (mg)	Sodium bicarbonate (mEq)	Normal saline (l)
0.15% lidocaine	1,500	0.5–1	10	1
0.1% lidocaine	1,000	0.5–1	10	1
0.075% lidocaine	750	0.5–1	10	1
0.05% lidocaine	500	0.5–1	10	1

35 mg/kg. The same is true for those patients with decreased hepatic perfusion due to medications or cardiovascular disease that can lead to possible impaired lidocaine metabolism and toxicity [7, 15].

The issue of medication interactions is especially important when considering the choice of ancillary medications that are to be used. A discussion of these ancillary medications can be found in the following. Careful attention must be paid to possible cytochrome P450 interactions when choosing prophylactic antibiotics, analgesics, and anxiolytics. For example, benzodiazepams are frequently administered orally prior to tumescent liposuction. While most benzodiazapams are metabolized by CYP3A4, lorazepam is not and can be safely used without altering lidocaine metabolism [15].

In addition to concomitant medication use and underlying medical disease, there are several factors that should be considered in determining the maximum safe dose of lidocaine. Both male patients and thinner patients tend to have a lower volume of distribution for lidocaine in the subcutaneous compartment and may not tolerate extreme doses of lidocaine. Elderly patients as well may not tolerate higher doses owing to diminished liver perfusion that occurs with age [20].

When lidocaine is employed properly, the risk of lidocaine toxicity is very low with the pure tumescent liposuction technique. However, all surgeons practicing tumescent liposuction should be familiar with the signs of lidocaine toxicity that occur when serum levels exceed 5 µg/ml (Table 10.3). Treatment of lidocaine toxicity, which is beyond the purview of this text, includes supportive measures and seizure treatment. It is recommended that all liposuction surgeons be certified in advanced cardiac life support.

Table 10.2. Drugs with potential cytochrome P450 interactions

Acebutelol	Midazolam (Versed)
Acetazolamide	Nadolol
Alprazolam (Xanax)	Naringenin (grapefruit juice)
Amiodarone (Cordarone)	Nefazodone (Serzone)
Anastrozole (Arimidex)	Nelfinavir (Viracept)
Atenolol	Nevirapine (Viramune)
Cannabinoids	Nicardipine (Cardene)
Carbamazepine (Tegretol)	Nifedipine (Procardia)
Cimetidine (Tagamet)	Norfloxacin (Noroxin)
Chloramphenicol	Norfluoxetine
Clarithromycin (Biaxin)	Omeprazole (Prilosec)
Cyclosporine (Neoral)	Paroxetine (Paxil)
Danazol (Danocrine)	Pentoxyfylline
Dexamethasone	Pindolol
Diazepam (Valium)	Propranalol
Diltiazem (Cardizem)	Propofol
Erythromycin	Quinidine (Quinaglute)
Esmobolol	Remacemide
Felodipine (Plendil)	Ritanavir (Norvir)
Fluconazole (Diflucan)	Saquinavir (Invirase)
Flurazepam (Dalmane)	Sertinadole
Flouxetine (Prozac)	Sertraline (Zoloft)
Fluvoxamine (Luvox)	Stiripentol
Indinavir (Crixivan)	Terfenadine (Seldane)
Isoniazid	Thyroxine
Itraconazole (Sporanox)	Timolol
Ketoconazole (Nizoral)	Triazolam (Halcion)
Labetalol	Troglitazone (Rezulin)
Methadone	Troleandomycin (TAO)
Metoprolol	Valprolic acid
Metronidazole (Flagyl)	Verapamil (Calan)
Mibefradil (Posicor)	Zafirlukast (Accolate)
Miconazole (Monistat)	Zileuton (Zyflo)

10.4 Alternative Anesthetic Agents

Various alternative tumescent formulations have been utilized, including infusion of dilute epinephrine without local anesthesia with supplemental bupivacaine after surgery [22]. However, owing to bupivacaine's effect on myocardium, the potential for cardiotoxicity is greater and its use is not advocated [23]. Use of prilocaine at 35 mg/kg was reported in the European literature at and it was found to be safe. Methemoglobinemia is a potential side effect of prilocaine, however, and there is a paucity of data in the literature to date on this anesthetic agent's use in liposuction [24]. At this time, the use of alternative anesthetic agents is not well studied and their safety profiles remain unclear. Lidocaine is well documented to be safe and effective in tumescent liposuction and remains the standard in the USA.

10.5 Ancillary Pharmacology

The material in this section is presented as a general discussion only, and not as a complete reference on alternative and additional drugs. The reader should

Table 10.3. Signs of lidocaine toxicity

Lidocaine level (µg/ml)	Signs of toxicity
3–5	Nausea, vomiting, drowsiness, lightheadedness tingling
5–8	Tinnitus, paresthesias, CNS changes, cardiovascular toxicity
>8	Coma, seizures, and severe cardiac and respiratory depression

be well conversant with the medications before prescribing for any particular patient.

The decision for prophylactic and perioperative antibiotics has no current standard. As discussed earlier, infection rates are extremely low with the tumescent technique. This may be related to lidocaine acting as an antibacterial agent as discussed earlier in this chapter [5, 9, 10]. Clinically the decision for antibiotics at this time is determined by the surgeon. We routinely prescribe prophylactic broad-spectrum antibiotics initiated the day prior to surgery. It is essential that the antibiotic of choice is not metabolized by the CYP3A4 system so as to avoid interaction with lidocaine metabolism.

Lorazepam by mouth (usually 1–2 mg) should be considered as the recommended sedative preoperatively because it is not metabolized by the cytochrome P450 system. Other benzodiazepams, including diazepam, may have interactions with lidocaine through the CYP3A4 system and are generally avoided. Orally administered lorazepam can be used to produce the same sedative, anxiolytic, and anterograde amnesic effects as 10–20 mg diazepam. Nausea may occur with 2 mg and often only 1 mg is needed. The drug has a half-life of 10 h or longer and frequently a dose taken the night before might be all that is needed. Alternatively, a dose of 1 mg lorazepam may be administered 1 h prior to surgery [1].

Clonidine has been popularized as an effective analgesic with mild sedative and antianxiolytic properties at a single dose of 0.1 mg orally and can be safely used unless patients have low blood pressure or slow pulse. It is also especially useful in patients who may be borderline with regard to tachycardia and hypertension to maintain a lower heart rate and blood pressure during surgery. Clinical effects begin 20–40 min after ingestion. Repeated doses should not be given. Clonidine is a drug underappreciated by liposuction surgeons and should be recognized as an effective supplement for analgesia, which can help minimize the need for narcotics. Furthermore, clonidine may potentiate the anesthetic effects of lidocaine and enhance the effects of opiates [15].

Klein also advocates the use of 0.3–0.4 mg of intravenous atropine given in a dilute mixture after intravenous access has been established to prevent vasovagal events when clinically needed [15].

Midazolam is widely used by surgeons and anesthesiologists in cosmetic surgery both before surgery and as part of intravenous sedation. According to Klein, 3% of patients require intravenous Midazolam at a dose of 1 mg during infiltration to supplement oral clonidine and lorazapam. Midazolam has a short duration of effect after a single dose. Problems with disinhibition may occur with this drug but the amnestic effect is significant and often beneficial during the infiltration phase where discomfort may be present in select patients [15]. While respiratory depression is possible, the drug may be immediately reversed with intravenous Flumazenil [25].

There is a theoretical problem with concomitant use of beta blockers in conjunction with epinephrine as unopposed alpha stimulation could result. However, this appears to be primarily a theoretical issue. In clinical practice it appears that the absorption of epinephrine from the tissue is too slow to result in a significant problem. This problem has not surfaced in any of the major studies on morbidity and mortality (Sect.10.9). As a result, patients on beta blockers generally continue their usual doses [17]. However, if a modified tumescent technique is used and general anesthesia is employed, the anesthesiologist should be advised to avoid the use of propranalol owing to the potential for unopposed adrenergic stimulation [21].

Narcotics are utilized by many liposuction surgeons [26]. They may be provided as part of intravenous sedation and anesthesia, or as supplemental analgesia for surgeons utilizing the local anesthetic liposuction approach. The combination of meperidine and antihistamine has a long and established usage for all types of pain management and may be provided by intravenous or intramuscular routes. Sometimes doses as low as 10 mg can be effective in the author's experience, although dosing of 50 mg may be necessary. Naloxone should always be available when administering narcotics. Butarphanol in low doses is a safe alternative [27]. Fentanyl in a 25–50-µg dose may be substituted for meperidine, although caution must be exercised as it is metabolized by the cytochrome 3A4. In general, with intravenous dosing, fentanyl has a relatively short duration of action and causes less nausea and orthostatic hypotension [15].

10.6 Tumescent Liposuction Technique

10.6.1 Tumescent Fluid Infiltration

Various techniques for fluid infiltration have been described and individual variations among surgeons are extremely common. Routinely, a warmed solution of the tumescent formula is prepared. An ideal temperature of 37–40°C has been reported to be ideal to maximize patient comfort upon infiltration [28]. The use of bicarbonate buffer also helps to minimize discomfort.

The tumescent fluid is infiltrated first using a 25-gauge spinal needle to sprinkle the fluid diffusely. Once a small amount of fluid has been distributed over the area to be treated, a 20-gauge needle is subsequently used to infiltrate more fluid. Finally, small incisions with a no. 11 blade or a 2-mm punch are made in the skin, and a 14-gauge multihole infiltration cannula is inserted into the subcutaneous plane to achieve complete tumescence. Most surgeons utilize the same incision ports for infiltration that are used for fat aspiration. When performed in this stepwise fashion, patient comfort is maximized. Although spinal needles may help with patient comfort, some surgeons opt to avoid these needles and use only the blunt infiltration cannulas, as they are potentially less traumatic.

During the infiltration process, attention must be paid to maintaining the needle at approximately a 30–45° angle with respect to the horizontal plane. A fanlike pattern is utilized to ensure wide distribution of the fluid (Fig. 10.1). The surgeon at all times should be aware of where the end of the needle resides to avoid injury to thoracic and intra-abdominal structures. When the infiltration cannula is used in the final stages, it is passed in a plane that is parallel to the horizontal plane. Fluid must be delivered to all levels of fat. Infiltrating only the more superficial fat may clinically give a tumesced feel to the skin but the deeper fat has not been anesthetized; therefore, it is recommended that the deeper fat be infiltrated first. The subcutaneous tissue can be gently grasped and lifted during the infiltration process to ensure that the deeper fat is anesthetized and to prevent inadvertent injury to deeper structures (Fig. 10.2).

The tumescent fluid is infiltrated under pressure. Most physicians utilize pumps where the rate can be preset and a foot pedal allows on/off control.

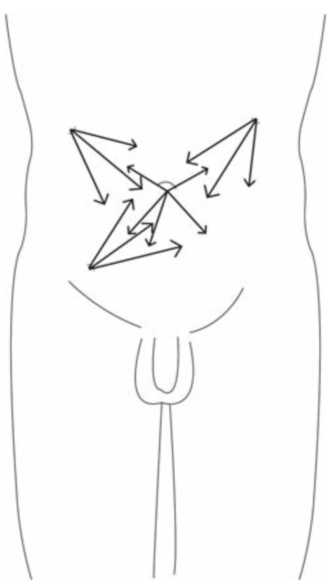

Fig. 10.1. Fanlike pattern from multiple sites for infiltration and liposuction

The amount of time required for infiltration can be reduced by increasing the rate of lidocaine infusion but this is often accompanied by increased patient discomfort and may require more premedication depending on patient tolerance [29]. Additionally, rapid infusion may result in patchy or uneven distribution and incomplete anesthesia and hemostasis. Meticulous infiltration with tumescence throughout the fat results in less than 1% blood loss per liter of aspirate, whereas rapid infiltration results in 7% blood loss per liter aspirated (Fig. 10.3) [15]. It has been shown that serum levels of lidocaine are not affected by the pressure or the rate of infusion [30, 31]. Alternative methods include hanging an intravenous bag with a pressure cuff. The surgeon must monitor both the total volume infiltrated and the total lidocaine dose carefully during the infiltration process.

Infiltration is continued until the tissue has become fully tumesced. The infiltrated areas have a firm, edematous quality to palpation. The skin is

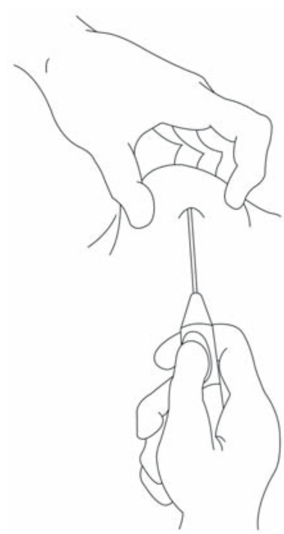

Fig. 10.2. Fat being grasped and lifted to infiltrate deep layers without injuring deeper structures

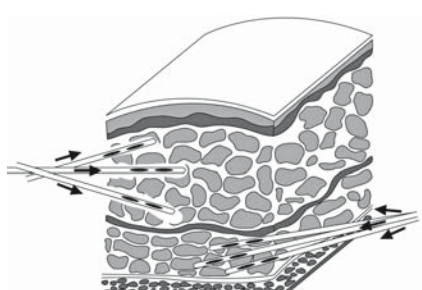

Fig. 10.3. Fat aspiration in multiple planes with a fanlike pattern

characterized by pallor and is slightly cool owing to the vasoconstrictive effects of the tumescence. A *peau d'orange* appearance is undesirable and should be avoided.

Hydrodissection secondary to tumescent fluid helps maintain patient comfort in that the infiltration cannula is not pushed through the tissue so much as the fluid is utilized to open the tissue beyond the cannula tip. Properly performed, infiltration is slow and steady, allowing the cannula to slip between fibrous septa smoothly rather than imposing excessive traction as it is pushed through resistant tissue.

The volume infiltrated is the minimal amount to achieve complete local anesthesia. Empirically it is usually on the order of 2:1 or 3:1 (fluid infiltrated to aspirated fat) [15]. Maximum tumescence is not required for complete anesthesia or vascular stabilization and excess volumes should be avoided as it results in a more difficult liposuction.

10.6.2 Microcannulas and Lipoaspiration

The tumescent liposuction technique is nicely complemented by the use of microcannulas. These cannulas are designed to have a narrow diameter and may have multiple apertures or only one or two holes. They vary in length, so both large and small areas can be effectively treated and proximal and distal areas can be reached from a single incision site. Microcannulas offer a number of advantages. First, owing to the small diameter, they are generally less painful as they penetrate through the subcutaneous tissue. Additionally, the smaller-diameter cannulas often pass more easily through fibrous tissue, which is especially advantageous in specific areas such as the upper abdomen, back, and breasts. Generally, the microcannulas remove small amounts of fat with each stroke. This allows for gradual and precise removal of fat to prevent textural irregularities and depressions. Although slower than larger cannulas, microcannulas can ultimately be just as aggressive in removing large volumes of adipose tissue. Cannula size and type is a matter of each surgeon's individual preference and a variety of cannulas can be used effectively, depending on the surgeon's experience and skill.

Before beginning infiltration, the areas to be treated should be marked in a topographical fashion while the patient is standing. These markings should indicate those areas of denser fat accumulations where more fat is to be removed as well as those areas where less fat is present. The markings should also designate the edges of the region being treated where feathering will occur for optimal blending and cosmetic outcome [15].

After infiltration of the tumescent fluid, the surgeon should wait approximately 15–30 min to allow the tumescent fluid to reach maximum effect. As patients generally are awake during the tumescent liposuction procedure, they can be positioned precisely to allow for optimal liposuction.

Initially, smaller-diameter cannulas can be used to penetrate the subcutaneous tissue and create tunnels through which larger cannulas can be passed. Through this method, intraoperative comfort will be maximized [26]. The cannula is generally passed through the same incisions used for infiltration of the tumescent fluid. These entry points are strategically placed to be minimally visible after the patient has fully recovered. Multiple entry points are required to access the entire area to be treated. Entry sites should be randomly placed without symmetry within any given area that is being treated. This will ultimately produce the most inconspicuous results.

The fat is removed in layers, starting first with the deepest layers. The skin is lifted with the non-dominant hand to create a tunnel of tissue through which the cannula is passed. A fanning pattern is used to remove an entire plane of fat. This fanning pattern can be repeated in different planes, starting in the deep subcutaneous fat and moving more superficially (Fig. 10.3) [15]. The end point with tumescent liposuction is somewhat different from that of non-tumescent techniques in that there is still fluid in the tissue after the appropriate amount of fat has been aspirated. Determining the end point is a matter of surgical experience and depends on tissue palpation and visual configuration. Further details of the microcannula technique are outlined in Chap. 27.

10.7 Postoperative Care: Open Drainage and Compression

The postoperative course following tumescent liposuction is generally rapid and comfortable; however, patients must be well informed as significant edema, purpura, and fluid drainage can occur. Furthermore, the drainage may be blood-tinged and alarming to the unprepared patient. The entry sites through which the liposuction is performed are not closed. Rather, they remain open and serve as drainage points through which the tumescent fluid can flow resulting from a combination of compression and gravitational forces. Open drainage can continue for up to 3–4 days and appropriate absorbent dressings are required [15].

Immediately after the procedure is completed, highly absorbent pads are applied. The pads are applied under compressive elastic garments and left in place for 24 h. They can be replaced every 24 h if they become soaked and should be utilized until drainage ceases. After the drainage has discontinued, the dressing should be changed to a mildly compressive support garment. This dressing provides support and can help to contour the skin as it retracts during the weeks following liposuction. Heavy compression during this period is unnecessary and may be counterproductive by impeding lymphatic drainage. Klein [32] has described this two-phased postoperative compression system as "bimodal compression".

Rapid return to normal function with tumescent liposuction can be dramatic. In general, for abdomen and flanks, most patients prefer a few days of rest and typically return to work 5 or 5 days after surgery. However, with tumescent liposuction many patients rebound quickly and we have had patients leave on vacation the next day or return to work within a day or two. This is because of the less traumatic nature of tumescent liposuction under local anesthesia owing to techniques of infiltration and use of microcannulas.

Skin retraction during the postoperative period occurs over several weeks (Fig. 10.4). Some postoperative edema in the treated fields may persist for a few weeks. Patients need to be reassured that the final cosmetic outcome will not be apparent for at least 2 months after the procedure. Occasionally, touch-up procedures can be performed if needed but waiting at least 2–3 months or longer after the initial procedure is prudent.

Fig. 10.4. Liposuction of lateral thighs and hips: **a** preoperative; **b** postoperative

10.8 Complications

As with any surgical procedure, inherent risks and potential complications exist with tumescent liposuction. A detailed discussion on liposuction complications can be found elsewhere in this book. The advantage of the tumescent microcannula liposuction technique is that the potential risks of liposuction are minimized. Given the excellent hemostasis provided by the epinephrine in the tumescent fluid, the risk of postoperative bleeding is very low. Thorough knowledge of the underlying anatomy is essential, however, to make sure that larger vessels are not transected by the smaller-diameter cannulas, which are potentially more traumatic than larger-diameter cannulas [15]. As discussed earlier, there is a low rate of postoperative infection possibly owing to antibacterial properties of lidocaine [9, 10]. Perioperative prophylactic antibiotic use may also help to minimize infection rates. Scarring is generally minimal if microcannulas and small entry points are used. Reduced scarring is a major advantage of the microcannula technique but patients must still be warned of possible pigmentary alteration and even hypertrophic scarring in prone individuals. Patients should also be advised that persistent numbness or dysesthesia may occur in treated areas, although this is usually not permanent [15, 33].

Textural irregularities, rippling, and dimpling are complications associated with liposuction that are greatly minimized with the tumescent microcannula technique. Because small volumes of fat are removed with each stroke, the fat can be removed in thin layers to achieve a gradual and uniform reduction in the subcutaneous layer. This allows for sculpting the tissue with uniformity, giving a smooth, even result.

Some complications unique to or more pronounced with the tumescent technique relate to the large volumes of lidocaine-containing fluid that are infiltrated. Significant ecchymoses and edema can occur especially in the scrotal/labial areas or the distal upper and lower extremities. When performing liposuction of the abdomen, thighs, arms, or distal lower extremities, patients should be forewarned that this is normal for the postoperative course. Gradual resolution of the purpura and edema occurs over several days following the procedure [15, 32–34].

In some patients, seromas may form and larger patients with a pannus where fluid can collect are at an increased risk for this complication. Small seromas generally spontaneously resolve but larger seromas may require aspiration of the fluid with a 20-gauge needle [15, 34].

Skin ulceration secondary to necrosis is a rare complication, and can occur from excessive injury to the dermis. Care must be taken to avoid superficial liposuction in the dermis, which can compromise the dermal and epidermal vascular supply. With proper liposuction technique, a superficial layer of fat should be left intact and the dermis should be free from injury, thereby avoiding the risk of skin ulceration and necrosis [15].

10.9 Safety of Tumescent Liposuction

A 1999 article detailing five deaths involved patients with systemic anesthesia, either intravenous sedation or general anesthesia [35]. None of the patients had evidence of lidocaine toxicity. One developed an abrupt EKG and physiologic changes within 30 s of being rotated from the prone to the supine position, which may have been related to severe hypotension that can develop with combinations of droperidol and fentanyl [36]. None of these patients had true tumescent liposuction in that the tumescent fluid was not used as the main source of pain control. Three patients succumbed to intraoperative hypotension of unknown cause, one from pulmonary thromboembolism, and one from fluid overload. Only one patient had an elevated lidocaine level of 5.2 but this was after resuscitative efforts. The author concluded that two of the cases may have been caused by lidocaine toxicity, but this does not appear to be supported by the data [13].

In 2000, Coldiron [37, 38] reviewed reports of deaths in Florida and concluded that specific details were lacking but that the complications were not specific to an office setting or involved tumescent liposuction.

The association with systemic anesthesia was seen in a study of 95 liposuction deaths in a study of plastic surgeons [39]. The survey of 1,200 plastic surgeons performing a total of 496,245 procedures demonstrated a mortality of 1 in 5,224 procedures, which was computed to a rate of 19.1 per 100,000; 47.7% occurred after office-based surgery and 16.9% after hospital-based surgery. The primary cause of death was thromboembolism in 23.4% of cases. None of the patients succumbed to lidocaine toxicity.

A survey of dermatologists was performed looking at complications occurring from 1994 through 2000. Data were obtained on a total of 66,570 liposuction procedures. No deaths occurred, and the serious adverse event rate was 0.68% [13]. In this review, procedures had been performed in non-accredited office settings, ambulatory surgical centers, and hospitals. Adverse event rates were higher for tumescent technique liposuction combined with intravenous or intramuscular sedation than for tumescent technique liposuction combined with oral or no sedation. Of the 45 adverse events recorded, only one is listed as lidocaine toxicity. The conclusion was that tumescent liposuction performed by dermatologic surgeons is safe in an office setting [13].

Other studies have found that tumescent liposuction as performed per American Society of Dermatologic Surgery (ASDS) guidelines is considered very safe and should be differentiated from more aggressive liposuction methods [1, 40–42]. The ASDS data base of over 300,000 procedures from 1995 to 2000 performed according to ASDS guidelines demonstrates no deaths [1].

Similarly, a 1988 survey encompassing 9,478 tumescent liposuction procedures performed by dermatologists without intravenous sedation documented no fatalities [43]. A 1995 survey of 15,336 tumescent procedures as performed by dermatologists showed no fatalities [12].

A 1999 analysis of malpractice claims from 1995 to 1997 showed that dermatologists performing liposuction in the office had fewer malpractice claims than plastic surgeons performing liposuction in the hospital. The conclusion was attributed to the use of the tumescent liposuction technique and the smaller volumes of fat removed by dermatologic surgeons [44].

Fatality factors with liposuction may include general or intravenous sedation, multiple surgeries performed concurrently, removal of large volumes of fat during one procedure, inpatient setting, administration of toxic doses of lidocaine combined with general/intravenous anesthesia, and intravenous fluid overload [45].

Dermatologists commonly rely on tumescent anesthesia as the primary pain management method during liposuction. When intravenous or general anesthesia is added, a variety of drugs that are metabolized by the same cytochrome enzymes or reduce hepatic blood flow may be utilized, resulting in diminished lidocaine metabolism. Further, the subcutaneous tissue may be underinfused, which means the tissue may not be fully tumesced. It is thought that full tumescence protects blood vessels in the fibrous septae by compression, making liposuction less traumatic. Intravenous sedation and general anesthesia are commoner when larger-volume liposuction is planned or in conjunction with other cosmetic procedures. The combination of multiple forms of anesthesia and the combination of drug effects and large-volume liposuction may be the cause of the mortalities [46].

One issue of concern is deep venous thrombosis leading to pulmonary embolism subsequent to liposuction and its relationship to hormonal therapy. Butterwick [47] indicates that the incidence of deep venous thrombosis with true tumescent liposuction without general anesthesia or deep intravenous sedation appears no greater than the general incidence in women on oral contraceptive or hormone replacement. The conclusion is that these medications need not be discontinued prior to surgery unless additional risk factors are present, such as estrogen content greater than 35 mg/day. One additional recommendation is proper fitting of postoperative garments to avoid constricting venous return and making sure women ambulate postoperatively. Graduated support hoses were recommended for women with increased risk factors of deep venous thrombosis [47].

10.10 Guidelines for Maximum Volumes of Lipoaspiration

Guidelines for safety establishing the maximum volume of aspirate have been set by the American Academy of Dermatology as 4,500 ml of fat and by the ASDS as 5,000 ml of total fluid/fat [1, 34]. We remove no more than 4–5 l of fat during each session. If patients have several areas requiring treatment, multiple sessions must be planned. Safety of the tumescent liposuction technique is maximized when it is performed in compliance with these guidelines.

10.11 Conclusions

Tumescent liposuction under local anesthesia with the microcannula technique allows for very safe and effective body sculpting and fat reduction entirely under local anesthesia. Thorough understanding of the pharmacology of lidocaine and implementation of the infiltration and aspiration guidelines and techniques associated with tumescent microcannula liposuction are essential to achieve optimal outcomes.

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11 Tumescent Technique

Melvin A. Shiffman

11.1 Introduction

In the early days of liposuction, the dry technique was used with general anesthesia. The technique used had no fluids injected into the tissues and resulted in 20–45% blood loss [1–6]. Liposuction was limited to 2,000–3,000 ml because of the blood loss and patients were frequently given transfusions [2].

The wet technique relies on infusions of 100–300 ml of normal saline into each site but has blood loss of 15–30% [7–11]. With epinephrine added to the fluid, the blood loss is reduced to 20–25%.

The tumescent technique has improved the problem of blood loss reducing it to 1–7.8% [12, 13]. The term "superwet anesthesia" has been used to describe the same fluid injection as with the tumescent technique [14]. This technique consists of an infusion of saline with epinephrine and an aspirate removal of approximately 1:1. Local tumescent anesthesia usually has a fluid infusion to aspirate ratio of 2:1 or 3:1.

11.2 Local Tumescent Anesthesia

Klein reported the use of local tumescent anesthesia in 1987 [15]. The report described solutions used that consisted of:

1. For general anesthesia:
   (a) Normal saline: 1,000 ml
   b) Epinephrine: 1 mg
2. For local tumescent anesthesia:
   (a) Normal saline: 1,000 ml
   (b) Epinephrine: 1 mg
   (c) Lidocaine: 1,000 mg

The ratio of the amount of tumescent solution compared to the amount of aspirate removed was 1:1.

Klein, in 1990 [16], showed that 35 mg/kg was a safe amount of lidocaine to use for local tumescent anesthesia. The solution utilized at that time consisted of:

1. Normal saline: 1,000 ml
2. Epinephrine: 1 mg
3. Lidocaine: 500 mg
4. Sodium bicarbonate: 12.5 mEq

Klein, in 1993 [12], changed the local tumescent anesthesia solution to:

1. Normal saline: 1,000 ml
2. Epinephrine: 0.5–0.75 mg
3. Lidocaine: 500–1,000 mg
4. Sodium bicarbonate: 10 mEq
5. Triamcinolone: 10 mg (optional)

The amount of mean tumescent solution compared to the total aspirate was 4,609 ml:2,657 ml or almost 2:1.

By 1995, Klein [17] had changed the tumescent formula to:

1. Normal saline: 1,000 ml
2. Epinephrine: 0.5–0.65 mg
3. Lidocaine: 500–1,000 mg
4. Sodium bicarbonate: 10 mEq
5. Triamcinolone: 10 mg

In 2000, Klein [18] described a variation of drugs in the local tumescent solution according to the area being liposuctioned. The basic solution to be changed after checking for completeness of anesthesia was:

1. Normal saline: 1,000 ml
2. Lidocaine: 500 mg
3. Epinephrine: 0.5 mg
4. Sodium bicarbonate: 19 mEq

If the anesthesia was not adequate then a variety of formulations were proposed for each area of the body areas and ranged from 750–1,500 mg lidocaine, 0.5–1.5 mg epinephrine [12, 15–26], and 10 mEq sodium bicarbonate.

Local tumescent anesthesia is used as the anesthetic for performing liposuction, especially with small cannulas. The same fluid can be used with conscious sedation to provide the necessary local anesthesia.

11.3 Tumescent Technique

Compared with local tumescent anesthesia, the tumescent technique is used to diminish blood loss and bruising, provide fluid replacement, and act as a local anesthetic after surgery. The tumescent technique is used with deep sedation or general anesthesia.

The solution utilized is a variation on local tumescent anesthesia with the main elements being the fluid, either normal saline or lactated Ringer's solution (1,000 ml), and 1 mg epinephrine for vasoconstriction. There is some use for the inclusion of lidocaine but not at the levels necessary for local tumescent anesthesia. The expected tumescent fluid to total aspirate ratio is usually 1:1.

The author's formula for the tumescent technique with general anesthesia, deep sedation consists of:

1. Lactated Ringer's solution: 1,000 ml
2. Epinephrine: 1 mg
3. Lidocaine: 250 mg

Sodium bicarbonate, 12.5 mEq, is added and lidocaine increased to 350 mg if local tumescent anesthesia with or without conscious sedation is utilized. The total aspiration, except for rare cases, does not exceed 3,500ml. Tumescent fluid, with 250 mg lidocaine in 1,000 ml, with a total of 3,500 ml administered gives a total of 875 mg lidocaine, which is well under 35 mg/kg in most patients. This allows 3,500 ml total aspirate (1:1) and in a 70-kg (150-lb) patient the lidocaine infused is 12.6 mg/kg. In contrast, local tumescent anesthesia using 500 mg lidocaine per liter in a 70-kg patient requires 7,000 ml tumescent fluid to obtain 3,500 ml total aspirate (2:1) and the total lidocaine is 3,500 mg or 50 mg/kg.

Cardenas-Camarena [27] reported the use of the tumescent technique with the fluid consisting of 1,000 ml normal saline and 1 mg epinephrine in patients having general anesthesia or peridural regional block (with lidocaine). The ratio of the volume of tumescent fluid to that of extracted fluid was 1:1.

In the facial area, the total lidocaine should probably not exceed 7 mg/kg early in the injection since absorption of the lidocaine with epinephrine peaks within 15 min (because of the high vascularity of the face and epinephrine takes 15 min to cause adequate vasoconstriction) and then a second peak occurs in 8–14 h. Lidocaine in facial tumescence can exceed a total of 490 mg in a 70-kg patient if infused slowly. The rapider the infusion, the lower the blood level of lidocaine needed to result in toxicity.

11.4 Discussion

Most patients in the author's practice prefer not to be awake during the liposuction procedure. They are frightened and anxious and have heard things from friends or over the internet about the "gross" methods used in liposuction. Watching or hearing the sounds (machines and talking) with the liposuction procedure is abhorrent to some patients. Just the thought of the slightest discomfort during the procedure is enough for some patients to prefer general anesthesia or deep sedation. There have been instances of surgeons performing liposuction with local tumescent anesthesia where the patient has complained about pain and the surgeon would not reinject tumescent fluid or avoid the painful area since the procedure "is almost done."

The use of the tumescent technique combined with low vacuum [28] has resulted in minimal blood loss, better patient satisfaction with the results of liposuction, and less bruising. The idea is to fill the areas to be liposuctioned with enough fluid to swell the tissues but not cause blanching. Injection of fluid begins with tunnels in the deep subcutaneous tissues and ends in tunnels in the superficial fat. Total aspirate usually approximates the amount of infusate without consciously attempting to get them equal.

Liposuctioning is stopped in any tunnel that produces blood. It is possible to infuse more tumescent fluid if the preliminary results are not satisfactory to the surgeon, blood is beginning to appear in some of the tunnels, and more liposuctioning is required.

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Safety of Lidocaine During Tumescent Anesthesia for Liposuction

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12.1 Introduction

Tumescent anesthesia for liposuction is a technique based upon the infiltration of large volumes of a dilute concentration of local anesthetic, lidocaine. Although developed by Klein for liposuction, this method of anesthesia has allowed surgical treatment for many different procedures, including rhytidectomy, abdominoplasty, hair transplantation, vein surgery including ligation and stripping, as well as newer less-invasive endolumenal radio frequency or laser closure/ablation of the greater saphenous vein.

When a dilution of 0.1% lidocaine solution is used, peak plasma levels of lidocaine have been well documented to occur anywhere from 4 to 14 h after beginning infiltration [1, 2]. Most studies that have demonstrated this delayed absorption have followed plasma lidocaine levels in 2–3-h increments after rather than during infiltration. However, the infiltration is theoretically a critical time for lidocaine absorption given that pharmacokinetics studies have shown that not only the dilution of lidocaine but also the rate of subcutaneous infiltration is an important variable for lidocaine absorption [3]. Piveral's [4] study showed that rapid systemic absorption resulting in potentially toxic peak levels may occur as quickly as 15 min after injection of a stronger concentration of 1.0% lidocaine delivered during tumescent liposuction. Lidocaine absorption may thus occur rapidly until epinephrine-induced vasoconstriction occurs, thereby slowing absorption.

Other studies have underscored the importance of the infiltration period. The study of Hanke et al. [5] showed that dermatologic surgeons are using infiltration pumps that now allow increasingly rapid rates of infiltration of tumescent anesthesia. The rapidity of infiltrating solution is assisted by providing adequate preoperative medication to reduce the pain of infiltration. In addition, intravascular injection of lidocaine during infiltration of a tumescent solution of lidocaine has been reported during phlebectomy when infusion was performed with a non-aspirating injection syringe [6]. We have evaluated the effect of rapid versus slow infusion of dilute lidocaine in tumescent anesthesia. We measured the serum level of lidocaine within the early time interval of the procedure to determine whether epinephrine-induced vasoconstriction is rapid enough to prevent rapid absorption of dilute lidocaine.

12.2 Materials and Methods

Eighteen patients who underwent standard tumescent liposuction participated in this study. Preoperative medications varied among the patients. Some patients received 1.0–2.0 mg lorazepam orally (p.o.) and 25–50 mg meperidine and phenergan intramuscularly (i.m.). Other patients received 0.1 mg clonidine p.o. and/or 30 mg flurazepam p.o. and/or 1.0–3.0 mg midazolam intravenously prior to administration of tumescent anesthesia.

The tumescent solution consisted of two concentrations of lidocaine, 0.05 or 0.1% lidocaine , both concentrations mixed with 0.75 mg/l epinephrine (in 16 of 18 patients), 0.65 mg/l epinephrine (in two of 18 patients), and 10 mEq/l sodium bicarbonate. The liter bag was warmed to achieve a temperature of 37–40°C. Infiltration was accomplished with no. 25 and/or no. 20 gauge spinal needles and a no. 14 gauge multihole infusion cannula given with a Klein infusion pump at settings ranging from three to nine (corresponding to flow rates varying from 50 to 450 ml/min). The actual rate of flow from a given numerical setting on an infusion pump varies depending on the infusion instrument, tubing size, clamp pressure, and tissue resistance). Serum levels of lidocaine were taken every 15 min during the first hour of the procedure and again at 2 h.

The dose of lidocaine, the rate of injection, and the time for the peak concentration for each patient are given in Table 12.1. The rate of infusion of tumescent anesthesia ranged from 27.1 up to 200 mg/min over an infiltration time of 5 min to 2 h. The total lidocaine dose ranged from 7.4 up to 57.7 mg/kg.

Table 12.1. Patients and results (From Butterwick et al. [12])

No.	Patient Sex	Age	Weight (kg)	Lidocaine Total dose (mg)	Dose (mg/kg)	Infiltration Total time (min)	Rate (mg/min)	Lidocaine peak Concentration (µg/ml)	Time (min)
1	F	45	59.0	3,250	55.0	120	27.1	0.6	15
2	F	37	54.5	2,000	36.7	60	33	1.9	120
3	M	43	89.0	3,775	42.4	45	83	0.6	120
4	F	55	59.5	3,000	50.4	22	136	1.1	45
5	M	24	74.5	4,300	57.7	30	143.3	1.6	15
6	M	65	85.9	5,000	58.2	27	185	0.9	120
7	F	54	62.8	3,600	57.3	18	200	1.0	120
8	F	26	58.1	2,725	46.9	100	27.2	<0.5	15–120
9	F	19	51.8	2,500	48.2	90	27.8	<0.5	15–120
10	F	46	59.0	3,325	56.3	115	28.9	<0.5	15–120
11	F	40	45.5	2,350	51.7	75	31.3	<0.5	15–120
12	F	26	57.9	2,325	40.1	73	31.8	<0.5	15–120
13	F	39	47.2	2,700	57.2	75	36.0	<0.5	15–120
14	F	62	61.0	2,850	46.7	75	38.0	<0.5	15–120
15	F	30	64.5	2,000	31.0	45	44.4	<0.5	15–120
16	F	40	69.2	3,600	52.0	80	45.0	<0.5	15–120
17	F	44	89.5	4,900	54.7	105	46.7	<0.5	15–120
18	F	56	74.5	550	7.4	5	110.0	<0.5	15–120

F female, *M* male

12.3 Results

In all 18 patients, peak lidocaine levels remained significantly below the toxic range and were less than 2.0 µg/ml. In 11 patients, the lidocaine levels at all time intervals were below 0.5 µg/ml, the lowest detectable level of the laboratory. The relationship between the plasma lidocaine concentration and the lidocaine dose is shown in Fig. 12.1. There was no linear correlation between peak plasma lidocaine level and lidocaine dose. Figure 12.2 depicts plasma lidocaine levels as a function of the rate of lidocaine infused (milligrams per minute). Again, no linear relationship was appreciated.

Seven patients did have varying levels of lidocaine during the first 2 h of the procedure, as shown in Table 12.2. Figure 12.3 represents these serial measurements in graphic form. Lidocaine levels were variable and were highest at 15 min in two patients, 45 min in one patient, and 2 h in four patients. In these seven patients, the total lidocaine dose varied from 36.7 to 57.7 mg/kg and the rates of infiltration ranged from 27.1 to 200 mg/min. Patient no. 7, who was infiltrated most rapidly and received the highest dose of lidocaine, did not have the highest levels as may have been expected. Patient no. 1 had higher than expected levels, given that the total dose of lidocaine was relatively low (36.7 mg/kg) and the rate of infusion was slow, over a 2-h period. In 17 of 18 patients, lidocaine levels did not vary more than 0.5 µg/ml during the study period and in one patient it varied by 0.8 µg/ml.

12.4 Discussion

The safety of tumescent technique liposuction has been well established [7]. A safe threshold for total lidocaine dose has been estimated to be up to 55 mg/kg when a dilute solution is infused [1]. Lidocaine toxicity is directly correlated with plasma lidocaine levels with non-specific subjective symptoms occurring between 3.0 and 6.0 µg/ml. Objective signs may occur between 5.0 and 9.0 µg/ml (Fig. 12.4).

The rates of lidocaine delivery have increased in recent years with rapid-infusion pumps and double-infusion pumps. However, there has been little information in the literature on lidocaine absorption with rapid delivery either during infiltration or in the early hours of the procedure. Some studies examined levels after infiltration is complete [8] or measured the first level 3–4 h after infiltration [1, 9]. Rapid delivery of tumescent solution generally requires more sedation to relieve discomfort [5]; therefore patients may be less able to report early subjective signs of toxicity.

Five studies have specifically looked at lidocaine levels in the early hours of the procedure. Piveral [4] reported potentially toxic levels of lidocaine when he infused a solution of 1.0% lidocaine and 1:100,000 epinephrine, checking the level every 15 min during infusion and thereafter for a total of 4 h. Two patients had potentially toxic concentrations of 4.2 and 6.3 µg/ml at 15 min. Subsequent samples had levels of 1.2 µg/ml or below, indicating that rapid absorption had occurred during infusion, which would have gone undetected if not for the 15-min sample. This elevation in lidocaine levels may have occurred because the concentrations of lidocaine used by Piveral were higher than the standard concentration used in tumescent liposuction today. Rates of infusion were not noted.

In another study during infiltration, Lewis [10] followed levels every 5 min during the first 3 h of the procedure in six patients. Lidocaine levels peaked in the early phase of the procedure at 15 and 30 min, again when utilizing a higher than standard dilution of lidocaine of 0.25%. The patients had non-toxic levels of 0.8 µg/ml but were given relatively small total doses of lidocaine up to 13.8 mg/kg.

In Klein's [2] study documenting the safety of a total lidocaine dose of 35 mg/kg, lidocaine levels were checked during slow infiltration in one patient infused with 900 mg lidocaine (0.1% solution over 45 min). The levels were less than 0.1 µg/ml at 5 and

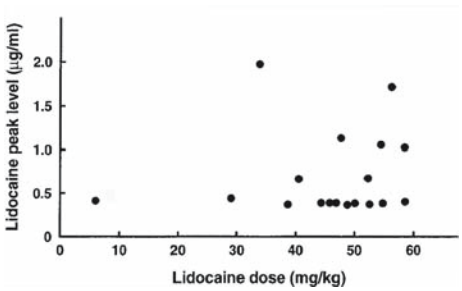

Fig. 12.1. Lidocaine concentration and dose. (From Butterwick et al. [12])

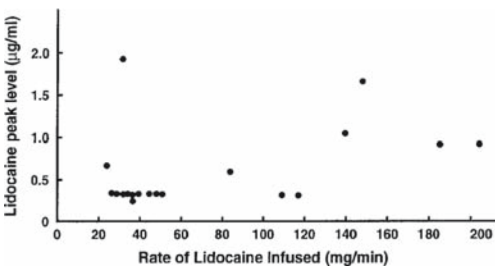

Fig. 12.2. Lidocaine levels and rate of infusion. (From Butterwick et al. [12])

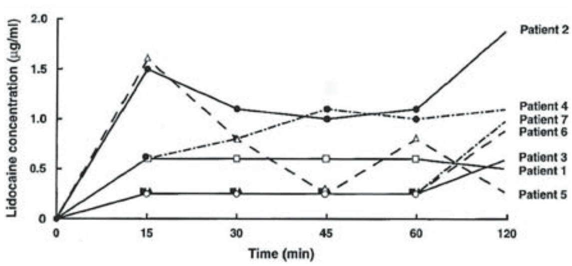

Fig. 12.3. Lidocaine levels over 2 h. (From Butterwick et al. [12])

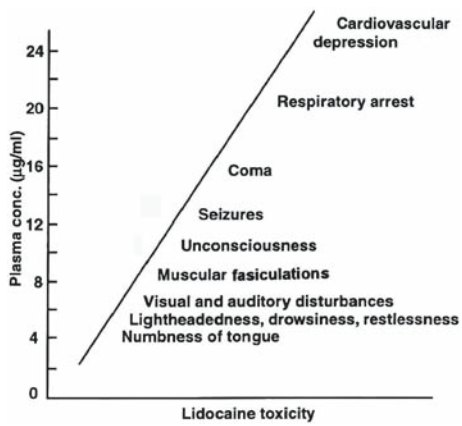

Fig. 12.4. Liocaine levels and toxicity. (From Butterwick et al. [12])

Table 12.2. Lidocaine levels over 2 h (From Butterwick et al. [12])

Patient	Total lidocaine (mg/kg)	Rate (mg/min)	Plasma lidocaine levels (µg/ml) at 15	30	45	60	120	Preoperative medication
1	55.0	27.1	0.6	0.6	0.6	0.6	0.5	Lor, M/P
2	36.7	33.0	1.5	1.1	1.0	1.1	1.9	Lor, M/P
3	42.4	83.0	<0.5	<0.5	<0.5	<0.5	0.6	Flu, Clon
4	50.4	136.0	0.6	0.8	1.1	1.0	1.1	Mid
5	57.7	143.3	1.6	0.8	<0.5	0.8	<0.5	Flu, Clon
6	58.2	185.0	<0.5	<0.5	<0.5	<0.5	0.9	Clon, Mid
7	57.3	200.0	<0.5	<0.5	<0.5	<0.5	1.0	Mid

Clon clonidine, *Flu* flurazepam, *Lor* lorazepam, *Mid* midazolam, *M/P* meperidine/phenergan

15 min. Subsequent levels every 30 min over 7 h were less than 0.5 μg/ml

Lillis [8] also followed lidocaine levels in the first few hours of the procedure utilizing 0.1% lidocaine. Levels were not checked during infiltration but rather were checked 15, 30, and 60 min after a relatively rapid infiltration. In 20 patients, lidocaine levels were less than 1.7 μg/ml even when they were infused with up to a maximal concentration of 88 mg/kg of 0.1% lidocaine.

The study of Samdal et al. [11] resembles our study in that plasma lidocaine samples were taken during infiltration at 5, 15, and 30 min and again at 1 h. He studied four patients during this time frame who were infiltrated with 0.1% lidocaine, with a relatively low total dose ranging from 10.5 to 34.4 mg/kg and with injection speeds of 60–78 ml/min. The levels obtained in the first hour were between 0.04 and 0.6 μg/ml. In an additional 12 patients, he followed levels at 1, 2, 3, 6, 8, 10, 12, 14, 18, and 24 h after infiltration. Peak levels occurred between 6 and 12 h and varied between 0.9 and 3.6 μg/ml. A linear correlation was found between the total dose of lidocaine (milligrams per kilogram) and the peak concentration in plasma.

Other studies have also examined lidocaine levels during tumescent liposuction but not during infiltration. Most of these have examined levels over a 24-h period and not specifically during the first few hours. Ostad et al. [1] reported non-toxic lidocaine levels when up to 55 mg/kg was infused in a study following levels at 4, 8, 12, and 24 h. The infusion pumps were set at a rate of 150 ml/min, but the actual infiltration times were 90–120 min, corresponding to infiltration rates of approximately 25–35 mg/min. Therefore, the infiltration rates (milligrams per milliliter) were much slower than the pump flow setting of 150 ml/min. The levels peaked in 4–8 h, which was a somewhat rapider peak than seen in other studies [2, 8].

In the study of Ostad et al., the linear relationship between total lidocaine dose and peak plasma lidocaine concentration was not seen. The reason for the non-linear relationship between these two variables was attributed to the "unequal volume of distribution of lidocaine in the subcutaneous tissue of each patient resulting in potential differences in absorption among each individual." Ostad et al. did use varying concentrations of lidocaine, which may explain in part the non-linear relationships as seen in both of our studies.

Burk et al. [9] studied both lidocaine and epinephrine levels in tumescent technique liposuction at 3, 12, and 24 h after infiltration was complete in ten patients undergoing liposuction under general anesthesia. A dilute solution of lidocaine was infused (0.025% lidocaine) with a mean lidocaine dose of 21.6 mg/kg. In nine of ten patients the peak was predictably at 12 h with levels less than 2.0 μg/ml. The levels during infiltration and in the first 3 h were not examined. The study of Burk et al. was one of few to study epinephrine levels. The levels were highest at the 3-h measurement and were approximately 4 times the physiologic level.

The authors have demonstrated that lidocaine at a concentration of 0.05–0.1% may be infused slowly or rapidly without threat of a bolus of lidocaine resulting in toxic plasma lidocaine levels during infiltration. Therefore, it appears that epinephrine-induced vasoconstriction is rapid enough to prevent rapid absorption of lidocaine during infusion, with an epinephrine concentration of 0.65 or 0.75 mg/l. The rate of infusion is not defined by the infusion-pump settings, which vary with tissue resistance and instrumentation, but rather by the total number of milligrams infused over the time in minutes of infusion. By this definition, it is safe to infiltrate up to 200 mg/min with 25- and 20-gauge spinal needles and a 14-gauge infusion cannula. Lidocaine levels at all time intervals remained within a narrow range for each patient (below 0.8 μ/ml) and at 2 h, the levels were similar to the 2–3-h values found in other studies following lidocaine levels over a 24-h period. There was no correlation between plasma levels of lidocaine and the maximum dose of lidocaine or the rate of lidocaine delivery. There was no correlation between lidocaine level and the type of preoperative medication. Despite variability, patients showed no evidence of a toxic bolus of lidocaine during infiltration.

12.5 Conclusions

Tumescent anesthesia using 0.05–0.1% lidocaine mixed with 0.75 mg/l epinephrine can be safely given in rapid fashion without concern for developing lidocaine toxicity.

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13 Tumescent Local Anesthesia with Articaine

Afschin Fatemi

13.1 Introduction

The introduction of tumescent local anesthesia (TLA) has been a tremendous advance in outpatient surgery, particularly for minimally invasive surgery applications in dermatologic surgery, phlebology, aesthetic and plastic surgery. Liposuction is the primary indication in which TLA is used in large amounts, as described by Klein [1]. Anesthetic components of TLA include mostly lidocaine (Klein's solution) or prilocaine (Sattler's solution [2]). The development of Sattler's solution has been a notable landmark for decreasing the risks of of lidocaine and its main metabolite xylidine.

Toxic reactions due to the high cardiotoxicity of lidocaine and its metabolites have been described with implications of death after liposuction [3]. The less toxic prilocaine causes clinically significant methemoglobinemia in doses higher than 7 mg/kg. Methemoglobinemia, possibly up to 25%, is caused by the metabolite *ortho*-toluidine. *ortho*-Toluidine, like xylidine, is proven to be a genotoxin and is in addition strongly suspected to be a human carcinogen [4]. Potency, pK_a, and elimination half-time of lidocaine and prilocaine are similar. The slow resorption into the blood circulation and the long time that the local anesthetics remain in the fatty tissue cause a regional anesthetic effect of up to 18 h [5]. The amide-type local anesthetics like lidocaine or prilocaine and also the main metabolites are primarily metabolized in the microsomes of the liver via cytochrome P450. Saturation kinetics of this enzyme and the high concentrations of the reactants cause accumulation of prilocaine or lidocaine and especially their metabolites, raising the probability of toxic events. Elimination of the local anesthetics and metabolites is prolonged and peak plasma levels occur between 6 and 10 h after infiltration because of the slow systemic resorption and the accumulation of the substances in the serum [6]. Peak plasma levels of methemoglobin occur between 14 and 18 h after infiltration of prilocaine TLA. The prolonged high plasma levels of these local anesthetic drugs and their metabolites become even more dangerous through drug interaction. The drugs mentioned may inhibit cytochrome P450 or compete with plasma protein-binding and therefore further slow down elimination of local anesthetics and raise their toxicity [7].

Some physicians have tried to reduce lidocaine-related toxicity or prilocaine-related methemoglobinemia in TLA by mixing them or one of them with ropivacaine or bupivacaine. The use of ropivacaine or bupivacaine in higher doses, as needed for liposuction however, is contraindicated because of their very high toxicity [8]. Also the toxicity of two mixed amide-type local anesthetics is not independent or reduced but additive [9] and therefore such a mixture is not recommended.

13.2 Articaine

The author has used articaine as the local anesthetic of choice for TLA. In contrast to the agents mentioned, articaine is an acid–amide-type local anesthetic. There is a thiophene ring in the structure instead of a phenylene ring like in other local anesthetics (Fig. 13.1).

Articaine was described for the first time in 1976 and is preferentially used in dental surgery. Articaine exerts high anesthetic potency (Table 13.1) and low toxicity (Table 13.2) [10]. It is more potent than lidocaine and prilocaine and it is less toxic than ropivacaine, bupivacaine, mepivacaine, lidocaine and prilocaine [11]. Since unspecific esterases in the tissue

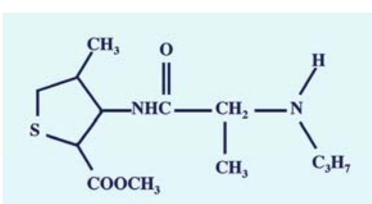

Fig. 13.1. Articaine chemical structure

and blood inactivate 90% of articaine very quickly by hydrolization into articainic acid, the plasma half-time is only 20 min. The inactive main metabolite, articainic acid, is a pharmacologic and biologic inert substance; therefore, it is non-toxic.

The bioavailibility of articaine and articainic acid in the serum is very low [12]. Toxic events after usage of articaine even in higher doses are less probable than with other local anesthetics.

Articaine and its metabolite articainic acid show linear rise and fall of serum levels, even after repeated injections (Fig. 13.2). Other than with the other local anesthetics, no change of the dose of articaine is necessary in elderly patients [13].

Table 13.1. Anesthetic potency and duration of local anesthetics

Local anesthetic	Relative potency	Duration
Procaine	1	<1
Lidocaine	4	<2
Mepivacaine	4	<3
Prilocaine	4	<3
Articaine	5	<2
Bupivacaine	16	<5
Ropivacaine	16	<6

Table 13.2. Toxicity of local anesthetics

Local anesthetic	Relative toxicity	LD_{50} mouse (mg/kg)
Procaine	1	56
Lidocaine	2	28
Mepivacaine	2.2	42
Prilocaine	1.8	50
Articaine	1.5	41
Bupivacaine	8	8
Ropivacaine	7	11

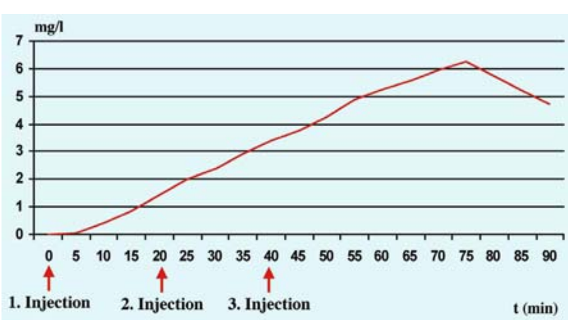

Fig. 13.2. Articainic acid in serum after repeated injections

13.3 Articaine Study

Articaine seems to be the perfect local anesthetic agent for TLA and a study was performed to test its practical application in TLA [14]. The objective of the study was to assess the safety and efficacy of articaine in TLA even with use of high quantities. Twenty-five patients with a signed informed content underwent tumescent liposuction using a solution of 0.038% articaine TLA (Table 13.3).

Approximately 4,000 6,000 ml of TLA was infiltrated. Methemoglobin levels were measured in all patients before, during and after liposuction every hour for up to 24 h and standard blood tests were performed. The amount of infiltrated solution, as well as the aspirate, and the duration of treatment were recorded. Patients were monitored to evaluate adverse side effects such as cardiac symptoms. In selected patients a 48-h ECG was applied. Using a standardized needle test on two parallel surgery sites, patients were asked to qualify the sensation on a pain scale from 0 to 10.

In all patients normal methemoglobin levels could be measured before treatment. These values were not significantly influenced by TLA with articaine (Fig. 13.3). None of the patients had a methemoglobin level above 0.7%, remaining in the physiologic range.

No neurotoxic or cardiac side effects due to articaine were observed during or after the treatment. No irregularities were noticed during monitoring, in 48-h ECG or in blood screenings. The evaluation of the

Table 13.3. Articaine tumescent local anesthesia

Articainic hydrochloride	400 mg
Epinephrine	1mg
Triamcinolone	1 mg
$NaHCO_3$	15 mEq
Physiologic saline	1,000 ml

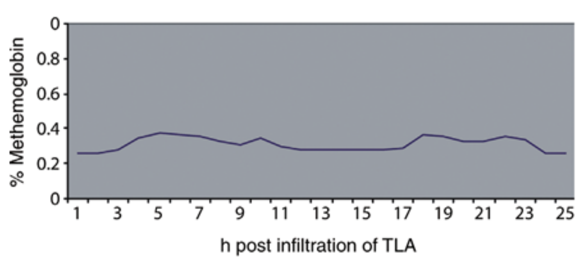

Fig. 13.3. Methemoglobin levels following articaine tumescent local anesthesia (*TLA*) (levels with prilocaine measure up to 20.0%)

anesthetic potency of articaine TLA revealed equipotency in comparison with equimolar lidocaine or prilocaine TLAs during and after liposuction. The short half-time, which is a great advantage in elimination of articaine in the serum, does not bring about better anesthetic efficiency in the area of liposuction.

The maximum recommended dose is 35 mg/kg (body weight).

13.4 Discussion

These observations clearly demonstrate that TLA using articaine adds an extra margin of safety compared with using lidocaine or prilocaine with equivalent efficacy. It should be regarded as the ideal local anesthetic in TLA and we need to seriously consider it the drug of choice for TLA in the future.

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Part III
Cannulas

Cannula Designs

Paul S. Collins

14.1 Introduction

During the last 2 decades, liposuction surgery has undergone a significant transformation. In the early 1980s, general anesthesia with large-diameter cannulas was the norm for most liposuction procedures. Conversely, only small limited areas, such as the neck, could be adequately anesthetized via local anesthesia. Unfortunately, complete anesthesia of other surgical sites were not always obtained with local anesthesia, resulting in less than optimal fat removal. Thus liposuction surgery for most procedures required general or deep sedation intravenous anesthesia. Liposuction is a safe procedure if the anesthesia is carefully given and the tumescent technique is used [1].

14.2 Anesthesia

Initially there was no consensus as to the use of local anesthetic. There were advocates for the additional use of local anesthesia (wet anesthesia), while others stated that local anesthesia was unnecessary if general anesthesia was utilized (the dry technique). It soon became apparent that the use of local anesthesia with epinephrine reduced the extent of bruising and enhanced recovery and healing time.

The reliance on general or intravenous sedative anesthesia was complicated by a state's legal environment. The legal liability for anesthesia was transferred from the anesthesiologist to the surgeon if a nurse anesthetist was employed for the surgery. This was especially a thorny issue with dermatologists who now had to invest in an anesthesia machine and find an anesthesiologist who was willing to administer anesthesia in an office setting.

Klein [2] in 1987 solved this perplexing problem with the introduction of tumescent anesthesia. Now adequate anesthesia for liposuction could be obtained without the use of general anesthesia. Patrick Lillis followed with his concept of large-volume liposuction utilizing tumescent anesthesia. He proved that the use of a concentrated lidocaine tumescent solution injected into subcutaneous adipose tissue did not result in dangerous blood levels of lidocaine.

A significant secondary benefit of tumescent anesthesia is the duration of anesthesia the patient experiences after the surgery. Whereas with general anesthesia, upon awakening, the patient typically complains of discomfort and pain, the opposite is true for tumescent anesthesia. The surgical site remained anesthetized for 24–36 h. Recovery now is relatively painless. When sensation returns, soreness, rather than pain, is experienced.

14.3 Cannulas

Paralleling these transformations in anesthesia was the diminution in the diameter of the liposuction cannula. Surgeons first utilized the large-diameter cannula because of its ability to remove large quantities of fat rapidly. The utilization of the larger cannulas, however, produced several significant problems. The rapid removal of fat can be difficult to control. Waves, ridges and irregularities apparent on the skin surface were due to the unequal removal of the underlying subcutaneous fat. Adding to this problem, if the surgeon kept the cannula stationary, excessive fat removal and an unsightly depression could easily occur. These cosmetic defects marred adequate fat removal and patient satisfaction. The defects could be difficult to correct, and some remained.

Switching to a smaller-diameter cannula reduced the incidence of these cosmetic defects. Using larger-diameter cannulas was more traumatic and painful and contributed to widespread bruising. A small-diameter cannula with decreased cross-resistance minimizes the pain of thrusting the cannula through the subcutaneous tissue. There was minimal trauma to the fat septae and the accompanying neurovascular bundle. Patient complaints of pain and discomfort lasting for weeks after surgery became an uncommon occurrence.

Tumescent anesthesia does not always produce as complete an anesthesia compared with general anesthesia or deep sedation intravenous anesthesia. Using a smaller-diameter cannula with tumescent anesthesia rectified this dilemma. When pain is perceived during tumescent liposuction, switching to a smaller-diameter cannula or one with a less aggressive tip alleviates the discomfort and the procedure can continue. Thus, both the use of a smaller-cannula diameter and the presence of tumescent anesthesia eliminated most cases of postsurgical pain. The reduction in cannula diameter paralleled the development of tumescent anesthesia. Even if tumescent anesthesia had never been developed, cannula diameter was decreasing because it rendered superior results with fewer problems and complications. However, it is unlikely the cannula diameter would be as small as it is now without the existence of tumescent anesthesia.

Finally the length of the cannula has decreased. One reason was the decreasing diameter of a cannula. As the diameter decreased, the cannula length also had to be reduced to prevent bending of the shaft. The size decrease required a smaller entrance port in the skin. This wound then heals with a visually insignificant scar. Thus, it was no longer so necessary to place the cannula entrance port remote to the site of suctioning or to close the incisions with sutures. Multiple entrance ports allowed the modern shorter cannulas to harvest the fat. With these advancements, the long, large-diameter cannula has essentially disappeared from use.

The contemporary liposuction cannula has multiple designs. It can differ in the design of its handle, shaft, aperture(s), tips or composition. Some designs have a major significance in the harvesting of fat, while other designs are only of theoretical advantage to the surgeon. Adding to this confusion is the availability of an overwhelming number of cannula choices produced by liposuction equipment companies. The surgeon must first determine the type of liposuction practice he or she plans to pursue. A liposuction practice limited to the removal of fat from small select areas such as the neck or face will require a totally different cannula assortment than that of a body-contouring practice. The volume of fat to be removed as well as the operative setting (hospital, surgicenter or office operating room) will also determine cannula preference. Time restraints at a hospital or surgicenter may force the surgeon to utilize a more aggressive cannula. Ultimately, each surgeon will have his or her own personal choice of cannula, dependent on his or her surgical techniques, nuances and prejudices.

Cannula size selection will be based on the following factors: the ease of fat removal, the ability to dissect through the subcutaneous tissue and fat with minimal trauma to the vascular septae, and the maximal cannula size that will easily extract fat with a minimal risk of ridging. A cannula with the aperture(s) located on a rounded shaft will harvest large fat globules proficiently. If the aperture is located on a flattened shaft, large fat globules cannot be suctioned into the cannula. The flat cannula design is desirable at such body areas as the face where the surgeon desires to remove only a minimal volume of fat.

The number and type of apertures present on the cannula tip significantly affect the ease of fat removal. Aperture design can also be a factor in septae injury, paresthesia, bruising, surface irregularities and slow healing. Multiple apertures or a basket-tip cannula

Table 14.1. Types of cannulas

Cannula handles
Round
Round with a thumb indent
Octagonal
Grip
Universal (one handle accepts different shafts)
Cannula shafts
Straight
Angled
Short, medium and long lengths
Diameter
Cannula tips
Round (aperture located caudal to the tip)
Tapered (aperture located caudal to the tapered tip)
Flat (aperture located within the flattened tip)
Spatula (widened flat tip with the aperture located within the tip)
Round open (open aperture at the end of the cannula, i.e., no tip present)
Open end (two oblong-shaped apertures occupying one half of the cannula tube and located immediately posterior to the tip)
Basket (four apertures located directly at the tip, each separated by 90°)
Keel or arched (a central arch over two apertures directly opposite each other at tip end)
Dissecting (flat or notched tip without an aperture in the tip or on the shaft)
Cannula apertures
Single (the aperture is either part of the tip or located posterior to the tip)
Multiple in-line (two or three apertures in a straight line)
Offset (two or three apertures offset along one side of the cannula)
Direct access (the aperture is located at the tip and fat can enter the cannula directly as it is pushed through the fat)
Specialized liposuction apparatus
Custom-made tips
Custom-made cannulas
Disposable cannulas
Detachable cannulas (interchangeable with a universal handle)
Syringe cannulas

will shred the adipose tissue and its septae, a desirable feature when treating lipomas or body areas where fat is located in compact septae. Treatment of superficial adipose layers mandates a cannula and aperture design that will minimize trauma to the compact septa. A round- or tapered-tipped, single-aperture cannula will inflict less damage to the septae than the cutting edges of a multiple aperture or a basket- or open-tip design. Some body areas require an aggressive design. It can be difficult to harvest fat from the flanks unless the fat is literally curetted, as by a multiple-holed or open-aperture cannula.

The cannula tip is essentially either aggressive or conservative. Conservative tips have openings that are situated away from the tip, while aggressive tips have openings that involve the tip of the cannula. By increasing the number of openings, a more aggressive cannula is created. Utilizing aggressive tip cannulas will increase the rate of fat removal and compensate for the decrease in lumen size. Openings at the tip have direct access to harvesting the fat as it is pushed through the adipose layer. They also have the ability to tear through tissue. This increases septal injury with more pain and bleeding. Switching from an aggressive to a conservative tip will reduce pain and trauma to the subcutaneous tissue and increase patient comfort during surgery.

The number and types of cannula selections is immense and confusing and in some cases unnecessary (Table 14.1) [3]. The method of cannula manufacture may affect the ability to thoroughly clean the shaft and handle [4]. A discussion of the various designs will hopefully unravel some of the mystery in cannula selection.

14.3.1 Cannula Handles

Cannula handles (Fig. 14.1), unlike the shaft, which requires the strength of stainless steel or titanium, can be made of a variety of materials and alloys, including plastic, stainless steel, titanium and aluminum. The lighter alloys are utilized to minimize the overall weight of the cannula and thus theoretically decrease arm fatigue. However, the most important factor in arm fatigue is the cross-resistance created by the cannula tip as it is pushed through the adipose layer. A round tip or a tip with a direct-access aperture will produce more resistance than a tapered or flattened tip.

There are now several types of universal handles. These handles allow the surgeon to interchange different cannula shafts during the surgical procedure without removing the handle from the aspiration tubing. An experienced liposuction surgeon can relate to the difficulty in removing the tubing from the handle once an adequate seal has been obtained. After the handle-tubing seal has been broken, it may be difficult to reestablish an adequate seal owing to the bloody and oily fluids at the end of the tubing. Likewise, inserting the handle into the tubing can be an exasperating experience culminating in torn gloves. With the universal handle, the shafts are exchanged while the handle remains connected to the tubing.

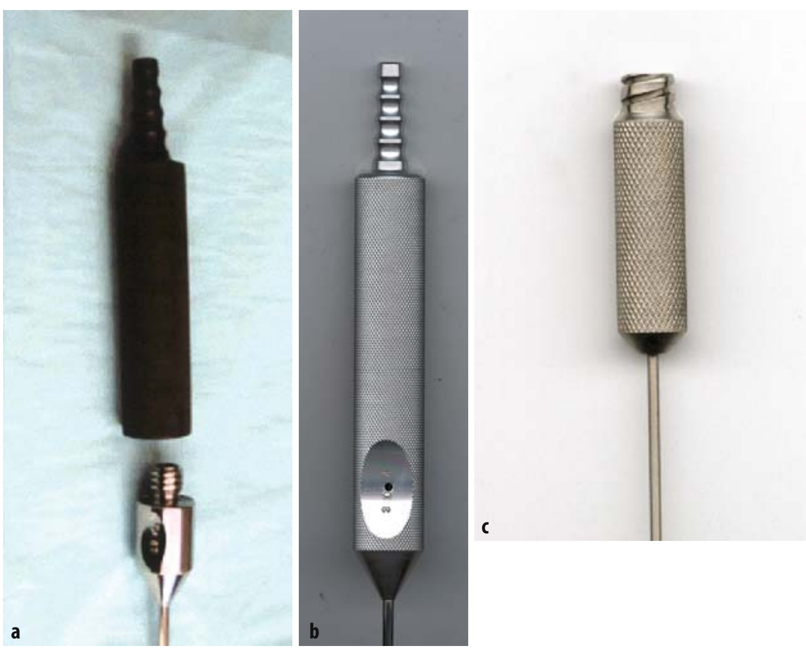

Fig. 14.1. Cannula handles: **a** older detachable handle; **b** handle attached to shaft; **c** syringe attachment

The universal handle should also decrease operative time and minimize breaks in sterility due to glove tears, splattered fluids and dropped tubing or cannulas experienced during cannula exchange.

14.3.2 Cannula Shafts

Reusable cannula shafts, owing to the mechanical stress applied along their length and tip apparatus, are presently only made of stainless steel. Small-length shafts are utilized when suctioning the face, neck, knees or localized lipomas. Medium- or long-shaft cannulas are appropriate to use on large or long body areas such as the stomach or thighs. Many surgeons now prefer a smaller shaft diameter (6 mm or less) that minimizes the risk of postoperative rippling and dimpling. The smaller the diameter, the less septal trauma and hemorrhage executed by the cannula tip despite the design. It is also common practice to produce multiple entrance wounds. This allows the use of smaller-aperture cannulas of shorter length. It eliminates the possibility of snapping or bending the shaft of a longer cannula.

Interchangeable cannula shafts with a universal handle allow the replacement of cannula shafts without removal of the handle from the liposuction tubing. The surgeon can now freely interchange cannula shafts of different apertures, diameters and lengths during a procedure without struggling to remove the handle from the liposuction tubing. Since most liposuction procedures require several different types of cannulas, the interchangeable shaft and universal handle can be advantageous. The surgeon is more apt to utilize the optimal diameter and tipped shaft if he or she does not have to struggle with cannula exchange.

Cleaning and sterilization of a liposuction cannula without a handle is simpler. Thin stilettes with bristles effectively remove any residual debris prior to sterilization. Thus, a universal handle with interchangeable shafts is easier to adequately clean than a cannula with a fixed handle.

14.3.3 Cannula Tips

Essentially there are three main designs for cannula tips: the round, tapered and aperture tips (Fig. 14.2) . The round tip has more cross-resistance than a pointed tip and thus is more difficult to push through compact tissue. When a round tip is pushed through tissue and meets resistance, the tip will be redirected to an area of less resistance. It is unlikely not to disrupt the resistant fibrous, vascular septa. Minimal trauma to the septae equates to minimal bleeding and bruising and a rapid postoperative recovery. In contrast, adipose tissue in a loose, widely spaced septal network offers little resistance to the probing cannula no matter what the tip design or shaft diameter. There is minimal hemorrhage as the septae are widely spaced and pliable and can be pushed out of the way of the cannula tip.

A tapered tip is more likely to traumatize the septae only because it has the ability to slice through the adipose tissue. The tip will strike the septae with force, tearing the enclosed vessels. However, the smaller the shaft diameter, the smaller the size of the tip cross dimension that can strike the septa. A tapered tip will penetrate adipose tissue that is within a compact septae network more readily than a round tip. Operating with a small-diameter tapered tip will impart less septal and vessel damage while slicing through the adipose layer.

The aperture tip is a cannula with the opening designed at the tip or end of the cannula. The opening has direct access to harvesting the tissue as it is pushed through the adipose layer. Fat is harvested efficiently as the cannula is pushed through the adipose tissue. The aperture is also within the area of cross-resistance when the cannula is forced through the adipose layer. When the tip meets resistance at the septae, it is apt to tear and thus rupture the enclosed blood vessels. In a loose adipose septal network, trauma may be minimal but always greater than that seen with a round or tapered tip. In a compact adipose layer severe septal trauma may occur with profuse hemorrhage. It is not unusual to see strands of traumatized fibrous septae at the aperture when the cannula is withdrawn from the surgical site. This tip design, while very efficient at harvesting fat, must be utilized cautiously and preferably in loose adipose tissue.

14.3.4 Cannula Apertures

The openings or apertures (Fig. 14.3) may be engineered within the structure of the cannula tip or located on the side of the shaft cylinder. Some apertures at the tip have direct access to tissue, i.e., they are structurally part of the cannula tip. The advantages and disadvantages of this direct-access aperture were noted earlier in this chapter. It is the most efficient harvester of fat.

Multiple apertures can also be efficient harvesters of fat. They will produce less septal damage than the direct-access aperture. Adipose tissue is compacted and fixated when grabbed and held by the surgeon's hand. The ability to harvest fat is increased as the cannula is pushed through the artificially compacted tissue. The ability to shear and tear is also increased. A single aperture on the shaft has a relatively small

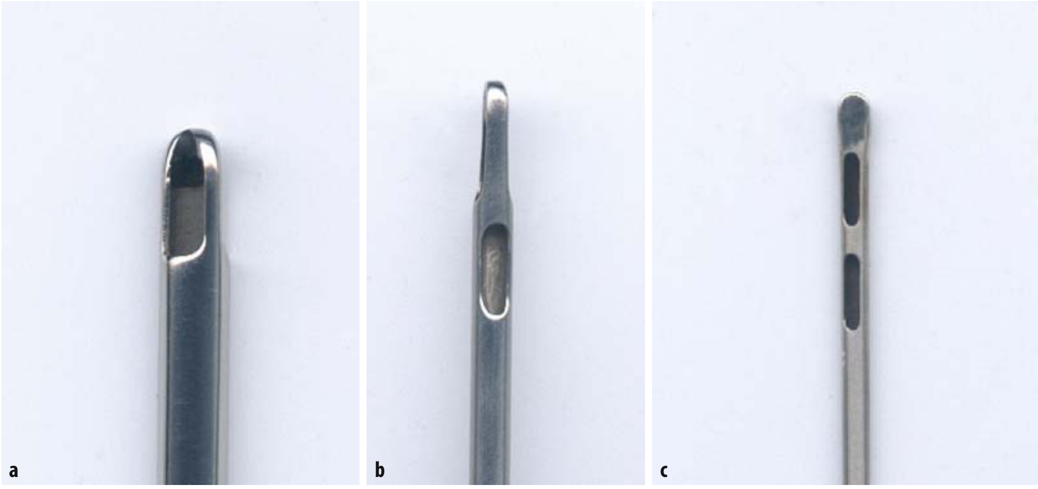

Fig. 14.2. Cannula tips: **a** round or Mercedes tip; **b** cobra tip; **c** spatula tip

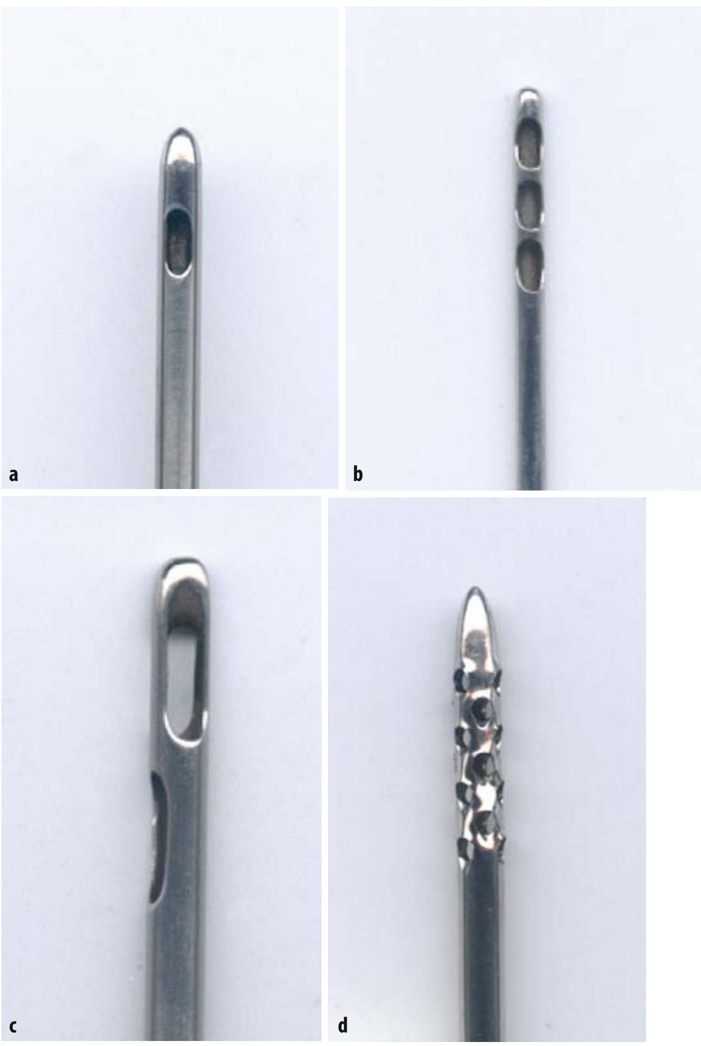

Fig. 14.3. Cannula apertures: **a** single opening; **b** multiple openings in same plane vertically; **c** multiple openings in different planes; **d** multiple openings completely around the cannula

cutting edge as it is pushed through the fat. Multiple in-line apertures can significantly increase the total cutting edge when the cannula is pushed through fat that is fixated. This is advantageous when suctioning lipomas or pseudogynecomastia.

Multiple offset apertures will not have the same ability to shear and cut, as the cutting edges are not in-line and therefore do not have an additive effect. One has the advantage of increased fat harvesting without excess cutting ability. A surgeon may inadvertently harvest excessive fat from a surgical site if he or she is only experienced with single-aperture cannulas.

14.4 Summary

New and recent concepts in liposuction surgery have resulted in a multitude of cannula designs. The contemporary liposuction surgeon may now choose among a variety of handles, shafts, and apertures and tip designs. There is no one proper cannula for a liposuction procedure. In many cases utilization of more than one type of cannula is prudent to obtain optimal surgical results. The inexperienced surgeon will find the classical round- or tapered-tip, single-aperture cannula a safe and conservative choice for many liposuction procedures. With experience a variety of designs can be utilized depending on the site and type of adipose tissue present. A universal handle allows rapid interchange of cannula shafts.

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Inadequate Sterilization of Liposuction Cannulas: Problems and Prevention

Allan E. Wulc, Brenda C. Edmonson

15.1 Introduction

Recent reports have documented the potential for inadequate sterilization to result in the transmission of viral and mycobacterium infections in many different surgeries, including facial plastic surgery, cardiothoracic surgeries, gynecological surgeries, and augmentation mammoplasty [1, 2, 3, 4]. The potential for ineffective or improper chemical sterilization to result in infections as well has been documented with regard to liposuction [1, 5]. Liposuction cannulas, by virtue of their cutting effects on tissue and the fact that the lumen may retain unseen tissue, also pose particular sterilization difficulties [6].

Prevention is obviously the best means of avoiding these complications. This chapter reviews proper techniques for caring for, handling, and sterilizing liposuction cannulas. We also review the literature regarding improper handling and sterilization, particularly with regard to liposuction.

15.2 Cannula Types

Lipoaspiration cannulas can be broadly classified into those that are disposable, and those that are not. Most cannulas are fabricated of stainless steel and are single-molded, but several companies manufacture cannulas that detach from the handpiece for ease of removal from the lipoaspirator. Handpieces are also fabricated of aluminum, Delrin (a plastic polymer), titanium, and brass [6, 7]. These cannulas are screwed to a handpiece with fitted wrenches [8]. These latter cannulas should be sterilized separately so their component parts are sterile.

Disposable cannulas are made of plastic polymers such as poly(vinyl chloride), and are meant for single use. They are shipped sterilely and thrown away after use, and thus do not require sterilization. However, some disposable cannulas have non-disposable handpieces. These handpieces should be cleaned and sterilized according to the manufacturer's guidelines.

Recent advancements in liposuction have brought forth other, more complex cannulas, such as the double-lumen cannula, cannulas for ultrasound-assisted liposuction, and reciprocating cannulas which vibrate [8–10]. As cannula design becomes more complex, the cleaning can become more difficult.

15.3 Decontamination and Sterilization Techniques

Most recommendations for sterilization of non-disposable cannulas include a multiple-step process. It should be emphasized that cannulas should be kept free of visible detritus during the surgery to minimize the potential for drying and adhesion of tissue contents within the lumen of the cannula [11]. At the end of the procedure, cannulas should be decontaminated as soon as possible. Two-piece instruments should be taken apart to facilitate cleaning. The cannula should be soaked in water and an enzymatic solution. The enzymatic solution aids in the breakdown of proteins. There are also enzymatic solutions that are specific for degreasing and thus are most helpful in the cleaning of liposuction cannulas [12]. The cannula should then be washed either by hand with a brush and detergent or with a mechanical washer such as an ultrasonic cleaner. The purpose of this step is to remove any residual organic soil [13]. When washing the cannula by hand, a brush designed specifically for the cannula should be used [12, 14]. Manufacturers of the individual liposuction cannulas usually make recommendations for the most specific cleaning instructions, types of detergents, enzymatic cleaners, brushes, and ultrasonic cleaners for their products.

When using instrumentation for ultrasonic liposuction, the cannula should be placed in a horizontal position in the ultrasonic cleaning machine for at least 10 min [11, 12]. Ultrasonic cleaning assists in the removal of small debris and particles from the cannula [13]. Hand washing followed by ultrasonic cleaning is also recommended by manufacturers as a way to help insure adequate cleaning of these instruments with small lumenae [14].The cannulas are then rinsed, dried, and inspected for any residual debris and damage. Water-soluble lubricants are recommended by some manufacturers to be used during steam sterilization. Different lubricant solutions exist; it is always best to check with the manufacturer of the cannula to determine what kind of lubricant is needed. Lubrication may help prevent rusting and facilitate the penetration of steam during the sterilization process [14].

The different modalities of sterilization usually recommended by cannula and handpiece manufacturers are heat or ethylene oxide (gas) sterilization [14, 15]. Heat sterilization is performed either dry or with steam. Most autoclaves in operating rooms and physicians' offices in the USA are steam sterilizers [12]. Steam sterilization is the oldest and most dependable form of sterilization and should be used to sterilize instruments that are not heat- or moisture-sensitive [11, 13, 15, 16]. Steam sterilization depends upon steam under pressure to sterilize instruments. It inactivates microorganisms by denaturing proteins important to the organisms' survival, such as enzymes and structural proteins [15]. The two commonest types of steam sterilizers are gravity-displacement and prevacuum. Gravity-displacement uses steam to remove the air in the sterilizer. The prevacuum uses a vacuum to pump the air out of the sterilizer [13]. The parameters necessary to sterilize instruments vary with different steam sterilizers. The instructions from the manufacturer of each steam sterilizer should be followed closely to insure adequate sterilization; however, the general minimal requirements for sterilization with steam under pressure are temperatures of 121°C (250°F) for 30 min or 132°C (270°F) for 15 min for gravity-displacement sterilizers and 132°C (270°F) for 4 min or 135°C (275°F) for 3 min for prevacuum sterilizers [11, 12, 15, 16]. Drying time varies between 16 and 45 min. Steam must be able to reach all surfaces being sterilized. This is the main reason why detachable cannulas must be autoclaved with their component parts separate [11, 13, 15, 16]. Sterilization with dry heat is only recommended for materials or instruments that might be damaged by steam or for materials for which moist heat cannot penetrate [15]. The minimal parameters for dry-heat sterilization are 160°C for 2 h. Different dry-heat sterilizers will vary, and thus the guidelines provided by the manufacturer should be followed [16]. All of the instruments sterilized with heat must be cooled prior to handling. Cooling time will vary with different machines and the manufacturers' recommendations should be followed [11, 13, 15, 16].

"Flash" sterilization is sterilization of unwrapped instruments with steam at minimal parameters of 132°C for 3 min at 27 28 lb of pressure in a gravity-displacement sterilizer. Flash sterilization should only be used for emergent situations and not for routine sterilization [15].

Ethylene oxide, a chemical gas sterilizer, is considered effective for sterilization of heat- and moisture-sensitive items [15, 16]. As in the case of steam, the chemical must be able to reach all surfaces that need to be sterilized. The disadvantages of ethylene oxide sterilizers are long cycle times, expense, and potential hazards from the chemical to patients and staff [15].

Disinfection is a term applied to the process that can kill or inactivate many or all microorganisms except for bacterial spores. Chemical sterilants, active through a process known as "cold sterilization," are actually disinfectants that can kill bacterial spores only if the chemical is exposed to the instrument for a prolonged time such as 6–10 h [15]. Examples of chemical sterilants include 2% glutaraldehyde and hydrogen peroxide. Both of these chemicals are most commonly used for high-level disinfection of instruments such as endoscopes and anesthesia and respiratory equipment [15]. Their role as the only sterilization process for liposuction cannulas is not well established, but studies suggest that it is not adequate [2]. This is not the consensus among operating surgeons. In an informal study performed by the authors of recently trained board certified surgeons, 20 of 20 surgeons were unaware of the aforementioned guidelines, all significantly underestimating the time that was required for chemical sterilization of operating room equipment. This underscores the need for further work to determine the minimum time required for chemical sterilization, as well as the need to educate surgeons as to the current recommended and aforementioned guidelines.

15.4 Infections Secondary to Surgery

Postoperative and nosocomial infections are a major expense to the healthcare system and cause serious risks to patients. The reduction of infections is important especially in the setting of surgery [11, 13]. Potential sources of intraoperative, iatrogenic communications of pathogens include poor sterilization technique and inadequate maintenance of intraoperative sterility. Stringent guidelines to accomplish and maintain sterility throughout a procedure are published every year by organizations such as the Association for the Advancement of Medical Instrumentation (AAMI) [11, 13]. These guidelines are extremely important to insure sterility and diminish the risk of introduction of microorganisms during surgery, whether in the office or the hospital setting.

Since the time of Semmelweis, we have been made aware of the importance of sterility in reducing the incidence of surgical infection. Prevention of infectious disease begins with hand washing with antiseptic solutions followed by use of sterile gloves, a sterile field, and strict aseptic technique [11, 13].

Infections reported after surgery include infections from common skin bacteria such as staphylococcal and streptococcal species to infections caused by blood-borne pathogens, especially viruses like human immunodeficiency virus and hepatitis B [2, 3, 17, 18]. Similar infections can occur in liposuction procedures from breakdown in meticulous aseptic technique.

Reports of rapidly growing mycobacterium (RGM) infections and group A streptococcal fasciitis have been reported in patients after liposuction [1, 17, 19]. Cold-sterilization techniques have been implicated in some of these cases [1, 17, 19]. The etiology of disease transmission in these cases remains speculative; however, all of the authors emphasized the importance of clean, sterile cannulas. The best defense against introducing infection starts with decontamination followed by steam sterilization. These techniques remain the gold standard for effective elimination of bacteria, especially mycobacteria, and viruses [1, 19].

Some instruments cause cleaning and sterilization problems because of their inherent design. Any instrument with a lumen causes more difficulty in the decontamination and sterilization process secondary to the difficulty of reaching the inside surface. Liposuction cannulas are no exception. Two-piece cannulas may be more readily accessible because the components can be and should be separated in order to adequately clean them. However, with one-piece-cannula and handpiece instruments, there is the potential for retained human tissue to remain in the handpiece portion after cleaning [6]. As fat is removed by the smaller-diameter cannula and enters the larger-diameter handpiece, it can become impacted in the larger-diameter handpiece. Residual fat can routinely be found in a cleaned, liposuction one-piece cannula, and was documented as a concern as early as 1998 [6]. If tissue is inadvertently left in the handle portion of the cannula, pathogens may survive after sterilization and have the potential to transmit infectious diseases. The authors recommended a continuous-diameter single-lumen cannula and handpiece to help eliminate the problem of retained human tissue [6].

Recommendations for prevention of possible infections, including RGM, with reusable cannulas consist of decontamination and sterilization of the cannulas and include thorough soaking in detergent followed by cleaning the lumen with the appropriate-sized brush, and ultrasonic cleaning [11–14]. Cold sterilization seems to be an ineffective means of sterilizing these instruments. Manufacturers of the instruments stress that the instruments be cleaned prior to steam sterilization and that steam be able to access all surfaces to be sterilized in order to be effective [11, 13, 15, 16]. Sterilization with steam heat is the recommended method of sterilization for stainless-steel and moisture- and heat-tolerant cannulas [11–14]. Steam sterilization should be performed using the individual autoclave manufacturer's guidelines with reference to specific time and temperature [11–14].

The best way to avoid microorganism transmission perioperatively is prevention [1, 15]. Prevention can be best accomplished with sterility of surgical instruments and the maintenance of sterility throughout the procedure [11, 13]. The problem with liposuction cannula sterility is the potential for the cannula to be sterilized ineffectively either from inadequate knowledge of the correct process for cleaning and sterilization or from tissue being inadvertently left in the handle of the cannula as found by Weber et al. [6]. These problems can be best minimized by following vigorous cleaning and sterilization guidelines from the cannula manufacturers and from organizations such as AAMI. Other ways to minimize the problem include different cannula designs such as the continuous-lumen cannula which can help facilitate the removal of residual tissue simply by their design [6, 11–14]. Unfortunately, cleaning and sterilization may become even more difficult as cannula designs become more complex, with double lumens and rotating parts making the potential for increased incidence of infections possible.

15.5 Conclusions

Infections occurring following liposuction are fortunately very rare. Most of these infections arose despite the use of a sterile technique.

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Part IV
Preoperative

Preoperative Consultation

16

Melvin A. Shiffman

16.1 History

The patient must have a sufficient history taken to establish the problem of which the patient complains. Past history, review of systems, and family history should include all information that may impact on the proposed surgical procedure and its outcome such as prior abdominal surgeries. There must be an attempt to rule out cardiac or pulmonary problems, allergies, bleeding problems, diabetes mellitus, and other serious medical disorders. Information should be obtained about any medications being taken such as aspirin, ibuprophen, herbals, antihypertensives, anticoagulants, and estrogens. It is important to elicit prior thrombophlebitis or pulmonary embolus. Family history should include questions about bleeding tendencies or thromboembolism.

16.2 Physical Examination

The physical examination should not be cursory. The systems examined should include the heart and lungs as well as the area(s) of the body involved in the patient's complaint(s). There should be a careful evaluation for possible abdominal wall or umbilical hernias if abdominal liposuction is to be performed. The medical record should contain all of the appropriate information for another physician, who may examine the record, to come to the same conclusions and to make the same decisions. Preoperative and postoperative photographs are essential.

16.3 Medical Record

The content of the medical record should be sufficient to show that an informed consent has been given through explanation of the proposed procedure, possible viable alternatives, and the risks and complications. This does not mean only forms signed by the patient containing the information. The physician should state in the record that the discussion took place on the day of the discussion. The patient must make a knowledgeable decision about the proposed procedure and the physician must take an active part in making sure this is achieved even if some other health care provider has explained the procedure and risks.

The physical examination must be recorded with enough pertinent information that would allow another physician to come to the same conclusions as to the diagnosis and the treatment. This includes pertinent negative findings.

The medical record should contain the patient's request and the physician's recommendations and the reasons for the recommended procedure or treatment. The physician's thinking is an important aspect of the medical record and will substantiate any proposed or advised therapy.

Preoperative and postoperative photographs should be taken.

16.4 Consent

To obtain *consent* for a surgical procedure all that is necessary is for the patient to sign a consent form stating what the procedure is in lay terms. To obtain a legally valid *informed consent* requires much more. The patient should not only know the name of the procedure in lay terms but also what is being done in the procedure in simple language. The *material risks* and complications must be explained to the patient as well as any *viable alternatives* of treatment and their material risks and complications. The patient must make a *knowledgeable decision* concerning the surgery.

16.5 Preoperative Instructions

Preoperative instructions should not only be explained to the patient but should also be given in writing to the patient (Tables 16.1–16.3). Also risks and complications should be oral and in writing (Table 16.4).

16.6 Postoperative Instructions

The patient may be given postoperative instructions before surgery or after surgery (Table 16.5). These instructions should be explained to the patient and given to the patient in writing.

Table 16.1. Liposuction preoperative instructions

Liposuction (suction lipectomy, liposculpture, lipoplasty, lipostructure, lipexeresis) is a method of contouring body shape by removal of excess fat using suction cannulas through small incisions. It is rarely a procedure for weight loss. The area of the body and the amount of tissue to be suctioned determines whether local tumescent anesthesia or general anesthesia will be necessary.

INFORMATION ON LIPOSUCTION

A. Transfusions are almost never required
B. Preoperative chest X-ray, EKG and blood tests may be necessary
C. If varicose veins are present, these may have to be stripped 3 months before liposuction of the legs
D. Stretch marks cannot be removed
E. Absolutely do not gain weight before surgery

1. If you have any doubt about the surgery, do not have it done
2. If you have had problems with drug or alcohol abuse at any time, notify the surgeon prior to scheduling the surgery
3. Absolutely no smoking for at least 2 weeks before and 2 weeks after surgery
4. Report to the physician any history of excessive bleeding or bruising
5. Report all prior mental disorders or psychological problems to your surgeon
6. If you have high blood pressure, report this to your surgeon
7. If anticoagulants (blood thinning) medication is being taken, this must be stopped at least 5 days prior to surgery and blood tests must be taken before surgery
8. No aspirin or any products containing aspirin (salicylic acid) are to be taken for at least 2 weeks prior to surgery and for at least 1 week following surgery. This includes: Aspirin, Empirin, Alka Seltzer, Anacin, Bufferin, Ecotrin, Bayer, Motrin, Darvon Compound, Excedrin, Midol, Advil, Nuprin, Ibuprin, Medipren
9. Do not take any vitamins, especially vitamins C and E for 2 weeks prior to surgery AND for 1 week after surgery
10. Discontinue all hormones (check with your physician first) 3 weeks prior to surgery and for 2 weeks after surgery
11. Try not to schedule surgery on a day close to your menstrual period. It is preferable not to do surgery the first 5 days of menstrual bleeding
12. Take a shower daily with Phisohex or Hibiclens for 3 days prior to surgery and also in the morning on the day of surgery

Table 16.2. Smoking must be stopped

ALL SMOKING MUST BE STOPPED AT LEAST TWO (2) WEEKS PRIOR TO AND TWO (2) WEEKS AFTER SURGERY OR THE SURGERY WILL BE CANCELED

Table 16.3. Estrogens must be discontinued

ALL ESTROGENS (BIRTH CONTROL PILLS AND REPLACEMENT THERAPY) MUST BE DISCONTINUED AT LEAST THREE (3) WEEKS BEFORE SURGERY AND FOR AT LEAST TWO(2) WEEKS AFTER SURGERY

Table 16.4. Risks and complications of liposuction

Unsatisfactory results occur in 20% of patients

1. Asymmetry
2. Waviness, pitting, cobblestoning, rippling, sagging, bulges, depressions
3. Thick scar: hypertrophic, keloid. The scar may not be covered by a bathing suit
4. Insufficient fat removal
5. Excessive fat removal

Postoperative problems

1. Nerve damage, decrease or loss of sensation; parasthesias
2. Seroma (fluid collection in wound, lymphorrhea)
3. Hematoma, bruising
4. Scar: hypertrophic, keloid
5. Pain. May persist for months
6. Itching, burning
7. Infection, sepsis or septicemia (germs in the blood stream), cellulitis, toxic shock syndrome
8. Excess or decrease pigmentation of overlying skin
9. Skin necrosis (necrotizing fasciitis), skin slough
10. Prolonged wound drainage
11. Venous thrombosis, superficial or deep
12. Hypotension (drop in blood pressure)
13. Pulmonary (lung) emboli, fat emboli, pulmonary infarction
14. Bleeding: need for blood transfusions
15. Persistent edema (swelling). May be permanent. Labial and scrotal edema is common but temporary
16. Blisters
17. Lidocaine toxicity, drug reaction
18. Allergic contact dermatitis
19. Nausea and vomiting
20. Need for further surgery to correct postoperative problems
21. Psychological disorders
22. Perforation of the abdominal wall and underlying bowel, bladder, and/or vessels. This may require surgical repair and possibly including a temporary colostomy
23. Dissatisfaction with the results
24. Death

Table 16.5. Postoperative instructions

The patient or caretaker should call the doctor if there is bright red bleeding through the dressings, drainage of pus, increasing pain, or other unusual symptoms (shortness of breath, abdominal pain, chest pain, mental confusion, etc.). Some pink drainage, not bright red drainage, is to be expected and may be quite profuse the first night

Prescriptions for pain medication and an antibiotic will be given to the patient. Make sure there is no allergy to either drug. Usually, the dressings are changed the first postoperative day by the physician. The patient should be instructed in diet and limitations of activities

1. You should rest at home for 2 days. Ambulate to the bathroom only with help. Resume normal activity after 2–3 days
2. Some pink drainage from the wound is expected for 1–3 days. Dressings should be changed as needed. If bleeding appears to be very excessive call the doctor
3. Showers may be started after the 3rd day following surgery
4. The garment may be removed and washed at any time
5. You will be immobilized in a garment for 3 weeks or tape for approximately 3–6 days. In some cases a garment will have to be worn for 4–6 weeks
6. If the legs get swollen, especially after ambulating, spend more time daily and all night with the legs elevated
7. Edema in the areas liposuctioned may last for several months
8. There will be discomfort for a couple of weeks. If any area becomes more painful notify your surgeon right away
9. If fainting or collapse occurs notify your surgeon immediately
10. You will have fatigue for several weeks
11. Emotional depression after surgery is common
12. Lumps in the areas of liposuction may persist for months. Gentle but firm massage may be helpful
13. If necessary, physical therapy with massage and ultrasound may help persistent edema and lumps
14. You will be off work several days to 2 weeks depending upon the extent of liposuction
15. Take all medications as prescribed and instructed
16. Weight gain will replace all the fat that has been removed
17. Satisfaction with the results of liposuction may not occur for 3 months
18. Any further revision, repair, resculpturing can be done only after at least 3 months

17 Drugs to Limit Use of or Avoid when Performing Liposuction

Melvin A. Shiffman

17.1 Introduction

Liposuction is ordinarily a safe procedure when performed properly and with certain cautions. Excessive removal of fat with multiple other cosmetic procedures is prone to increase the incidence of complications. Certain drugs should be avoided prior to and after liposuction because of the problems of bleeding, clotting, or toxicity. Even using lidocaine should be avoided or reduced when using general anesthesia.

17.2 Estrogen and Thromboembolic Problems

17.2.1 Introduction

Oral contraceptives (estrogens) have been associated with a significant risk of thromboembolic disease. In fact, the *Physicians' Desk Reference* (PDR) warns physicians and patients about this risk when taking estrogenic hormones [1].

> Risk of developing blood clots: Blood clots and blockage of blood vessels are the most serious side effects of taking oral contraceptives and can be fatal. In particular, a clot in the legs can cause thrombophlebitis and a clot that travels to the lungs can cause a sudden blockage of the vessel carrying blood to the lungs .... If you take oral contraceptives and need elective surgery, need to stay in bed for a prolonged illness ... you may be at risk of developing blood clots. You should consult your doctor about stopping oral contraceptives three to four weeks before surgery and not taking oral contraceptives for two weeks after surgery or during bed rest.

Despite this warning, many cosmetic surgeons continue to ignore the requirement that oral contraceptives and replacement estrogenic hormones should be stopped before and after elective cosmetic surgery. If thrombophlebitis and/or pulmonary embolus occur after any cosmetic surgery in a patient who has not been forewarned to cease taking the hormones, then the surgeon exposes himself to medical malpractice litigation. If the failure to require the patient to stop taking hormones results in an injury, then if this failure to stop taking the hormones was more-likely-than-not (probable, more than 50%) to have caused the complication or even a substantial factor, the physician may be held liable for negligence. This may be true even if the surgeon warned the patient about the possibility of thrombophlebitis, pulmonary embolus, and death and took precautions to prevent thrombophlebitis [2]. Cosmetic surgeons forget that surgery over 1 h and patients over age 40 are already moderate risks for thromboembolism [2]. Consideration should be given to graduated stockings or better yet intermittent compression garments during surgery in moderate-risk patients.

17.2.2 Discussion

Venous thromboembolism afflicts 500,000–600,000 persons annually in the general population [3, 4]. The risk increases with a history of prior venous thromboembolism [5], recent surgical procedures [6 ,7], immobilization, fracture of lower extremity, and cancer [6, 8, 9], and with inherited coagulation disorders [10, 11]. Oral contraceptives pills are well known to be associated with an increased risk for venous thromboembolism [3, 4] owing to the estrogen and this risk is, also, dose-related [6, 7]. In the past, there have been reports that low-dose estrogens do not cause thromboembolism [12], but more recently, there has been evidence that low-dose estrogen therapy (postmenopausal replacement therapy) is associated with increased risk for venous thromboembolism [7–10]. Postmenopausal hormone therapy has been found to cause a twofold to fourfold increase in risk for idiopathic deep venous thrombosis and pulmonary embolism [11, 13–16]. The Heart and Estrogen/Progestin Replacement Study (HERS), a randomized, prospective, blinded study, found that postmenopausal therapy with estrogen and progestin increased the risk for venous thromboembolism in women with coronary artery disease with no prior venous thromboembolism [17–19].

What effort does it take to require that a patient cease taking estrogenic hormones at least 3 weeks before surgery and 2 weeks after surgery? If the patient refuses to stop taking the hormones or cannot stop taking the hormones because of the severity of postmenopausal symptoms, then it is up to the surgeon to decide whether or not to take the risk of possible litigation by performing the elective surgery. If the decision is to perform the surgery despite the refusal to stop taking hormones, there may be a serious question brought up at litigation as to why the surgery was performed at all since the patient did not have a medical need for the surgery. Of course, the mercenary aspects of performing the surgery may be insinuated. All of the information discussed with the patient concerning stopping taking hormones and the refusal to stop taking hormones should be well documented in the medical record. It is without doubt that the written record is the best defense.

There may be a role for 3-hydroxy-3-methylglutaryl coenzyme A reductase inhibitors (statin therapy) in the prevention of thromboembolism. Statins have a beneficial effect by modifying endothelial function, inflammatory responses, plaque stability, and thrombus formation [20]. There is a suggestion that statins foster stability through reduction in macrophages and cholesterol ester content and increase the volume of collagen and smooth muscle cells. The thrombotic sequelae caused by plaque disruption are mitigated by statins through inhibition of platelet aggregation and maintenance of a favorable balance between prothrombotic and fibrinolytic mechanisms.

17.3 Cytochrome P450 (CYP3A4) Inhibitors

Cytochrome P450 inhibitors compete with enzymes that breakdown lidocaine. The use of these inhibitors may result in lidocaine toxicity at a lower total dose than ordinarily used in tumescent anesthesia for liposuction. These drugs (Table 17.1) should be avoided for a period time (3–10 days) before liposuction surgery. Some of the drugs have such a short half-life that there is no need to avoid them (i.e., Versed and Diprivan).

17.4 Dangers of Herbals in Surgery

Herbals as medications have been in use for thousands of years. It has only recently come to the attention of the medical community that herbals may be dangerous if taken just prior to surgery. The US government allows herbals to be sold as food supplements, not as drugs, and there is no federal regulation for herbal dosages or drug interactions.

"Scientists need to challenge the popular belief that anything natural is safe" [21]. Allergies are known to occur and herb–drug interactions have been reported [22, 23]. Herbal medications can also affect the heart [24]. There is now a *Physicians' Desk Reference for Herbal Medications* [25] with a description of each of the herbals, actions and pharmacology, indications and use, contraindications, precautions and adverse reactions, dosage, and literature. Mixing herbal medications and surgery can prove fatal from bleeding, arrhythmias, stroke, thromboembolism, and interactions with anesthetic agents [26].

St. John's wort (*Hypericum perforatum*, Hypercalm, Centrum Herbals) has been reported to intensify or prolong effects of general anesthetics and, therefore, should be avoided for 2–3 weeks before surgery. This will decrease the risk of adverse reaction.

St. John's wort may inhibit monoamine oxidase (MAO). The use of agents which are MAO inhibitors (MAOIs), such as tranylcypromine and phenelzine, or have MAOI-like activity, such as dextroamphetamine, furazolidone, procarbazine, or selegiline, concurrently with St. John's wort can result in severe hyperpyrexia or hypertensive crisis, convulsions, or death. One agent should be discontinued at least 2 weeks before initiation of therapy with the other.

Table 17.1. Cytochrome P450 (CYP3A4) inhibitors and their plasma half-lives. Avoid use for 3–10 days preoperatively (depending on the drug half-life) and for 24 h postoperatively

Drug	Plasma half-life
Carbamazepine (Tegretol, Atretol)	25–65 h
Cimetidine (Tagamet)	–
Clarithromycin (Biaxin)	5–7 h
Dexamethasone (Decadron)	–
Diltiazam (Cardizem)	3–4.5 h
Erythromycin	–
Flurazepam (Dalmane)	47–100 h
Medrol	–
Metoprolol (Lopressor)	4–7 h
Metronidazole (Flagyl)	–
Midazolam (Versed)	15 min
Procardia	2 h (extended release 8 h)
Propanolol (Inderal)	4 h
Propofol (Diprivan)	10 min
Setraline (Zoloft)	26 h
Tetracycline	–
Thyroxine	–

Serotonin is deaminated by MAO type A and, therefore, administration of drugs that inhibit this enzyme used concurrently with St. John's wort should be avoided. The combination of one of these drugs and the herbal can lead to the "serotonin syndrome" which results in confusion, nausea, sweating, agitation, hypertension, and unresponsiveness. This type of reaction has been seen with the use of paroxetine and St. John's wort. Concurrent use of St. John's wort and tramadol or nefazodone can result in decreased uptake of serotonin and may increase the risk of the "serotonin syndrome."

St. John's wort should be used cautiously with sympathomimetics such as phenylephrine, phenylpropolamine, and pseudoephedrine as well as psychostimulants, isometheptene, dextromethorphan (one case of fatal drug reaction reported), and meperidine because of the ability of some plant components to inhibit MAO (in vitro). Of unknown clinical significance are the effects of ingestion of tyramine-containing foods and beverages such as red wine, yeast, cheese, and pickled herring with the concomitant use of the potential inhibition of MAO by St. John's wort. Dopamine and levodopa should be used cautiously in patients using St. John's wort.

Herbs, like licorice or *Ma huang*, can alter blood sugar levels and may be a critical problem in diabetics. Any herbals that are associated with bleeding risk should never be taken with anticoagulants such as coumadin, aspirin, and Ticlid. Valerian can compound the sedative effects of Valium, Xanax, Elavil, Benadryl, or Vistaril. Ginseng may cause irritability if mixed with caffeine. *Ma huang* may elevate blood pressure and accelerate the heart rate and should not be taken with blood pressure medications, Lanoxin, or MAOIs (Nardil, Parnate).

The American Society of Anesthesiologists recommend that patients stop taking herbal supplements 2–3 weeks before surgery since herbs may cause prolonged anesthesia effects, increased bleeding, delay in waking, and dangerous fluctuations in blood pressure [27]. Notice that some of these herbs are everyday spices and foods! The list of herbs, with the foods and spices in bold letters, can be given to each preoperative patient so that they understand the seriousness of taking these herbs prior to surgery (Table 17.2).

It is important for all surgeons to be aware of the possible detrimental effects of herbs and to prudently advise all patients to avoid the intake of any herb at least 2 weeks prior to any surgical procedure.

17.5 Toradol for Postoperative Analgesia

Toradol (ketorolac) is an effective means of obtaining better pain relief or enhancing postoperative analgesics [28–34]. Because of the possibility of bleeding and hematoma following the use of Toradol [35], this drug has been discontinued as a means of analgesia in cosmetic surgery patients. There have been some physicians who claim that a single injection of Toradol does not result in bleeding and that all the reports show that multiple doses may result in bleeding.

In reviewing the patient records at Emory University Hospital, Garcha and Bostwick [35] noted that the use of at least 30 mg of ketorolac resulted in hematomas. Conrad et al. [36] reported that 30 mg of ketorolac intramuscularly resulted in prolongation of the mean bleeding time from 4.9 to 7.8 min. Since a single dose of ketorolac consists of 30–60 mg, there is sufficient evidence to be wary of even a single injection of ketorolac.

Toradol has been shown to be 37 times more potent than aspirin in inhibiting platelet aggragation [37]. The elderly patient, patients with diabetes mellitus, postoperative septic patients, and individuals with chronic renal disease or decreased cardiac output may be susceptible to renal failure since ketorolac blocks prostoglandin synthesis and prostoglandin preserves renal function [38].

Cosmetic surgery, with skin flaps and the critical need for good hemostasis, cannot afford to be associated with a bleeding problem, which would definitely compromise the results of the surgery. At this time, it would not be within the standard of care to use Toradol for postoperative analgesia in cosmetic surgery patients unless there is more evidence that bleeding is unlikely to occur.

17.6 Droperidol in Cosmetic Surgery

17.6.1 Introduction

Droperidol is a commonly used drug for tranquilization and prevention of postoperative nausea and vomiting (PONV) following cosmetic surgery. Although it has been available for many years, the cosmetic surgeon is unaware of the potential problems that may arise with the use of the drug. The anesthesiologist or anesthetist is usually the one who makes the decision as to whether and when it is to be administered, and how much is to be administered but it is important for the surgeon to be aware of potential dangers in the practice of medicine and especially in the practice of cosmetic surgery.

Table 17.2. Herbs, foods, and spices to be avoided for at least 2 weeks prior to any surgery. Everyday foods and spices are listed in bold

Agrimony (*Agrimonia eupatoria*, agromonia, cocklebur): Coagulant effect from vitamin K constituent

Alfalfa (*Medicago sativa*, lucerne, purple medick): Anticoagulant effect from coumarin constituents and coagulant effect from vitamin K

Angelica (*Angelica archangelica*, root of the Holy Ghost): Anticoagulant and antiplatelet effect from coumarin constituents

Anise (*Pimpinella anisum*, aniseed, sweet cumin): Anticoagulant effect from excessive doses from coumarin constituents

Arnica (*Arnica montana*, leopard's bane, wolf's bane, mountain tobacco): Anticoagulant effect from coumarin constituents

Asafoetida (*Ferula assa-foetida*, assant, fum, giant fennel, devil's dung): Anticoagulant effect from coumarin constituents.

Aspen (*Populi cortex*, *Populi folium*): Antiplatelet effect from salicin constituent

Black cohosh (*Cimicifuga racemosa*, bugwort, black snakeroot, baneberry): Antiplatelet effect from salicylate constituent

Bogbean (*Menyanthes trifoliata*, water shamrock, buckbean, marsh trefoil): Bleeding risk from unknown constituent

Boldo (*Peumus boldus*, boldine): Anticoagulant effect from coumarin constituents

Borage seed oil (*Borago officinalis*, starflower, burage): Anticoagulant effect from γ-linolenic acid and antiplatelet effect

Bromelain (*Ananas comosus*, bromelin): Anticoagulant effect from enzyme constituent

Capsicum (*Capsicum frutescen*, African pepper, **cayenne, chili pepper**): Antiplatelet effect from capsaicinoid constituents

Celery (*Apium graveolens*, smallage, *Apii fructus*): Antiplatelet effect from apiogenin (coumarin) constituent

Clove (*Syzygium aromaticum*, caryophyllus): Antiplatelet effect from eugenol constituent

Danshen (Salvia miltiorrhiza, red sage, salvia root): Anticoagulant effect from protocatechualdehyde 3,4-dihydroxyphenyl-lactic acid constituent

Dong Quai (*Angelica sinensis*, Danggui, Chinese angelica): Anticoagulant and antiplatelet effect from coumarin constituents

European mistletoe (*Viscum album*, devil's fuge, drudenfuss, all-heal): Coagulant effect from lectin constituent

Fenugreek (*Trigonella foenum-graecum*, bird's foot, Greek hay): Anticoagulant effect from coumarin constituents

Feverfew (*Tanacetum parthenium*, bachelor's button, featherfew, midsummer daisy): Antiplatelet effect from the crude extracts

Fish oils (omega-3 fatty acids): Antiplatelet effect with prostacyclin synthesis, vasodilatation, reduced platelets and adhesiveness, and prolonged bleeding time

Fucus (*Fucus vesiculosis*, kelp, black tang, bladder wrack, cutweed): Anticoagulant effect which can increase the risk of bleeding

Garlic (*Allium sativum*, nectar of the gods, stinking rose): Inhibition of platelet aggregation and possible increase risk of bleeding in excessive doses

Ginger (*Zingiber officinale*): Anticoagulant effect with increased risk of bleeding

Ginkgo (*Ginkgo biloba*, maidenhair): Inhibits platelet aggregation and decreases blood viscosity

Ginseng (*Panax ginseng*, Asian ginseng, Korean red, jintsam): Anticoagulant and antiplatelet effects

Goldenseal (*Hydrastis canadensis*, eye balm, yellow puccoon): Coagulant effect from berberine constituent

Horse chestnut (*Aesculus hippocastanum*, escine, venostat): Anticoagulant effect from aesculin (coumarin) constituent

Horseradish (*Armoracia rusticana*, pepperroot, mountain radish): Anticoagulant effect from coumarin constituents

Licorice (*Glycyrrhiza glabra*, sweet root): Antiplatelet effect from coumarin constituent

Meadowseet (*Filipendula ulmaria*, bridewort, dropwort): Anticoagulant effect from salicylate constituents

Northern prickly ash (*Xanthoxylum americanum*, pepper wood, toothache bark): Anticoagulant effect from coumarin constituents

Onion (*Allium cepa*): Antiplatelet effect from unknown constituent

Papain (*Carica papaya*): Bleeding risk from unknown constituent

Passionflower (*Passiflora incarnata*, apricot vine, Maypop): Anticoagulant effect from coumarin constituents

Pau D'Arco (*Tabebuia impetiginosa*, ipes, taheebo tea, lapacho): Anticoagulant effect from lapachol constituent

Plantain (*Plantago major*, common plantain, greater plantain): Coagulant effect from vitamin K constituent

Poplar (*Populus tacamahacca*, balm of Gilead): Antiplatelet effect from salicin constituent

Quassia (Quassia amara, bitterwood): Anticoagulant effect from coumarin constituents

Red clover (*Trifolium praetense*, trefoil, cow clover, beebread): Anticoagulant effect from coumarin constituents

Roman chamomile (*Chamaemelum nobile*, English chamomile, whig plant, garden chamomile): Anticoagulant effect from coumarin constituents

Safflower (*Carthamus tinctorium*, **saffron**, zaffer): Anticoagulant effect from safflower yellow constituent

Southernprickly ash (*Zanthoxylum clava-herculis*, sea ash, yellow wood): Anticoagulant effect from coumarin constituents

Stinging nettle (*Urtica dioica*, nettle): Coagulant effect from vitamin K constituent

Sweet clover (*Melilotus officinalis*, hay flower, common melilot, sweet lucerne): Anticoagulant effect from dicumarol constituent

Sweet vernal grass (*Anthoxanthum odoratum*, spring grass): Anticoagulant effect from coumarin constituent

Tonka bean (*Dipterux odorata*, coumarouna, torquin bean): Anticoagulant effect from coumarin constituent

Table 17.2. *Continued*

Turmeric (*Curcuma longa*, **Indian saffron**, tumeric): Antiplatelet effect from curcumin constituent **Vitamin E** (α-tocopherol): Inhibits platelet aggregation and adhesion and interferes with vitamin-K-dependent clotting factor in large doses Wild carrot (*Daucus carota*, Queen Anne's lace, beesnest plant): Anticoagulant effect from coumarin constituents	**Wild lettuce** (***Lactuca virosa***, **green endive**, lettuce opium): Anticoagulant effect from coumarin constituents Willow bark (*Salix alba*, white willow, silbereide): Antiplatelet effects from salicylate constituents Yarrow (*Achillea millefolium,* wound wort, thousand-leaf): Coagulant effect from achilleine constituent

The Food and Drug Administration (FDA) has issued a warning concerning droperidol because of reports of death associated with QT prolongation and *torsades de pointes* even within the approved dosage range.

17.6.2 Droperidol in the Physician's Desk Reference

In 1997, the listing under droperidol in the PDR included Inapsine (Akorn, Abita Springs, LA, USA) as droperidol [39]. By 1998, droperidol was listed as Droperidol (SoloPak Pharmaceuticals, Boca Raton, FL, USA), Droperidol (Astra Merck, Wayne, PA, USA), and as the combination fentanyl citrate and droperidol (Astra, Wayne, PA, USA) [40]. In 2000, the only listing was a combination of fentanyl citrate and droperidol (Astra Zeneca, Wilmington, DE, USA) [41]. The 2001 (55th edition) and 2002 (56th edition) editions of the PDR no longer included droperidol in their listings; however, droperidol was still available through Abbott Laboratories, North Chicago, IL, USA.

17.6.3 Droperidol

17.6.3.1 Effects (Pharmacology)

Droperidol produces marked tranquilization and sedation as well as an antiemetic effect, lowering PONV [42]. The drug potentiates other central nervous system depressants and produces mild α-adrenergic blockade, peripheral vascular dilatation, and reduces the pressor effect of epinephrine. It can produce hypotension, decreased peripheral vascular resistance, and decreased pulmonary arterial pressure. The incidence of epinephrine-induced arrhythmias may be reduced.

The onset of action from intramuscular or intravenous injection is 3–10 min and the peak effect is approximately up to 30 min. The duration of effect is 2–4 h, although alteration of alertness may persist as long as 12 h.

17.6.3.2 Indications

Droperidol is indicated for the production of tranquilization and to reduce PONV [42]. It may be used for premedication, induction, and as an adjunct in the maintenance of general and regional anesthesia. Droperidol is used in combination with opioids for neuroleptanalgesia.

17.6.3.3 Precautions

Patients receiving droperidol should have appropriate surveillance [42]. Concomitant opioids should initially be used in reduced doses. Reduced doses should be used in elderly, debilitated, and other poor-risk patients. When droperidol is used during spinal or peridural anesthesia, the anesthetist must be familiar with the physiologic alterations involved with these types of anesthesia (i.e., alteration of respirations, peripheral vasodilatation, and hypotension). If hypotension occurs, hypovolemia should be considered and appropriate fluid resuscitation be utilized. If fluid volume replacement does not work, then pressor agents, other than epinephrine, should be administered. Epinephrine may paradoxically decrease the blood pressure in patients receiving droperidol.

Vital signs should be monitored routinely.

Droperidol should be administered with caution to patients with liver or kidney dysfunction since these organs metabolize and excrete drugs. Other depressant drugs such as barbiturates, tranquilizers, and opioids may have an additive or potentiating effect with droperidol. The dose of other depressant drugs or droperidol should be reduced.

17.6.3.4 Adverse Reactions

The commonest reactions to droperidol are mild-to-moderate hypotension and tachycardia that usually subside without treatment [42]. If hypotension persists, parenteral fluid should be administered because of possible hypovolemia.

Behavioral reactions include dysphoria, postoperative drowsiness, restlessness, hyperactivity, and anxiety. Extrapyramidal symptoms such as dystonia, akathisia, and oculogyric crisis can be treated with anticholinergic drugs. Postoperative hallucinations, sometimes associated with mental depression, have been reported.

Less commonly reported reactions are anaphylaxis, dizziness, chills, and/or shivering, laryngospasm, and bronchospasm. There have been reports of elevated blood pressure without preexisting hypertension.

17.6.3.5
Food and Drug Administration Warnings

In December 2001, the FDA required a black box warning labeling change be implemented. Akorn supplied the following drug warning:

> December 4, 2001
> Dear Health Care Professional,
> Reports of **deaths associated with QT prolongation and torsades de pointes in patients treated with doses** of Inapsine (droperidol) above, within, and even below the approved range have prompted Akorn to revise sections of the prescribing information, specifically 1) WARNINGS (include a new Box Warning), which call attention to the potential for serious morbidity and mortality, 2) INDICATIONS, which reinforces the appropriate patient population for whom this product is intended, and 3) DOSAGE AND ADMINSTRATION, which clarifies the available dosing information.

There have been a number of reports of patients who have been treated with droperidol and who developed suspected or established *torsades de pointes*, at times leading to death. There have been additional cases of symptomatic arrhythmia associated with a prolonged QT interval after droperidol administration that have been submitted via ongoing safety surveillance activities. In addition, clinical investigators have reported a dose-related increase in QT% prolongation with droperidol and replication of cardiac changes in a patient rechallenged with droperidol. Therefore, Akorn has made important changes in the Inapsine label.

The following box warning has been added:

> WARNING
> Cases of QT prolongation and or torsades de pointes have been reported in patients receiving INAPSINE at doses at or below recommended doses. Some cases have occurred in patients with no known risk factors for QT prolongation and some cases have been fatal.
> Due to its potential for serious proarrhythmic effects and death, INAPSINE should be reserved for use in the treatment of patients who fail to show an acceptable response to other adequate treatments, either because of insufficient effectiveness or the inability to achieve and effective dose due to intolerable adverse side effects from those drugs (see Warnings, Adverse Reactions, Contraindications, and Precautions).
> Cases Of QT prolongation and serious arrhythmias (e.g., torsades de pointes) have been reported in patients treated with INAPSINE. Based on these reports, all patients should undergo a 12-lead ECG prior to administration of INAPSINE to determine if a prolonged QT interval (i.e., QTc greater than 440 msec for males and 450 msec for females) is present. If there is a prolonged QT interval, INAPSINE should NOT be administered. For patients in whom the potential benefit of INAPSINE treatment is felt to outweigh the risks of potentially serious arrhythmia, ECG monitoring should be performed prior to treatment and continued for 2–3 hours after completing treatment to monitor for arrhythmias.
> INAPSINE is contraindicated in patients with known or suspected QT prolongation, including patients with congenital long QT syndrome.
> INAPSINE should be administered with extreme caution to patients who may be at risk for development of prolonged QT syndrome (e.g., congestive heart failure, bradycardia, use of a diuretic, cardiac hypertrophy, hypokalemia, hypomagnesemia, or administration of other drugs known to increase the QT interval). Other risk factors may include age over 65 years, alcohol abuse, and use of agents such as benzodiazepines, volatile anesthetics and IV opiates. Droperidol should be initiated at a low dose and adjusted upward, with caution, as needed to achieve the desired effect.

17.6.3.5
Conclusions

The potent warning supplied by Akorn requires that droperidol not be used on a routine basis but only when other medications do not work for postoperative nausea and vomiting. If there is a decision to use droperidol, then the medical record should contain a clear-cut explanation of the reasons for its use. Before using droperidol, a 12-lead ECG must be performed to determine if a prolonged QT interval is present.

Contraindications to the use of droperidol include known or suspected prolonged QT interval, including patients with congenital long QT syndrome. Droperidol should be administered with extreme caution in patients who may be at risk for development of prolonged QT syndrome

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Part V
Techniques

Facial Recontouring with Liposuction

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18.1 Introduction

Since Dujarrier's description of suctioning fat through a uterine curette in 1929 liposuction principles have remained essentially unchanged. Lipocontouring has continued to progress with improvements in technique and technology. Initially, lipocontouring was accomplished with the direct excision of fat through an open surgical approach; it now includes suction lipectomy, small-cannula lipectomy, liposhaving, and ultrasound-assisted liposuction. The goal of these procedures is to rejuvenate the face by altering the contour of the face and neck through the removal of localized fat deposits.

Liposuction is an effective means of recontouring the face that has been popularized and refined over the past 30 years [1–5]. As with all cosmetic surgery, understanding the anatomy, physiology, and changes affected by the aging process is imperative. On the basis of these differences, a logical approach to the integration of suction-assisted lipocontouring into the practice of facial plastic and reconstructive surgery is possible (Fig. 18.1).

Local adiposity is a consequence of genetics and is influenced by hormones, diet, exercise, medications, and patient age. It has become apparent through tissue culture studies that, after a critical mass within an adipocyte has been reached, hyperplasia can occur [6]. Although the mechanism of adipocyte hyperplasia has not yet been determined, the consensus remains that any significant change in fat deposition occurs through the enlargement rather than the addition of cells [7]. Diet-resistant localized fat deposits, which are ideal for lipocontouring, may represent localized adipocyte hyperplasia. Liposuction reduces the number of adipocytes regardless of their size and therefore should yield a lasting result unless excessive weight gain occurs. The liposuctioned regions of hypertrophy should respond to weight gain in a fashion similar to adipocytes in other regions of the body and, therefore, should be resistant to significant contour changes out of proportion to overall weight fluctuation.

Liposuction involves the application of negative pressure through a hollow cannula with a 2–6-mm lumen in the subcutaneous plane. Fat is then avulsed as atraumatically as possible. Loose intercellular connections are created secondary to the tunneling of the cannula in the subcutaneous plane. The fat cells are more easily aspirated than tissues with more structural integrity (e.g., muscle, vessels, nerves). Because the standard suction cannula has no cutting surface, structures with more integrity are protected. Liposhaving has been advocated as an alternative to liposuction. In this technique, a soft-tissue shaver is used with minimal suction to gently shave adipocytes [2]. Trauma is reportedly less than with standard techniques secondary to the excision of the fat versus avulsion of the fat [8]. Greater care must be used when using this device to ensure that only subcutaneous fat is excised and that no contact is made with the dermis. With liposuction and liposhaving, preserving important structures and maintaining bridges of uninterrupted tissue between the deep and superficial layers in an effort to maintain a healthier skin flap are the principles to be followed. Recently ultrasonography has been used both internally and externally to assist in liposuction. The ultrasonic energy is transferred into mechanical vibrations, which cause the microcavities in the adipocytes to implode, resulting in liquefaction of the fat [9]. Multiple studies have shown potential complications with the use of subcutaneous ultrasonic energy secondary to the heat generated at the cutaneous incision site and the more distal subdermal sites [10–12]. To this date there are no controlled studies that demonstrate any added benefit form ultrasound-assisted liposuction in the face and neck compared with the standard technique.

18.2 Patient Selection

One of the greatest challenges with facial plastic surgery is the art of proper patient selection, and lipocontouring is no exception. Patient selection begins with an informal interview to get a sense of the patient's motivation, expectation, and cooperation. The patient's

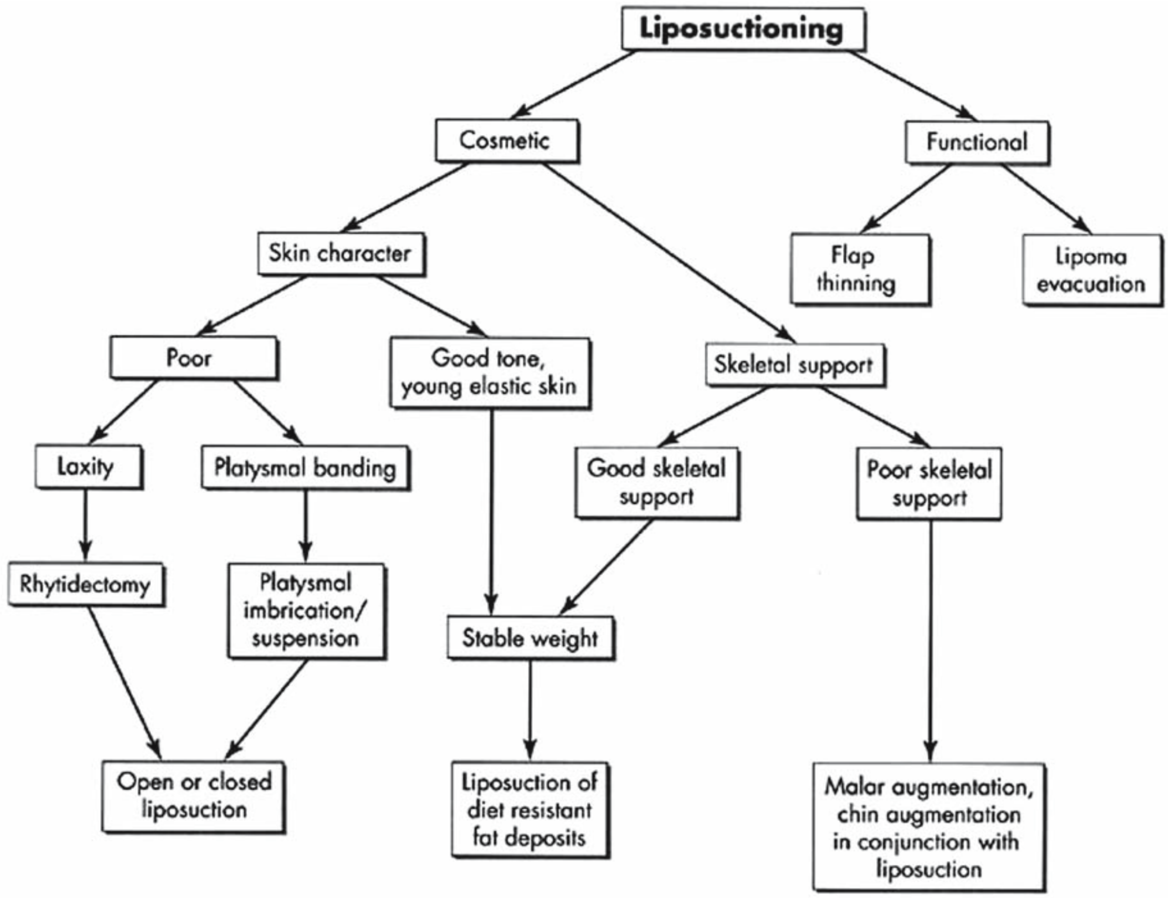

Fig 18.1. The integration of liposuctioning in facial plastic and reconstructive surgery

motivation for pursuing a cosmetic procedure should be investigated. Some patients expect a change in external appearance to significantly impact on their personal or professional lives (e.g., to get a promotion at work, to dissuade a spouse's infidelity). These patients are bound to be disappointed. A patient's expectations should be precise and realistic. Lipocontouring allows for the removal of a particular area of subcutaneous fullness, and although it will not directly impact other areas, the change in contour may create the illusion of affecting surrounding areas and thereby influence the overall balance of the face. For example, a submental lipectomy may appear to enhance chin projection (Fig. 18.2), shorten vertical height of the face, and create a wider and more cherubic appearing face. Likewise, facial and jaw lipocontouring may create a more angular facial contour (Fig. 18.3) but will not increase malar projection and could create a wasted appearance. The patient's expectations should be communicated preoperatively. Computer imaging can aid in communication, but it can also be misleading if not used prudently. Cooperation is imperative during the postoperative phase. A patient who cannot avoid the sun or continue with a pressure dressing postoperatively is a poor candidate for lipocontouring and should be dissuaded from pursuing surgery.

18.2.1 The Ideal Patient

The ideal patient is not particularly overweight and has a localized fullness that is secondary to an isolated pocket of subcutaneous adipose tissue refractory to weight loss. A patient who reports a familial pattern or who has had a double chin since childhood is a good candidate. Patients with a high posteriorly positioned hyoid and a strong chin are ideal for creating an acute submental angle. The submental, melolabial, submandibular, and buccal areas lend themselves well to lipocontouring. Younger patients tend to have greater skin elasticity, which contracts better on the new subcutaneous contour. These candidates are ideal for isolated lipocontouring. Conversely, the loss of skin elasticity and tugor in older patients will necessitate a

Fig. 18.2. **a** Preoperative and **b** postoperative photographs show the illusion of enhanced chin projection after submental and submandibular liposuction as well as enhancement of the mandibular margin with improvement of the cervicomental angle

Fig. 18.3. **a** Preoperative and **b** postoperative photographs show elimination of the double chin and augmentation of the facial skeleton status after jowl, submental, and submandibular liposuction

skin-tightening procedure. Obese patients have excess adipose tissue in multiple layers and do not respond well to lipocontouring. Moreover, this procedure is not intended to replace general weight control.

18.2.2 Common Pitfalls

Patient evaluation may yield common pitfalls that lead to untoward effects:

1. Significant ptosis of facial skin may appear accentuated after lipocontouring, creating a more aged appearance. These problems are best addressed with a formal face-lift [13].
2. Lipocontouring depends on the skin's ability to contract and adhere to the new subcutaneous bed, and several factors may interfere with this intrinsic property of the skin (e.g., age, radiation, scarring, actinic injury, smoking).
3. Skeletal insufficiency may reduce structural definition and give the illusion of excess fullness to that

area, such as the retrusive chin and low hyoid bone causing the blunted cervicomental angle. Ancillary chin implantation or genioplasty may significantly improve the aesthetic contour (Fig. 18.4).
4. Muscular problems (e.g., platysmal banding) are more evident following lipectomy in the submental area. It is imperative to recognize these problems and to address them with a face-lift or platysmal plication or imbrication.
5. Ptotic submandibular glands and hypertrophy of parotid glands can mimic areas of excess adipose collection and should be appreciated and not traumatized.

18.3 Instrumentation

The instrumentation for lipocontouring the face and neck remains uncomplicated: a vacuum generator with the capability of reaching 1 atm of negative pressure, a disposable canister to function as a trap for the aspirated fat, sterile tubing, and relatively few liposuction cannulas that are 2–6 mm. The cannulas are available from multiple manufacturers. Some surgeons prefer the round to the spatulated tip, and prefer the cannulas in which the distal 1.5–2 cm is slightly angulated. Angulation of the distal portion allows the positioning of the aspiration port (on the deep surface away from the skin) to be determined on palpation. Cannulas that are 2–6 mm are most useful. The larger the opening, the more suction force will increase. For liposhaving, a soft-tissue shaver is used (Fig. 18.5), such as the endoscopic soft-tissue shaver or the cartilage shaver used in joint surgery. Cannula size varies from 2.9 to 4.8 mm.

18.4 Technique

18.4.1 Patient Preparation

Preoperatively, the patient is given routine instructions, such as take nothing by mouth after midnight, avoid any medications that alter platelet function, and avoid the consumption of alcohol. Patients are instructed to wash their face and hair with an antiseptic soap and to remove all make-up and hair-care products. Prescriptions for antibiotics and pain medicine are given to the patient preoperatively. When the patient arrives for surgery, an intravenous line is started and preoperative antibiotics are administered. The patient is marked in the upright position, circumscribing the areas to be suctioned and indicating zones of feathering (Fig. 18.6). Anatomic landmarks, including the angle of the mandible, the anterior border of the sternocleidomastoid muscle, and the hyoid bone and thyroid notch, may also be marked (Fig. 18.6). Preoperative marking is imperative because once the patient lies supine there can be a shift in the fatty deposits and they can even disappear. After marking has been completed, the patient is taken to the operative suite, where sedation and infiltration are carried out before preparing and draping the patient. This approach allows additional time for vasoconstriction to occur before surgery.

18.4.2 Anesthesia

Cervicofacial lipocontouring can be performed with only local infiltrative anesthesia or it can be combined with intravenous sedation. An anesthetist administers sedation with close monitoring of the patient,

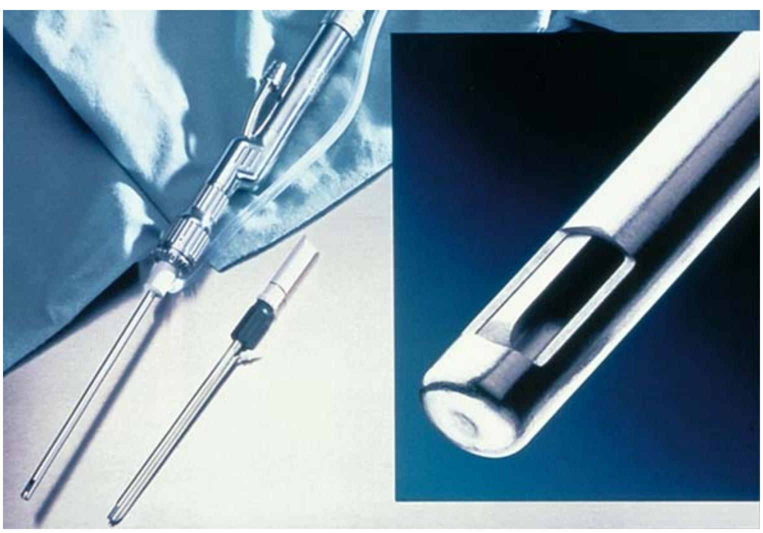

Fig. 18.4. Soft-tissue shavers and cannulas of various sizes

allowing for the virtually painless infiltration and nerve block. Submental and submandibular sculpturing are done with a block of the cervical plexus and mental nerve and with direct infiltration. Facial and melolabial contouring is accomplished with mental and infraorbital nerve blocks. Blocks and infiltration are achieved using 0.5% lidocaine with 1:200,000 epinephrine.

Adequate sedation is paramount but generally needs to be heavy only during nerve block and infiltration of the local anesthetic. Midazolam, fentanyl, and propofol are short-acting and combine sedation with analgesia and amnesia. When necessary, these procedures are performed under general anesthesia. In this case, infiltration without nerve block is sufficient to obtain vasoconstriction and improve hemostasis.

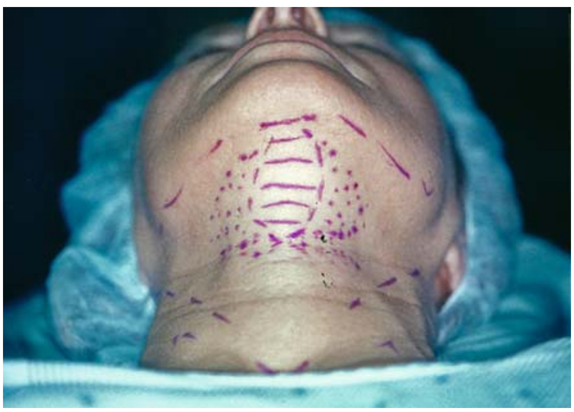

Fig. 18.5. Preoperative marking of anatomic structures, including the margin of the mandible, sternocleidomastoid muscle, and hyoid bone with stippling of lateral feathered regions and a vertical line through the prominent submental fat pad

Fig. 18.6. Use of the suction cannula to develop subcutaneous tunnels while stabilizing the skin with a skin hook

18.4.3 Surgery

The location of the incisions depends on the site to be contoured. Marking and infiltration are done accordingly. Incisions are limited to 5–10 mm and are made within relaxed skin tension lines. Making the incision small can result in friction burns secondary to the back-and-froth motion of the cannula. Incisions can be placed in the submental crease, posterior lobular crease, or in the nasal vestibule. These incisions are well hidden and allow excellent access to the cervicofacial region. The skin incisions are stabilized with countertraction using a skin hook, and the correct plane is identified with scissors (Fig. 18.7). The submental region will usually be done first, then the jaw and posterior cervical areas, followed by the region of the melolabial fold as indicated.

Flaps are elevated starting with a small cannula and graduating to the cannula size to be used for the lipectomy. A 5-mm cannula is usually used in the submandibular, submental, and jowl areas and a 3-mm cannula is used for the melolabial fold. A non-aspirative cannula is used to make multiple interconnecting tunnels throughout the region to be aspirated. During the non-aspirative phase of flap elevation, it is important to follow the same technique that would be followed when aspirating. The aspiration port should be directed toward the subcutaneous tissue and away from the skin.

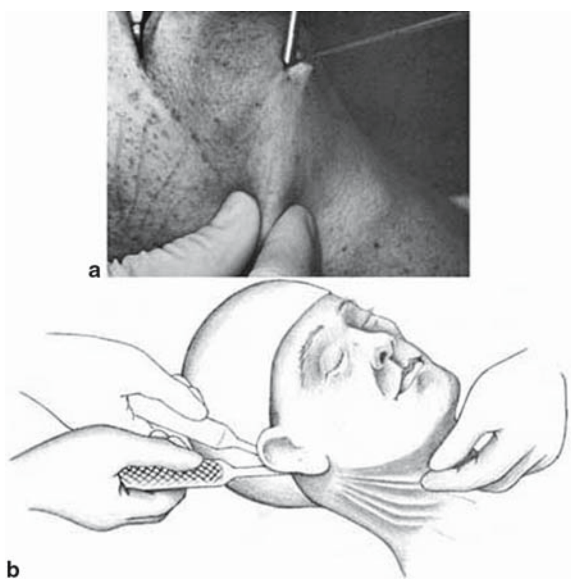

Fig. 18.7. **a** Preoperative and **b** postoperative photographs show chin augmentation in conjunction with cervical liposuction

Graduating cannula sizes are used to develop the tunneling once in the correct plane (Fig. 18.8). The free, non-dominant hand is used to palpate the cannula tip, to determine the depth of dissection, and to access the amount of residual fat. Dissection is carried out in a spokelike fashion from the incision. Multiple distal pseudopods from each spoke are used to ensure that lateral aspiration with feathering is executed thoroughly (Fig. 18.9). Additionally, non-aspiration tunneling is performed beyond the margins of the area to be aspirated to allow complete redraping. The surgeon should concentrate on distal aspiration because each repetitive motion (Fig. 18.10) of the cannula will cross over the proximal adipose tissue in the region adjacent to the original insertion and may result in a hollowed appearance at that point. Hollowing and inconsistent flap elevation can also be avoided by palpating the cannula tip and preserving some fat on the undersurface of the flap. After complete non-aspiration elevation has been accomplished, the suction is applied at 1 atm of negative pressure and multiple passes reexecuted. Assessment of evacuated fat may require the release of the vacuum so that any fat in the cannula and tube may be drawn into the canister. This approach may be necessary when the volume removed is small. Once the prominent fat accumulations have been removed a smaller cannula (2–3 mm) can be used for sculpting and feathering.

Aspiration from the postauricular incision includes the jowl, posterior cervical, and submandibular regions (Fig. 18.11). Crosshatching occurs with the submandibular portions aspirated from the submental incision. In aspiration of the jowl, it is imperative to release suction when withdrawing the cannula over the posterior facial soft tissue and masseter because this area may not require aspiration and a groove may be created in the posterior face. The margins can be tapered with a smaller cannula or with fewer passes. Liposuction of the melolabial fold or, more appropriately, of the superior border of the fold is performed with a small cannula through an incision in the nasal vestibule (Fig. 18.12).

Submental lipectomy should extend inferiorly to the level of the thyroid cartilage, posteriorly to the anterior border of the sternocleidomastoid muscle with feathering over the muscle, and superiorly to the margin of the mandible. Lipectomy directed from the postauricular incision can extend anteriorly in the submandibular area to the anterior border of the platysmus muscle and superiorly to the margin of the mandible. In the jowl, the specific deposit is aspirated

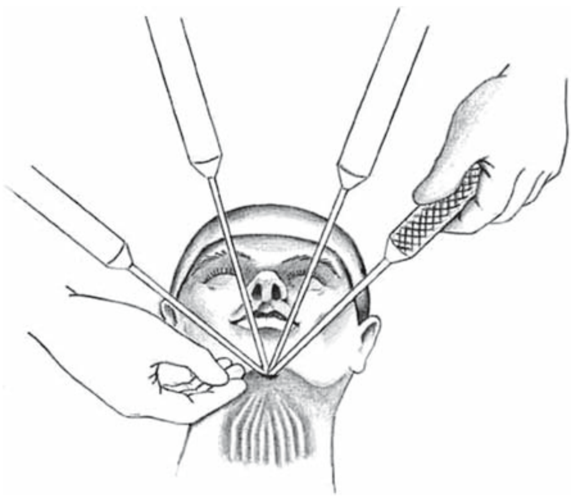

Fig. 18.9. Distal feathering to ensure a smooth transition to non-aspirated sites

Fig. 18.8. Palpation of the distal cannula to ensure the depth of dissection and location of the distal cannula lumen

Fig. 18.10. Multiple distal tunneling to ensure a smooth transition in all regions and to avoid overreduction of the immediate submental adiposity

and feathering should be extended to the oral commissure and inferiorly to the margin of the mandible.

With liposhaving, flap elevation is done in a similar fashion. The cannula is inserted with the blade inactive. Once the blade is activated, extreme care should be exercised at the incision to avoid damage to the skin margins. The cannula is passed in a more delicate fashion at a slower rate than with liposuction because shaving rather than avulsion is occurring.

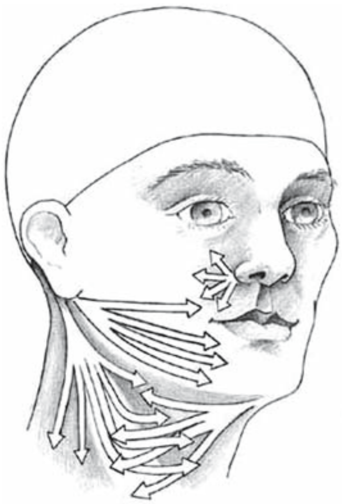

Fig. 18.11. Suction lipectomy of the jowl, posterior cervical, and submandibular regions, which can be approached through the postauricular incision

Fig. 18.12. Sites that can be approached through the submental, postauricular, and vestibular incisions

Minimal amounts of suction are applied, and the cannula must remain in motion when the blade is active because it will shave progressively deeper, jeopardizing other structures.

Ultrasound-assisted liposuctioning can be performed with either an external hand-held device that is placed external to the skin, or a cannula with an incorporated ultrasonography system [11, 14]. After liquefaction of the fat has occurred it is easily removed with a cannula. Cannula cooling irrigation systems have been developed that decrease the thermal and friction burns previously discussed [11, 14]. The long-term benefit for ultrasound-assisted lipocontouring of the face and neck has yet to be determined.

Regardless of the specific technique used, at the end of the procedure the contour of the face and neck should be inspected and palpated. The face and neck should be massaged to remove any excess blood and loose fat globules. Dimpling is usually secondary to residual subcutaneous attachments to the overlying skin. Releasing these attachments usually resolves the problem. Subtle preoperative platysmal banding may be more prominent at the end of the procedure. These bands can be plicated through the submental incision in order to decrease their prominence.

Lipocontouring can augment other cosmetic procedures. In conjunction with cervicofacial rhytidectomy, the cannula can be used to elevate the flap while sculpturing the fatty tissue. The authors prefer to perform open liposuction for sculpturing after flap elevation. This approach frequently requires extension of liposuction tunnels beyond the limits of skin flap elevation. Open liposuction with cervicofacial rhytidectomy allows the surgeon to completely cross-hatch each area, thereby reducing the risk of banding. Additionally, uniform flap thickness can be assured at the time of sharp elevation, reducing the risk of dimpling of the skin. In combining lipocontouring with mentoplasty, the surgeon need only extend the submental incision to about 3 cm to allow placement of the implant. All wounds are closed in a layered fashion.

18.4.4 Dressing

Postoperatively, all patients require a pressure dressing circumferentially around the head and neck. Antibiotic ointment is first applied to the incisions. Fluffs are then placed over the region aspirated, and a rolled cotton gauze is used to hold these fluffs in place. Coban R (3M, St. Paul, MN, USA) dressing is applied using light but continuous pressure (Fig. 18.13). The dressing is left undisturbed for 2–3 days and is then removed. After this, an elastic dressing is used at night and when indoors and changed by the patient as

Fig. 18.13. Immediate postsurgical dressing

Fig. 18.14. A light dressing can be applied by the patient after the immediate postsurgical dressing has been removed

needed (Fig. 18.14). Antibiotics are used in all elective surgeries. Drains are not routinely used. Liposuction is usually not painful, but the circumferential dressing can be uncomfortable and anxiety-producing for some patients. For this reason, mild analgesics are helpful. Elevation of the head and continuous use of ice packs minimize swelling.

18.5 Recovery Phase

Diligent patient education regarding the recovery phase can be very comforting to all those involved. Some degree of bruising and facial edema are to be expected and may last 1 week. The elevated skin may be numb for several weeks. As the facial skin scars and adheres to the new underlying contour, patients often note some firmness and tightness that diminishes over months. Pain is usually minimal and sufficiently relieved with acetaminophen. When larger volumes of fat are removed, shallow dimpling and wrinkling from excess skin can occur as the skin adheres. Diligent massage and patience will lead to a smoother final contour. Exercise is to be avoided for 3 weeks after surgery and should be resumed gradually, beginning with aerobic activities and progressing to more strenuous exercise.

18.6 Complications

Complications from lipocontouring are uncommon but may be dramatic. The most frequent complication is hematoma or seroma, which is evacuated by needle aspiration and a pressure dressing is reapplied. If a hematoma accumulates acutely, one should have a low threshold for drainage and exploration in the operating room. Infections or cellulitis usually arise from a preexisting hematoma and should be managed aggressively to reduce the risk of skin-flap necrosis or scarring. Pigment changes can follow an undiagnosed hematoma and result from a breakdown in hemoglobin products. Contour irregularities and asymmetries may manifest after all swelling has subsided and are more likely to occur as residual fullness on the right neck area because most surgeons are right-handed, making the left neck more accessible than the right side. If significant, this complication is best repaired with minor touchup procedures using the hand-held syringe technique, but not before 6 months postoperatively to allow the full skin flap to soften as much as possible. For subtle areas, small quantities of corticosteroids can be injected to induce fat atrophy. This approach should be used conservatively because its effects continue for many months and are not reversible. Minor depressions can be remedied with autologous fat injection, but the longevity of the effects of the procedure is unknown. Motor or sensory neural injury is more serious but rare, usually representing a transient neuropraxia. Cardiovascular instability is associated with total body liposuction and results from massive fluid shifts. This complication does not occur from lipectomy in the head and neck areas. Pulmonary fat embolism can theoretically occur during any surgical procedure but has not been reported after liposuction alone.

18.7 Summary

Lipocontouring is a necessary adjunct to a plastic and reconstructive practice. It can be performed with hidden incisions, minimal tissue trauma, and a short recuperative period. Patient selection and education are paramount to achieving satisfaction. The judicious use of liposuction in conjunction with other cosmetic procedures will enhance the results and the satisfaction of the patient and surgeon.

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19 Liposuction of the Upper Extremitiest

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19.1 Patient Consultation

Liposuction of the upper extremities requires a careful examination and evaluation of the patient. The patient should be made aware of the general risks and complications of liposuction as well as the specific problems of performing liposuction on the arms.

The specific problems of liposuction in the posterior regions of the arms include:

1. Inadequate removal of fat
2. Removal of too much fat
3. Sensory loss (Fig. 19.1)
4. Motor nerve injury (Fig. 19.2)
   (a) Ulnar nerve

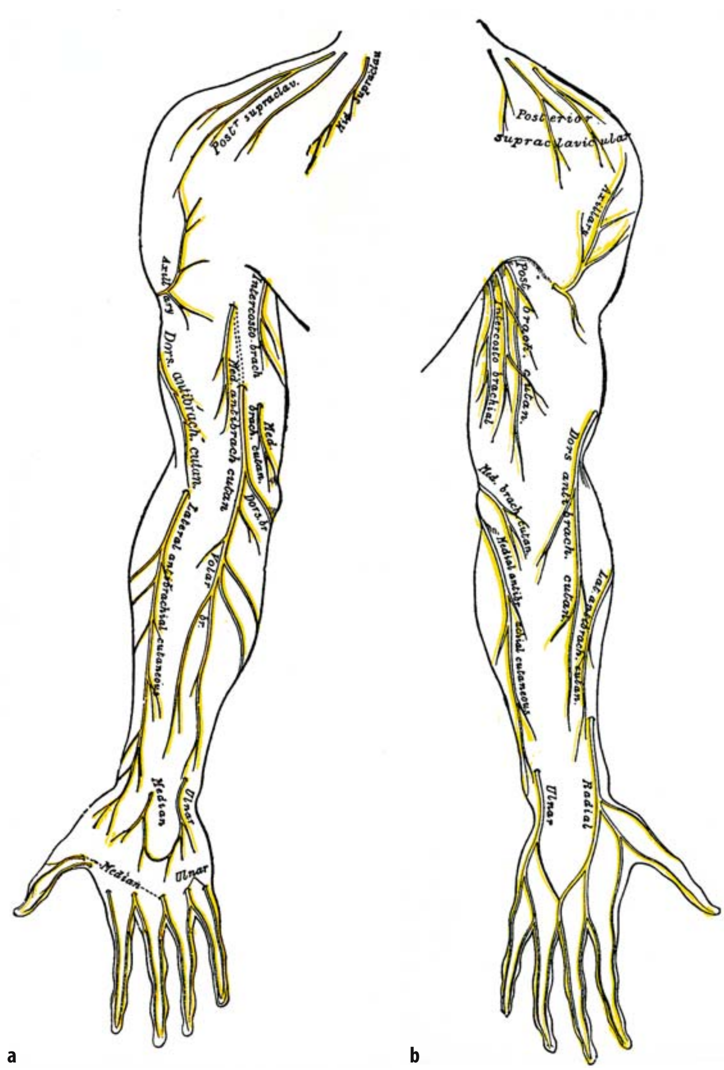

Fig. 19.1. Sensory distribution of the nerves of the right upper extremity. **a** Anterior view. **b** Posterior view

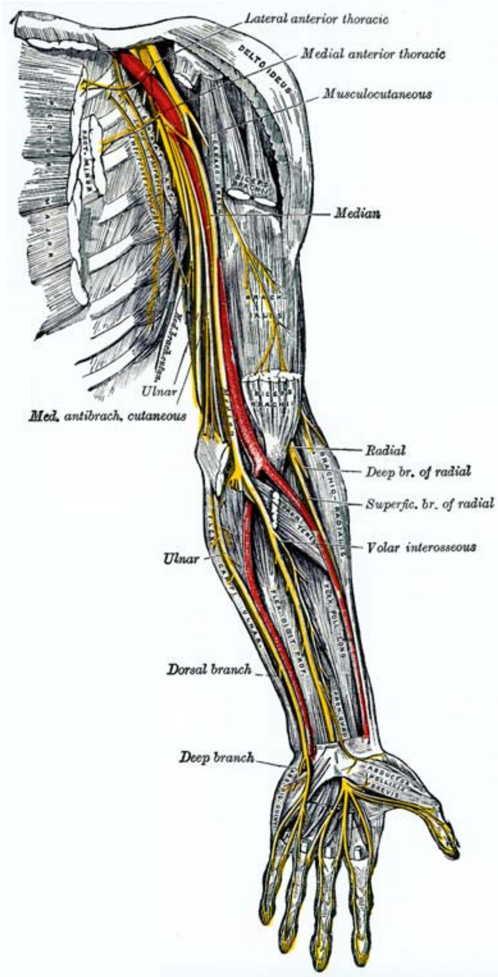

Fig. 19.2. Nerves of the left upper extremity

(b) Median nerve
(c) Brachial plexus

5. Vascular injury (Fig. 19.3)
   (a) Brachial artery
   (b) Axillary artery (P. Fournier, personal communication, 5 October 2002): Fournier described a patient who sustained an injury to the axillary artery during liposuction of the arms. The artery was repaired but the repair failed and, ultimately, amputation was required.
6. Indentations: There is a normal indentation along the edge of the triceps muscle in thin muscular arms (Fig. 19.4).
7. Infection
8. Asymmetry
9. Loose skin: May require surgical brachioplasty to resolve.

19.2 Technique

The patient is administered anesthesia, usually general but deep sedation or conscious sedation may be utilized through a needle placed in the hand. Cephazolin, 1 g, is administered intravenously. The skin is prepped with betadine from the wrists to the shoulders, including the axillae, and sterilely draped. The hands are wrapped with sterile towels (Fig. 19.5). The arms are placed on armboards at 85° abduction, never more than that (to prevent accidental stretching of the brachial plexus and traction nerve injury). The arms should not be strapped to the table since mobility may be necessary.

Tumescent solution is injected, through a small incision in the posterior portions of both upper arms just proximal to the elbow (olecranon process), with a solution containing:

1. Lactated Ringer's solution: 1,000 ml
2. Lidocaine: 250 mg
3. Epinephrine: 1 mg

Be very careful that the incision is not made medially since the ulnar nerve is medial to the olecranonon. The posterior arms are then massaged with a mechanical percussion massager (model PA-1, HoMedics, Commerce Township, MI, USA) for 5 min each side. This will emulsify the fat making extraction easier.

After waiting another 5 min, liposuction is begun on the first side infused with tumescent solution. A 2.5-mm cannula, through the incision in the distal portion of the upper arm, is used to remove the fatty tissue. Tunnels are made in a fanlike distribution and the cannula is pushed with long strokes several times in each tunnel. Make absolutely sure that the cannula does not enter the axilla except in a very superficial fashion and with complete control of the cannula tip with the non-dominant hand. Indiscriminate use of the cannula in liposuctioning in the axilla will frequently result in serious injury to nerves and/or vessels. The superficial fat is liposuctioned to allow better contraction of the skin but leaving a fat layer of 1 cm under the skin.

The tissues are checked with pinching to compare each side and any areas of excess fat remaining can then be identified and liposuctioned. The amount of aspirate from each arm is measured separately so that near equal amounts are removed.

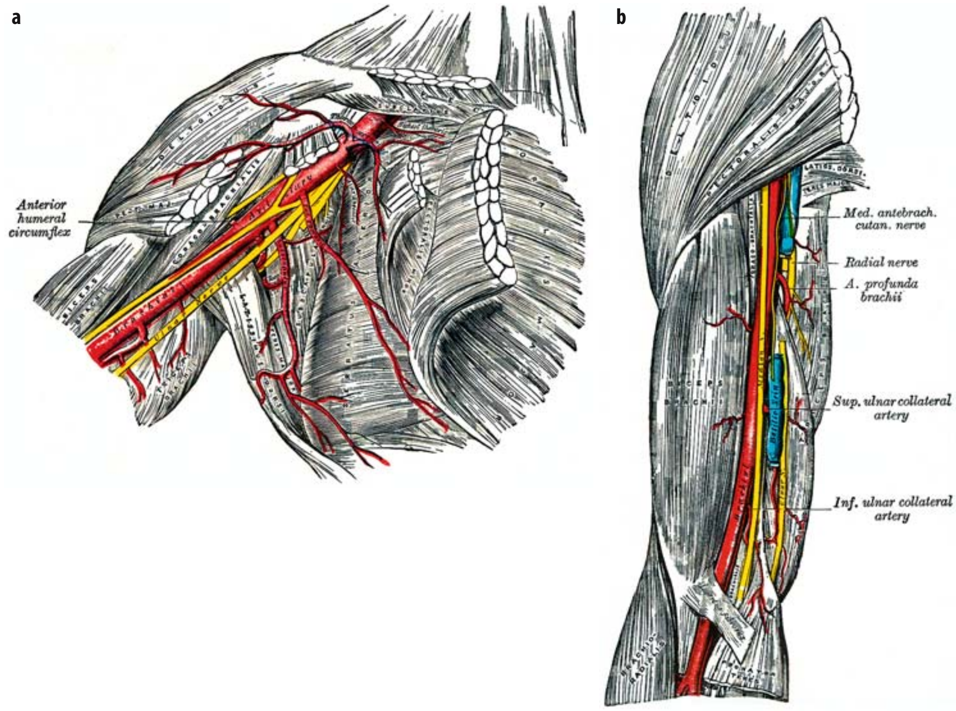

Fig. 19.3. Vessels of the right upper extremity. **a** Axillary artery and its branches. **b** Brachial artery

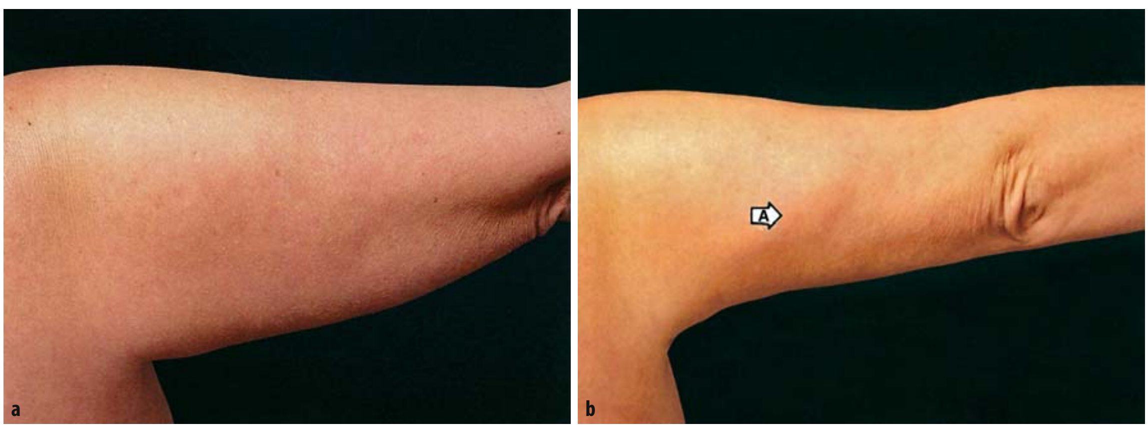

Fig. 19.4. **a** Posterior view of fatty arm with hanging skin. **b** Postoperative resolution of excess fat and hanging skin. There is a normal indentation (*arrow*) along the triceps muscle that now is evident

19.3 Postoperative Care

The arms have 4×4 gauze pads applied to the wounds and the arms are wrapped with foam pads that are kept in place with loosely applied ace bandages. The patient is instructed to keep the arms elevated on pillows when reclining for the first 3 days. Oral antibiotics (Keflex, 500 mg twice daily) are prescribed for 5 days.

The patient is seen in the office on the first postoperative day, at which time the dressings are changed and the foam removed. An ace bandage is reapplied, making sure that it is not tight (swelling of the distal arm will occur if the bandage is too tight). The patient is told to loosen the ace bandage if swelling occurs and to keep the arms elevated.

The patient is again seen on the third postoperative day and the dressings are removed. 4×4 gauze pads or bandaids (if there is no drainage) are applied to the incisions and held in place with tape. The patient is

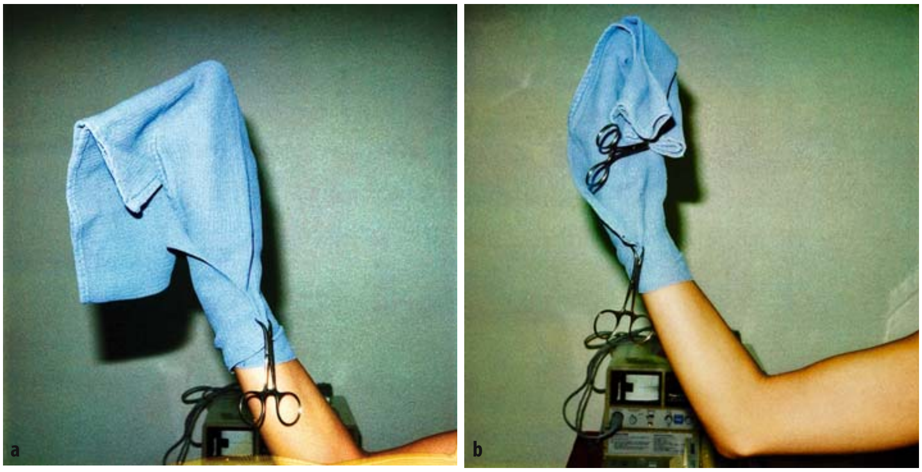

Fig. 19.5. Sterile wrapping of hands and wrists

instructed to take showers daily and to change the dressings after each shower. The dressings can be removed permanently when there is apparent healing of the wounds, usually by the fifth postoperative day.

There are then office visits ant 7 days, 30 days, and 4 months. At the last visit, the final results are evaluated and photographs taken.

19.4 Discussion

Liposuction of the arms can remove the excess fat and have contraction of the skin, resulting in a better cosmetically appearing arm (Fig. 19.4). Retraction of the skin of the arm may represent a direct relationship to the disposition and concentration of dermal collagen fibers associated with elastin [1]. The epidermis of the arm has sparse papillae and the collagen distribution in the papillary dermis is more frequently homogeneous and dense rather than parallel and flaccid and in the reticular dermis is more frequently parallel.

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20 Refinements in Liposculpture of the Buttocks and Thighs

Luiz S. Toledo

Beauty is an activity, not a state.
Aristotle

20.1 Introduction

It has been more than 20 years now since Illouz's [1] first lipoplasty paper was presented in Brazil by way of a film. It was a technique which allowed us to see new possibilities for improvement in many areas of plastic surgery. This paved the way for the "minimally invasive" procedures that followed, creating a new perspective for plastic surgeons and patients, with the possibility of altering the shape of the face and body through minimal incisions. Lipoplasty is a simple idea and this is why it works. We should not complicate it and as Illouz points out, sometimes it is very difficult to be simple.

Throughout the world the initial idea, spread by Illouz, has seen many changes in instrumentation, tactics, depth of aspiration, and anesthesia techniques. The principle, however, has remained the same: treating the localized fat deformities by aspirating subcutaneous fat.

The improvement of body contour irregularities need not be limited to fat suction alone. The treatment ideally should be global, involving different specialties. Plastic surgeons need to be familiar with the array of modern techniques available to obtain the best result. This evolution involves change.

After working with the traditional liposuction techniques of the early 1980s I decided to try the syringe liposculpture technique introduced by Fournier [2] eliminating the aspirator and using disposable syringes. It became simpler than liposuction with the aspirator, with the same effectiveness and without increasing its risks.

In 1985 I started using the syringe technique for facial work, not only to remove excess fat, but also to reinject aspirated fat in specific areas. At this stage I was still using the aspirator to treat the body, collecting the fat in a vial, and transferring it to 60-ml syringes for reinjection.

In 1988 I started using the tumescent technique of local anesthesia for face and body work. The original Klein formula was modified in 1989 to suit my needs, increasing the lidocaine and epinephrine concentration, and replacing the saline solution with Ringer's lactate [3].

In 1989, contrary to the belief held at that time that we should aspirate from only the deep layers of fat, Gasparotti presented superficial liposuction for the first time in São Paulo at the first "Recent advances in plastic surgery—RAPS symposium." The introduction of superficial liposculpture in 1989 widened the indication for lipoplasty to include older patients with a more flaccid skin tone [4].

I modified the Gasparotti technique of superficial liposuction with the aspirator to using the syringe for both aspiration and injection of fat. I called this technique superficial liposculpture [5]. Skin care and manual lymphatic drainage has helped enormously in improving patient satisfaction and postoperative comfort.

The mirror image system was introduced to my patients in 1992. The computer consultation is a key tool in surgeon/patient understanding of projected postoperative results. Using the patient's own images, the patient can have an explanation and be shown the change that can be expected through surgery alone. The degree of patient involvement needed is explained to the patient in order to obtain the final result and estimate the improvement.

From 1995 to1997 I tried using internal ultrasound but ultimately abandoned this technique.

The introduction in 1995 of megaliposculpture, the removal of large amounts of fat in one procedure, increased the risks and provoked skin irregularities. I prefer multiple procedures if more than 5–8% of the total body weight has to be aspirated. I never aspirate more than 8% in one procedure.

Since 1997, I have used external ultrasound for body contouring [6] alone or in conjunction with liposculpture when indicated [7]. Endermology was then used working with endocrinologists and personal trainers.

1999 saw the arrival of titanium-fused cannulas for the Toomey-tip syringes. The interior of the cannula is also treated, reducing friction to a minimum.

Body contour surgery today ideally involves several techniques, including syringe liposculpture, external ultrasound, manual lymphatic drainage, endermology, skin care, exercise, and diet. The goal in some cases is to motivate the patient to a change in life style. The modern facility should offer several options to improve what can be obtained through surgery.

20.2 Syringe Liposculpture

20.2.1 Instruments

Over the last 5 years the Tulip CF (cell friendly) cannulas, a titanium-fused instrument system, has been used with Toomey-tip 60-ml syringes. These cannulas are light and easy to handle, as there is almost no friction, resulting in the integrity of the aspirated fat cells being maintained to a higher degree, a desirable state if they are needed for reinjection. For the body 2–4.6-mm cannulas with lengths from 15–45 cm are used according to the areas to be treated.

For the face and other delicate work 10-ml syringes and cannula gauges between 1 and 3 mm are preferred. The tips are either the Pyramid type or one lateral hole. Specific tips are used for difficult areas, such as the flat tip with two holes, the Tiger tip, and the Toledo V-tip dissector cannula in different gauges and lengths for facial and body work (Fig. 20.1). The V-dissector is sharp on the inside of the V to cut the fibrous tissue and with blunt tips to avoid perforation of the skin. It is manufactured in different gauges, from 1.5 to 4 mm and lengths, from 12 to 45 cm, to be used on the face or to treat problems on the body (Fig. 20.1).

Blunt multihole cannulas are used for anesthesia infiltration. This helps avoid damage to the surrounding tissues, and this means less postoperative edema and ecchymoses.

Long cannulas are used to treat large adiposities, at least 10 cm longer than the area to be treated. A cannula shorter than the area of the deformity can provoke irregularities. The fat deposits are treated in units, terminating one area then moving to another.

Fig. 20.1. **a** *Clockwise from bottom*: CF cannulas, titanium-fused for less friction, a plunge locker (both by Tulip), a Toomey-tip 60-ml syringe and a 60–10-ml transfer with decanting stand (by Richter). **b** *From left*: a 3-mm-gauge multihole tip infiltrator and 3-, 3.7- and 4.6-mm-gauge CF cannulas (Tulip). **c** Special cannulas for difficult areas of aspiration, the two-hole flat tip and the Tiger tip (Grams Medical). **d** The Toledo V-tip dissector cannula (Byron)

Final passage with a fine cannula is necessary to feather any irregularities.

20.2.2 Anesthesia

Syringe liposculpture performed with a combination of "twilight" sedation and tumescent anesthesia means a faster recovery from the surgery. Heavy sedation is not needed. This combination also has a considerable advantage over general anesthesia [8] and, most importantly, the reduction of bleeding during suction. For small procedures, oral sedation with 15 mg midazolan can be used. For larger procedures, intravenous sedation with midazolan, propofol, and fentanyl is administered by the anesthesiologist.

The local infiltration formula contains 20 ml of 2% lidocaine, 1 ml of adrenaline, 500 ml of Ringer's lactate, and 5 ml of 3% sodium bicarbonate [9]. Sodium bicarbonate balances the pH, neutralizing the acidity of the lidocaine, and decreases the discomfort of the injection.

The whole body is not injected before suctioning but one side is injected, treated, and completed before turning the patient [10]. Three to four liters of pure fat can be removed safely without the need for blood replacement, keeping in mind that no more than 5–8% of the patient's body weight should be liposuctioned at one time. One liter of decanted fat (after removing the local anesthesia) weighs about 1 kg.

It is difficult to calculate the exact amount of anesthesia being injected in any one area when using an injection pump. For this reason injection using the syringe is preferred. It is fast and I know exactly the amount of anesthesia injected and can measure and record the exact amount of fat and fluid aspirated from each area. It is important to record precisely not only the total volume of aspirate of all the treated areas, but also the volume of pure fat. If we remove 3 l of fat from only one body area, the trauma is less than if we aspirate the same 3 l from several areas of the body. Ten to fifteen minutes after the injection of the anesthesia, the skin of this area will become whiter, owing to the vasoconstriction, a sign that we can start liposuctioning. If we do not wait, too much fluid and blood will be aspirated.

The tumescent fluid is injected slowly, at body temperature, i.e., 37°C [11], to avoid patient shivering and trembling during and after surgery, a discomfort provoked by the injection of low-temperature fluid. Warming the solution also significantly reduces pain [12]. The use of warm air blankets during and after the surgery helps in maintaining the ideal body temperature and helps improve patient comfort postoperatively.

The anesthesia solution is injected deeply, close to the muscle fascia, which allows for good tumescence and avoids distortions. For every 1,000 ml of aspirated fat, only 9.7 ml of blood is suctioned. The tumescent technique is a very safe method of liposuction, eliminates the need for general anesthesia and blood transfusions, and has fewer complications. Two milliliters of anesthetic solution is injected for each milliliter of aspirate to be aspirated. The blood loss with this tumescent technique is dramatically reduced compared with that with the dry or classical infiltration technique [13, 14].

Drug toxicity with local anesthesia was one of the most serious potential complications and a limiting factor of this type of anesthesia, owing to the peak concentration in the plasma. The safe upper limit of the lidocaine dose in tumescent anesthesia for liposuction has been reported to be 35 mg/kg, but there are studies that suggest that tumescent anesthesia with a total lidocaine dose of up to 55 mg/kg is safe for use in liposuction [15].

With the authors anesthesia formula [16] for the tumescent technique (a modification of the original Klein formula,) up to 6 l of this solution can be injected safely during a single liposculpture procedure. Several factors help in keeping this formula safe. First the fact that the entire body is not injected at the beginning of the surgery; it is preferred to inject and aspirate one side before going to another area. Some of the solution is removed with the aspirated fat, reducing the amount that will be reabsorbed. The solution with epinephrine allows the lidocaine dose to be increased because of the delayed clearance from the injection site. The serum lidocaine levels at 3, 12, and 23 h following infiltration of the tumescent solution with the tumescent technique have a mean of 22.3 mg/kg [17]. The peak epinephrine levels occurred at the 3-h blood draw and were approximately 4 times the physiologic level. There were no subjective or objective signs of lidocaine or epinephrine toxicity. The peak lidocaine level occurs 12 h after the infiltration of the solution.

Normally between 2 and 3 l of solution is injected evenly and painlessly. The tumescent state is reached when palpation shows the typical tension of the injected area.

20.2.3 Regularity

The depth and the regularity of the cannula strokes are controlled with an outstretched hand, the skin wet, and with an antiseptic solution, allowing the outstretched hand to move easily over the skin surface. To detect any irregularities the "pinch test" is used with dry skin to measure thickness. Skin irregularities are checked using light reflections on the wet skin. I call this "the panel beater trick."

In tennis you "keep your eye on the ball" and in liposculpture you "keep your eye at the cannula tip," which is fundamental in preventing secondary irregularities and sequelae. Once the syringe is full, liposuction is immediately resumed with an empty syringe and with the same-sized cannula. When the cannula gauge is the same, suction takes the same time either with the aspirator or with the syringe, because vacuum is vacuum.

Each area is treated with the body in a specific position on the operating table [18]. With the patient in the lateral position, the flanks and lateral thighs, the gluteal fold, and the "banana" fold are treated. In the prone position we treat the dorsal region, arms, flanks, and dorsal and medial thighs plus the knees. In the supine position the abdomen, medial thighs, calves, ankles, and axillary region are treated. By bending and separating the patient's knees, the treatment of the medial thighs, calves, and ankles is completed.

With the patient in the lateral position to treat the lateral thigh, it becomes more difficult to provoke a depression, usually owing to repeated suction of the subdermal layer.

To treat the abdomen in the supine position, the abdominal wall is hyperextended either by bending the table or by placing a pillow under the hips. This is one of the simplest ways to reduce the possibility of abdominal wall perforation. In this position the cannula introduced in the pubic area can reach the skin of the epigastrium.

Intraabdominal penetration with intestinal perforation is a relatively uncommon complication of liposuction, but eight cases have been reported in the literature, with a mortality rate above 50%. It is important to establish an early and aggressive diagnosis and treatment of liposuction patients who have gastrointestinal complaints in the early postoperative period [19].

20.2.4 Buttocks and Thighs

A flaccid buttock will have an accumulation of fat in its lower third and a depression in the gluteal trochanteric area. The excess weight provokes the so-called banana fold, a subgluteal accumulation of fat. To handle this problem, the flanks and lateral thighs are aspirated and then the area cephalic to the gluteal fold is treated with superficial suction to remove some of the weight of the buttock, provoking a slight retraction of the skin. If the subgluteal fold is too long, the lower third of the buttock is liposuctioned and the banana fold area reduced and treated with superficial suction while fat is injected into the trochanteric depression. The banana fold is always liposuctioned superficially. If suctioned deeply, the fibrous structures that hold the buttock in place will be broken, and this will result in a lengthening of the subgluteal fold. In secondary cases of the banana fold deformity it might be necessary to inject fat in the "banana" area that was overaspirated.

Injecting fat into the trochanteric region produces the illusion of an elevation of the buttock. Fat-grafting done in multiple tunnels is an efficient and safe procedure to correct or enhance contour deformities of the lower limbs [20]. In some cases the removal of excess fat from the lateral and posterior thigh will shorten the subgluteal fold and create a more gracious look. This combined procedure will result in the shortening of the gluteal fold and an illusion of an elevation of the buttock. The leg looks longer when there is a continuation of the buttock with the thigh. It is impossible to have the precision needed when treating these delicate areas using thick cannulas and traditional liposuction.

20.2.5 Internal Ultrasound

It has been said that ultrasound-assisted liposuction (UAL) was a revolutionary contouring technique with several advantages over the existing methods of suction-assisted lipectomy. My interest was to compare these advantages with syringe liposculpture. From April to December 1995 I used the UAL technique on 20 patients, varying from 25 to 55 years of age, treating one side with syringe liposculpture and the other with UAL, under local anesthesia with sedation. First the Brazilian Liposonic ultrasound aspirating machine was used with 20 MHz frequency on one side of the body and Toomey-tip syringes with Tulip cannulas on the other. My first experience was presented at the ASAPS meeting in April 1996 [21]. In 1996 and 1997 I tried the American Lysonics and the Italian SMEI machines over several months.

These were some of my findings. One advantage is that there is no need for physical strain. The ultrasound hand piece weighs 2 lb, the syringe weighs about 50 60 g, which is much lighter. The ultrasound probe/cannula slides more easily through the tunnels than the stainless steel cannula, but after you have held this hand piece for 1 h it can get heavy. The syringe with the zirconium-fused cannula is also very easy to use and there is almost no friction.

I have had two cases of hemorrhage with UAL (Fig. 20.2). In one patient, compression of the area and cessation of liposuctioning eliminated the bleeding. The second patient had a hemorrhage 10 h after the end of the surgery and needed 2 units of blood administered. In this case the lateral thigh was being

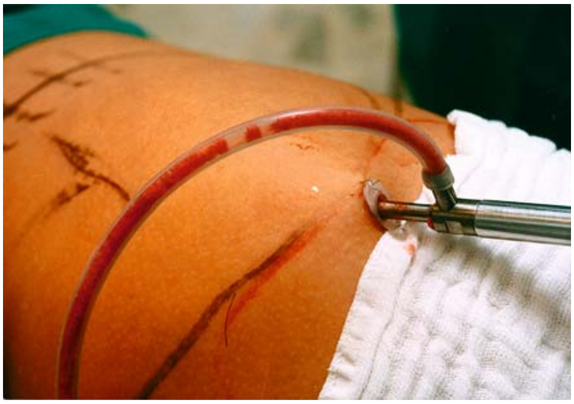

Fig. 20.2. Aspiration of the lateral thigh with the Liposonic internal ultrasound machine showing bloody drainage. Blood was squeezed from the lateral thigh and the area had to be compressed to stop bleeding

treated, which is an area with no large blood vessels that would provoke this degree of bleeding. Possibly it was due to destruction of superficial capillaries. This is the only blood transfusion I have prescribed since 1985, when I was still using the dry technique.

When I reported skin and tissue burns, a hemorrhage, and that my patients felt more pain and itching on the side treated with UAL, I was told it was due to technical problems either with the machine or my timing. I was advised to use the ultrasound for only 3 min and then proceed with a normal suction. I preferred not to use it at all.

The ultrasound should eliminate only the fluid fraction of the adipocytes, leaving in place the adipocyte wall and intercellular substances, producing a smooth and regular cutaneous surface. It is said that the ultrasound shows “a selective destruction of the underlying tissues” as opposed to an “anarchic and traumatic removal destruction of the area treated,” as apparently seen in traditional liposuction. I found that was not the case.

The advantages of UAL over the syringe technique should also produce a lifting effect, better skin retraction, but I did not see the evidence of this in the final result. The retraction was similar, the bruising was similar, and the procedure time much longer. Not only is it more expensive, but it can increase the risk of bleeding, tissue and skin necrosis, and cause prolonged pain and itching.

20.2.6 External Ultrasound

Lewis, Pruitt, and Hetter advocated external ultrasound to reduce edema after lipoplasty in 1984. The external ultrasound machine to destroy localized fat deposits was developed in California by Silberg and popularized by Hoefflin.

I called the technique lipotripsy, a non-invasive method using external ultrasound for body contouring. I used the Silberg–Wells Johnson external ultrasound machine for the non-surgical decrease of localized fat cells by increasing the intracellular volume and rupturing the cellular membrane with vectored ultrasound.

The 30-W machine produces ultrasound in continuous and 20% pulsed modes with two applicators, 10 cm^2 at 1 MHz for the body and 5 cm^2 at 1 MHz for the face and can be used in isolation or in conjunction with other body-contouring procedures [7]. The indication varied according to the volume of fat to be treated. The main indication for the isolated use of external ultrasound with no suction is for the non-invasive treatment of localized fat deposits of volume smaller than 300 ml. For volumes larger than 300 ml we can combine lipotripsy (external ultrasound) with syringe liposculpture (Fig. 20.3). It can be performed on different areas of the body with good results, on the neck of men and women and on primary or secondary cases and fat deposits with fibrosis. Although the use of external ultrasound alone, i.e., with no liposuction, can reduce the lipodystrophies, what it cannot do is to alter the shape of the body. For that it is necessary to use liposculpture. The technique can be performed under local anesthesia alone, or combined with sedation. The local anesthesia formula is injected slowly at body temperature, proportion 1:1 (500 ml Ringer’s lactate, 20 ml of 2% lidocaine, 1 ml of 1:1000 adrenaline, 5 ml of 3% sodium bicarbonate) After the area becomes numb this solution is injected at body temperature in the proportion 0.5:1 with 400 ml normal saline, 600 ml distilled water, l ml absolute alcohol, 2 ml of 2 mEq/ml potassium chloride, 0.5 ml verapamil, 0.5 ml of 1:1000 adrenaline, and 5 ml hyaluronic acid.

The main advantages when external ultrasound is used alone are that it is non-invasive, there is a fast recovery time, and there is no morbidity. The disadvantages are unpredictability, it only works for small adiposities, patients with metal prosthesis have to be treated cautiously, there is a possibility of cholesterol increase, and there is a theoretical possibility of release of free radicals. Combined with tumescent liposculpture, clinical results reveal that, although it increases the operating time, because of the application, liposculpture after use of external ultrasound was easier for the surgeon, required less physical effort, and there was less postoperative bruising, swelling, and discomfort for the patient. External ultrasound combined with tumescent liposculpture produced significant physician and patient benefit both operatively and postoperatively [22, 23].

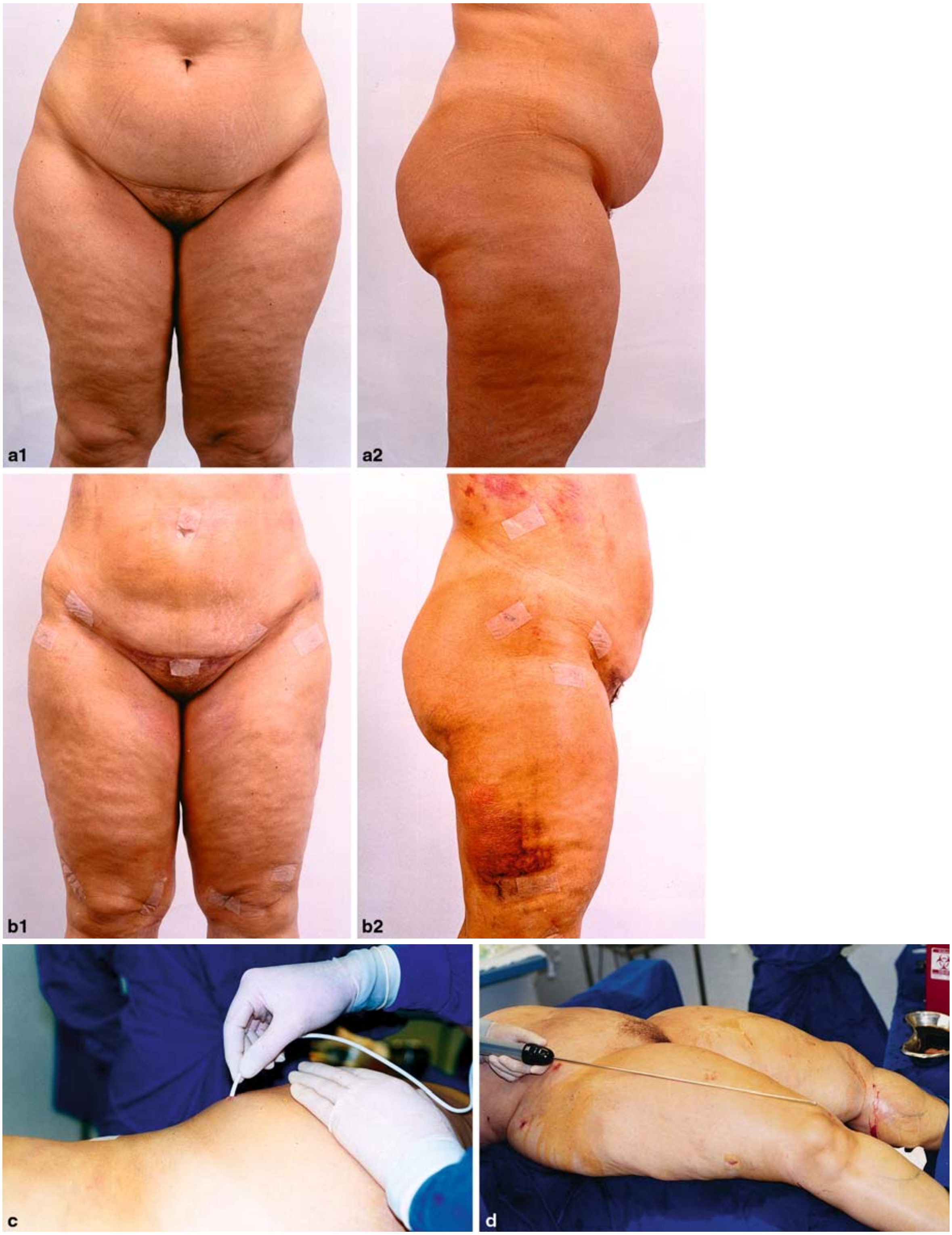

Fig. 20.3. **a** Preoperative patient. **b** Forty-eight hours postoperatively after external ultrasound lipoplasty with a total aspiration of 7,265 ml including anterior thighs, medial knees, lateral thighs, pretibial regions, flanks, back, and arms. **c** Thermometer inserted to measure the temperature of the fat during the procedure. There was a 5°F elevation of the temperature. **d** The anterior thighs were aspirated from the inguinal region and knees with special 45-cm-long cannulas

20.3 Discussion

Syringe liposculpture is a gentler technique than traditional liposuction performed with the aspirator owing to the precision the syringe allows. The syringe is safe, inexpensive, disposable, light, and silent. The aspirator is cumbersome, imprecise, costs a few thousand dollars, and is usually very noisy. Fat aspirated with this machine cannot be reinjected.

When treating the face or small areas of the body, the precision that the syringe gives in measuring fat removed is vital in obtaining an even result. When treating larger areas, the aspirate is precisely decanted and the volumes recorded. With this method the shape of the thighs, legs, and buttocks can be improved according to the patient's needs, remodeling, reducing, and augmenting. The results are different from those of traditional liposuction.

We weigh, measure, and photograph our patients before and at regular intervals after surgery. The possible dissatisfaction of the patients usually ends when they are shown their map recording the precise amounts of fat aspirated from each part of the body. The photographs sometimes do not clearly show the postoperative change if the patient's weight remains the same, it is the measurements that will show the difference.

This precise measurement of aspirated fat is important when comparing sides during the procedure, in keeping the patient's blood and fluid balance records, and also for medical-legal reasons.

With the tumescent technique, large volumes of fluid with lidocaine and epinephrine are infused subcutaneously. There are reports [24] of cardiopulmonary complications and, although they have been few, the anesthesiologist needs to take into account the fluid injected subcutaneously and balance the intravenous solutions injected to avoid this problem.

Preventive antibiotic therapy plus the constant wetting of the skin with an antiseptic solution helps to avoid infection. The instruments are gas-sterilized before use. Liposuction may result in major complications or death, especially when medical personnel are unfamiliar with the possible complications and underestimate the risks. Pain out of proportion to clinical findings is a hallmark of necrotizing fasciitis and should be considered even in the absence of cutaneous signs of infection. A definitive diagnosis is made by biopsy and rapid section histological analysis. In two reported cases of massive necrotizing fasciitis treated in a burn center after liposuction surgery, one patient died, and the second required lengthy hospitalization, extensive debridement, and split-thickness skin grafting of 22% of the total body surface area [25, 26].

Depressions on the body and on the face provoked by previous liposuction can be treated by breaking the fibrous adhesions with the Toledo V-tip dissector cannula, and injecting fat to help prevent the reattachment of these adhesions. I usually do not overinject on the face, but do overinject in the body by 50%. The reabsorption of fat varies from patient to patient, but there is always a significant improvement over the initial result with a second and sometimes a third injection of fat. Retracted scars can be treated without resection by freeing the scar from the underlying tissue with the V-tip dissector cannula. Old scars from cesareans or abdominoplasty can be improved when combined with superficial suction of the surrounding area and the result can be excellent. Scars on the face and neck, acne scars, and facial depressions are treated in the same manner, but with more delicate instruments, in combination with facial procedures.

20.4 Postoperative Care

The incisions of liposuction are not sutured, only the fat injection incisions. Liposuction incisions are covered with sterilized disposable diapers, to collect the oozing of the anesthetic solution for the first 24 h. This oozing of fluid diminishes the swelling and bruising and increases comfort. Patients are informed that there will be some leaking of a slightly bloody solution from the incisions for the first 24 h. Young patients with good skin tone who undergo deep body liposculpture do not usually need to wear a girdle, but they should avoid wearing tight clothes and underwear to prevent marking of the skin. After body liposculpture, elastic adhesive tape is applied and worn for 5 days, plus a girdle for 1 month to control edema and bruising and secure the skin while it retracts to its normal position. If after 24 h the dressing is marking the skin, or the girdle is provoking a depression, the dressing and girdle are removed and manual lymphatic drainage is prescribed to avoid permanent depressions.

Manual lymphatic drainage, a French massage technique, reduces swelling and bruising in the early postoperative days, increasing comfort and reducing pain.

Although rare, infection is always a possibility and 2 g cephalosporin is administered intravenously intraoperatively, then 2 g every 2 h on the first day (a total of 8 g) and 500 mg every 8 h orally for 1 week postoperatively.

20.5 Conclusions

My approach to body contouring does not rely on one surgical technique alone. It is a combination of

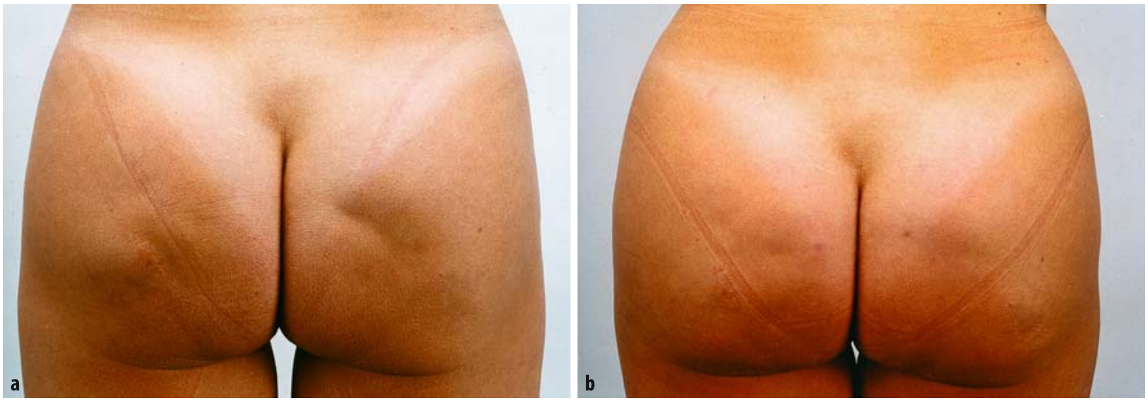

Fig. 20.4. **a** Preoperative 35-year-old patient wanting to improve her dorsal region, flanks, and buttock irregularities provoked by injections. **b** Six months postoperatively after aspiration of 1,920 ml from the dorsal region, flanks, abdomen, and waist. After freeing the buttock depressions, 90 ml of autologous fat was injected into each area of depression

different procedures to obtain the best possible result. The patient should always be aware that the degree of involvement postoperatively is proportional to the quality of the final result (Fig. 20.4).

Body contour improvement does not depend on surgical technique alone. Ideally the treatment should involve different specialties. In many cases one needs to help motivate the patient to a change in life style to obtain a lasting result.

A computer consultation helps the patient understand the limits of surgical improvement and in this way we can establish realistic postoperative expectations. We indicate the degree of patient involvement needed to obtain a lasting result and estimate the improvement according to this degree.

The contour is improved using the syringe liposculpture technique, often with the help of the external ultrasound to facilitate difficult areas and even out the results of the suction; manual lymphatic drainage is recommended from the second postoperative day, when the areas are too sensitive. A high-protein, low-carbohydrate diet is discussed with insistence that patient start walking 2 miles a day on the third postoperative day.

After 20–30 days patients can start exercising, preferably under the instruction of a professional trainer.

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Liposculpture of the Lower Extremities Using a Tourniquet

Kamal Cherif-Zahar, Soraya Bensenane-Hasbelaoui

21.1 Introduction

The calf and the ankles have not been considered good for liposuction because of significant postoperative pain and edema [1–5]. A pneumatic tourniquet, as orthopedic surgeons have used for a long time, allows precise liposculpture without infiltration and minimal postoperative sequelae even in the case of very large extractions [6, 7]. Experience with over 150 cases over a period of more than 7 years, has enabled the authors to formulate some new notions concerning the physiopathology of the heavy legs syndrome and modifications of the surgical technique.

21.2 Definition

Liposculpture of the legs under tourniquet is the extraction of adipose tissue from the inferior extremity (ankle, calf, knee, and inferior third of the thigh) by use of a pneumatic tourniquet, i.e., the ankle, the calf, the knee, and the inferior third of the thigh. This aspiration is performed without tumescent infiltration and after interruption of the blood circulation by inflating the pneumatic tourniquet. The operation begins as soon as the leg is emptied of its blood. When terminated, it is mandatory to place an elastic bandage before removing the tourniquet.

21.3 History

In 1985, Temourian [6] proposed (unpublished data) a liposuction technique under tourniquet but he infiltrated the tissues. In 1993, the authors devised the idea of using a pneumatic tourniquet in a case of adipose excess localized in the ankles, as practiced by orthopedic surgeons for the cure of hallux valgus. The postoperative course and results were surprisingly excellent. The procedure was repeated in other cases with similar encouraging results [8–10].

21.4 Anatomy

No precise description of the distribution of the adipose tissue in the human organism is found in classical anatomy books. Feminine and masculine morphologies are different. The gynecoid distribution results in a particular feminine morphology with excess fat distribution in the hips and thighs. It is, however, necessary to distinguish anatomical varieties according to the degree of excess weight and the morphological type. The underlying conventional anatomy should be considered for both technical and esthetic reasons.

For convenience, the leg is considered as the part of the lower limb situated beneath the pneumatic tourniquet. It comprises regions and spaces:

1. Regions:
   - Inferior third of the thigh included in the knee
   - Knee
   - Calf
   - Ankle
   - Foot
2. Spaces:
   - In reference to a surgical plan, one can consider that the adipose tissue is organized as extractable spaces. They are not partitioned anatomical entities with distinct limits and they are accessible by different surgical approaches.
   - The leg can be divided into four spaces by a sagittal and a frontal plane passing respectively by the tibial crest and the two malleoli. This permits an anatomical division.

   (a) The ankle: This comprises the antero-external malleolar space that extends from the tibial crest at the front to the fibula at the back, with a round inferior limit forming an inferior convexity. The fibula superposes the antero-external muscular compartment. At this level, a cutaneous pinch of the top of the foot can reveal in some individuals a true lipoma in the antero-external compartment. Above this, the

space is in continuity with the anterior surface of the leg.

The postero-external space extends from the fibula at the front to Achilles' tendon at the back. It continues below with the retro and external submalleolar compartment. Above, it continues with the internal adipose space of the knee and the subpopliteal space.

The antero-internal space extends from the anterior tibialis tendon and the tibial crest at the front to the internal malleolus at the back. In some cases, the internal malleolus is surrounded by adipose tissue that effaces its normal contour. Here also, a cutaneous pinch can make a distinction between the zone of excess adiposis and the skin of the foot.

The postero-internal space extends from the internal malleolus at the front to Achilles' tendon at the back. It is prolonged below by the retro and submalleolar space, and above by the internal adipose space of the knee.

The external submalleolar adipose lump at the ankle level is often a true lipoma situated above and slightly in front of the inferior edge of the external malleolus.

(b) Knee: The superior internal knee space is limited anteriorly by the prominence of the vastus internus of the quadriceps muscle, posteriorly by the grand adductor, superiorly by the tourniquet, and inferiorly by the articular interline. In muscular persons, a depression can be observed behind the vastus internus.

The inferior internal knee space is limited anteriorly by the fibular tendon, the anterior tuberosity of the tibia, and the tibial crest. Posteriorly, it continues below with the adipose spaces of the calf.

The supra-fibular space comprises the vastus internus and externus, which meet forming an inverted V, thus limiting the depression observed in muscular persons.

The internal and external subfibular lumps are situated on each side of the fibular tendon and efface its normal contour. At stages IV or V, (see classification infra) the fibula forms a depression in connection with the surrounding zones.

The superior external knee space extends from the vastus externus to the crural biceps tendon.

The inferior external knee space extends from the tibial crest to the relief of the antero-external leg muscle.

(c) Calf: The muscular rounded contour can be covered by a thick panniculus adiposus (a large calf).

A subpopliteal space has been described that reaches from the popliteal fold above to the junction of the pulpy bodies of the gemelli interior and exterior. This space joins the Achilles space. This long and tedious description is more useful for the surgical applications of the technique than the classical anatomical one is.

21.5 Classification

A classification can be established based on both the degree of weight excess and the morphological type:

1. Stage I: Quasi-total absence of adipose tissue. The skin directly covers the osteo-musculo-tendinous plan with no layer of fatty tissue. This is seen in lean subjects as well as in body builders who follow a protein diet.
2. Stage II: The adipose tissue is distributed harmoniously with an effacement of certain anatomical protrusions but with the presence of the bimalleolar and Achilles' tendon contours. This is the case of the famous beautiful legs of actresses and models.
3. Stage III: This corresponds to a light excess of subcutaneous adipose tissue but to the point that in certain zones it can be pinched like a lipoma. The surcharge can predominate at the knee or the ankle or be distributed uniformly. The quantity of fat extracted at this stage ranges from 300 to 400 ml.
4. Stage IV: The adipose excess is quite important and is distributed over the whole leg. It leads to a fading out of the normal contours to the point that the malleoli form a depression. The foot is little or not concerned. The quantity of fatty tissue aspirated can reach 1,500 ml on each limb. Such a situation corresponds to true elephantiasis.
5. Stage V: This is the extreme stage, with veno-lymphatic complications. The lipoedema is permanent. Extractions exceed 1,500–ml.

The authors have artificially defined stages III, IV, and V as a function of the volume of fat extracted. A more precise classification could probably be established, based on the exact assessment of subcutaneous adiposis by an investigation such as magnetic resonance imaging.

21.6 Physiopathology of the Heavy Legs Syndrome and Lipoedema

Improvement of the sensation of heaviness of the legs that is obtained by liposuction under pneumatic tourniquet, while no other apparent cause outside of the adipose excess was in evidence, came as an unexpected event. This led us to a reflection on the physiopathology of heavy legs in general, as well as to propose an explanation of lipoedema.

The notion of lipoedema is not new. It was mentioned in 1940 by Allen, who gave the name of lipoedema to this pathology [11]. In 1949, he defined it as an anatomo-clinical entity, and attempted to establish specific criteria. The literature is scarce on this subject. It recognizes the existence of lipoedema, but does not explain the mechanism nor the treatment [12, 13].

In addition, no mention of lipoedema is found in present-day medical books [14]. However, the notion of obesity is often evoked in the etiology, and a slimming cure is part of the therapeutic attempts to cure lipoedema.

The main data generated by the authors' study are the following:

- The adipose excess of the lower limbs almost always concerns women (99% of our cases).
- The average age is 44 years.
- A family history of adipose excess is frequent.
- The sensation of heavy legs is found in 80% of cases.
- The adipose surcharge is rarely associated with an obvious veno-lymphatic insufficiency (absence of varicosities).
- The adipose surcharge is associated with simple edema rather than lipoedema.
- Large-scale adipose excess simulating the features of elephantiasis is associated with veno-lymphatic disorders. Such a notion is found in the literature.

The physiopathological mechanisms of edema of the lower limbs are well known in general etiologies such as cardiac, renal, and veno-lymphatic insufficiencies, hypoproteinemia, etc. However, they are still poorly known in cases of isolated adipose excess. Therefore, how can one explain these edemas and this heaviness of the legs in so many patients with no apparent veno-lymphatic pathology, and no cardiac or renal disorder?

When an adipose dysmorphia exists, even discrete, the increase in the quantity of tissue that must be oxygenated and nourished augments the local arterio-veno-lymphatic flow in proportion. Likewise, the interstitial space increases in parallel to this augmentation of the flux of interstitial liquids. At this stage, the edema stays discrete in situ, but it is already symptomatic.

Beyond a certain increase in the flux associated with larger adipose excess, the capacity of veno-lymphatic adjustment may be overrun. This occurs by outbreaks upon the occasion of a prolonged sitting or standing position (e.g., long-lasting flights), by water retention of alimentary origin (meal too rich in NaCl), or by a hormonal cause (pregnancy, second part of menstrual cycle). Edema with pitting on pressure or an impression left by the stocking can be observed. This edema can be resorbed by a reclining position or avoided by an elastic support (varicose stockings).

In extreme adipose surcharges, the increase of the interstitial flux proportional to the quantity of tissue to nourish creates a larger edema that cannot be resorbed by rest or a change of position. The chronic functional lymphatic insufficiency finally results in organic lesions. This corresponds to the stage of elephantiasis, similar to a classical and unilateral one, which is secondary to an initial disorder of the lymph ducts.

21.7 Surgical Technique

In most cases the operation is performed under general anesthesia with endotracheal intubation. Sometimes a loco-regional anesthesia is administered (e.g., peridural) but never a purely local anesthetic.

During the whole surgical intervention the patient is placed on dorsal decubitus. The pneumatic tourniquet is placed on the mid thigh. Two pneumatic tourniquets, one or two sterile Esmarch bandages, an aspiration pump, several cannulas of gauges 2, 3, 4, and 5 mm, or Fournier's syringes [2, 14] are required for this intervention. The antiseptic must not erase the marks on the skin. The surgeon should check that all the equipment is ready for use in order not to lose time, because the tourniquet imposes a limited operation time of 1 h maximum.

The choice of approach is guided by two factors: (1) the cannula must stay parallel to the main axis of the leg and (2) the scars should be the least apparent possible and as few as possible. Eight incisional approaches of a diameter of approximately 3 mm are prepared without necessarily using all of them.

1. At the ankle there are four approaches:
   (a) Antero-internal: situated at one-finger width in front of the anterior edge of the malleolus internus

(b) Postero-internal: situated in the middle of a line extending from the malleolus internus to the heel
(c) Antero-external: situated at mid-distance between the malleolus externus and the anterior tendon of the leg at one-finger width towards the outside
(d) Postero-external: situated in the middle of the line joining the malleolus externus to the heel

2. At the knee level there are three approaches:
   (a) Internal: situated at the junction of the internal and external meridians of the leg and the thigh
   (b) External: situated at one-finger width above the contour of the peroneal head
   (c) Sub-fibular: Situated at the level of the superior edge of the fibula
3. At the calf level there is one approach. Posterior: situated at the median part of the gastrocnemius muscle (calf) between the contours of the gemelli externus and internus at the level of their musculotendinous junction.

21.7.1 Measurements

Starting at the inferior edge of the malleolus internus, the perimeters of the leg are measured every 5 cm with a measuring tape, and marked on the skin. These measurements are taken all along the leg up to the tourniquet.

21.7.2 Operation Tactics

- The leg is emptied of its blood with the help of an aseptic Esmarch bandage (Fig. 21.1).
- The tourniquet is inflated to 30–35 mmHg.
- The Esmarch bandage is removed as soon as the tourniquet is inflated.
- The iIncision is at the selected accesses previously marked with a felt-pen marker.
- The adipose extraction should be fan-shaped, homogeneous, and regular.

Experience has enabled us to develop and codify all of the surgical maneuvers for a complete sculpture of the leg. Short (3–5 mm) incisions are used in the direction of the natural fold and in positions that permit the best access to the areas of liposculpture (Fig. 21.2). Surgery is begun with the ankle at the end of the operation table, with the surgeon seated on a stool. The excess fatty tissue of the anterior external space is emptied by an antero-external incision, followed by the antero-internal space of the ankle by an antero-internal incision, the internal retro-malleolar groove is hollowed out via a postero-internal incision, and the postero-internal space is treated. A postero-external incision of the ankle is used to hollow out the external retro-malleolar groove and the postero-external space is sculptured.

Subsequently, with the surgeon standing at the right of the table at knee level, the internal side of the knee towards the lower end is incised, which permits the sculpture of the whole internal face of the leg. Moving to the left of the table, an incision and a fan-shaped extraction are performed in the direction of the anterior tuberosity of the tibia and the subfibular area and continuing without stopping, we return backwards to the right and upwards to the left supero-internal space.

With the leg flexed, its external face is treated via an external incision of the knee. With the leg in extension and in internal rotation, while the surgeon is standing at the end of the table, there is access to the external subfibular adipose lump, to the external edge

Fig. 21.1. Esmarch elastic bandage is applied and then the tourniquet is inflated

Fig. 21.2. Incision sites are marked at the ankle and the knee

of the fibula, and, with the knee in flexion, to the external superior space of the knee.

The supra-fibular space of the knee can be aspirated either in flexion or in extension via a fibular incision, then turning interiorly towards the superior internal space of the knee and the internal subfibular adipose lump. The same fanlike gesture permits the passage from the vastus externus to the tibial crest.

Lastly, via a posterior incision of the calf with the hip flexed, the knee in extension, and the foot held in flexion by the assistant, the Achilles' tendon, the calf, and the subpopliteal space can be precisely sculptured. The leg is transformed and sculptured according to the patient's request.

During the surgical procedure, a notice of the elapsed time is given every 10 min. Whether the incisions are closed or not depends on the surgeon's habits. The measurements of the leg circumference are taken again, noted, and photographs are taken at the end of the operation. They will serve as a reference for a procedure on the other leg.

The fat collected is pure yellow without any blood (Fig. 21.3). It takes approximately 30 40 min to do one leg and the other leg is operated on in a similar fashion (Fig. 21.4).

A large aseptic operative field isolates the opposite leg. Compression is mandatory before removing the tourniquet (Fig. 21.5). It consists of an elastic bandage by a double stocking for varicose veins (70 deniers) and then by a superposed elastic band of Biflex type. When the tourniquet is released, the capillary pulse of the toes is closely monitored after cutting off the stocking at toe level.

The fat volumes extracted from each space are noted during the operation in order to aspirate the same amounts on the other leg.

Fig. 21.3. Three liters of fat with no blood

Fig. 21.4. **a** Right leg with completed liposculpture with tourniquet. **b** Posterior aspect on an other patient

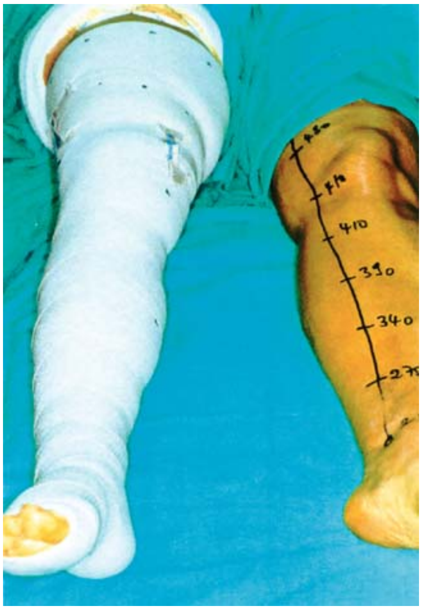

Fig. 21.5. Compression dressing applied to the leg

21.8 Postoperative Period

The immediate postoperative course is usually simple, with pain remaining moderate in spite of the large amounts of adipose tissue extracted. Edema and ecchymosis are practically absent. Patients are authorized to get up the next day. The day after surgery it is possible for stage III patients to go home, while one or two more days may be necessary for stage IV and V patients.

Sutures are removed between the eighth and the tenth days. Postoperative visits are made on days 1, 2, 6, 12, and 30. Compression devices are kept on for 1–2 months.

21.9 Complications

The authors observed five undesirable events. They were diverse in nature, but none of them were really serious or unresponsive to appropriate therapeutic actions.

The worst adverse reaction was in a patient who developed a paralysis of the popliteus externus. The latter was attributed to the slipping of the elastic bands due to movements of the knee. This induced a compression of the external popliteal branch of the sciatic nerve. Since then, we have abandoned the use of two elastic bands applied directly to the skin. We prefer compression by a pair of tights for varicose veins. The elastic bands put in place at the end of the intervention are then definitely removed o1 h later.

One case of a unilateral cellulitis was observed in a diabetic patient. The infection was treated and rapidly cured by several small cutaneous discharge incisions combined with antibiotics.

A case of major edema occurred after a large adipose extraction (1,500 ml) in one patient who returned to work the next day, in spite of our advice not to do this. The edema regressed after 3 months and the result after 1 year remained excellent.

In two cases, in the course of the operation the tourniquet let go on one leg. In one of these cases, the surgery was continued without putting the tourniquet back. The immediate postoperative consequences were simple for the side where the tourniquet stayed in place but there was more edema, pain, and ecchymosis in the leg where the tourniquet let go. Thus, we had the unsolicited opportunity to compare the two methods.

In the other case, the blood of the leg was reemptied by the use of an Esmarch bandage and the tourniquet was reinflated. The aspiration was carried on including both the adipose tissue and the extravasated blood. In this case, the immediate postoperative reactions were the same for the two legs.

21.10 Discussion

In our series of patients we did not control the results of the treatment by comparing the classical technique on one leg and the technique under tourniquet on the other leg, except for one case. Obviously, such a comparative approach would be of interest for a more rigorous evaluation of the procedure.

With respect to the complications, the authors observed a rate of 3.4% in 150 cases. There was no occurrence of life-threatening or otherwise major adverse events. In a review of the literature looking for potential complications associated with the use of pneumatic tourniquet, one can find mention of hemodynamic and biological changes such as an increase of the P_{CO_2} and a decrease of the P_{O_2}. These changes are rare and, when present, are temporary, and follow the release of the tourniquet. Most often, this occurred in older patients.

Phlebitis and pulmonary embolism represent the most frequently reported complications because of the use of the tourniquet [7]. These problems have been reported by orthopedic surgeons, who are the main ones to use pneumatic tourniquets. Our logical theoretical response is that if there is no blood there will be no clot. Correct emptying of the blood of the lower limb before inflating the tourniquet is mandatory and

Fig. 21.6. **a** Preoperative patient with lipodystrophy of the legs. **b** Postoperatively following liposculpture with the tourniquet

can avoid the formation of clots since the vessels are emptied of their blood.

Liposuction under tourniquet offers several significant advantages:

- No infiltration of solution is necessary. This not only permits a valid appraisal of the quantity of fat extracted, but also a satisfactory sculpture because of the absence of injection-induced modification of the form of the leg to be operated upon (Fig. 21.6).
- The absence of bleeding during the surgical procedure prevents the modification of the anatomical form that would occur by infiltration of the tissues. It thus permits a sculpture that corresponds to the precise image of the final result.
- Ecchymosis is rare and only minor.
- Pain and postoperative edema are practically absent, which permits early walking and a reduced length of hospital stay.
- Patients can rapidly return to their socio-professional activities, usually 1 week after the operation.

Liposuction under tourniquet also presents a few drawbacks:

- The absence of local anesthesia leads to the prescription of larger amounts of analgesics generally administered during the first postoperative hours.
- The duration of the procedure is limited by the use of the tourniquet. We voluntarily limit this time to 1 h. This is usually sufficient to achieve a complete sculpture of the leg. For large extractions, cannulas of larger gauge are used and touchups are left for a second operation.
- This technique does not permit the treatment of areas above the tourniquet during the same operating time, leaving them to be operated on secondarily by the classical technique.

21.11 Conclusions

Liposuction under a pneumatic tourniquet of the leg permits the treatment of zones that are known to be difficult and of which the indication has been challenged up to now. The results obtained over a 7-year period of time were most satisfying esthetically with the precision of the sculpture of the leg having never been achieved before. The unexpected functional improvement has led to a better understanding of the physiopathology of the heavy legs syndrome and of lipoedema.

Acknowledgement The English translation was by Andre Morin. Portions of this work are reprinted from Ref. [10] with permission from the *International Journal of Cosmetic Surgery and Aesthetic Dermatology*, Mary Ann Liebert, Inc.

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Liposculpture of the Trunk

Giorgio Fischer

22.1 Introduction

Before the advent of liposuction there was really little that could be done about shaping the upper part of the body. The trunk consists of the upper and lower abdomen, the flanks, the back, and the mammary region. All of these areas are very important when taking into consideration the silhouette of a person. With liposculpture, not only can large volumes of fat deposits be reduced in this area, but it can also give a new shape to the body.

Cosmetic surgery of the abdomen started in the nineteenth century. Between 1890 and 1910 several authors described the technique of dermolipectomy. In 1967, Pitanguy [1] published his work on abdominal lipectomy. It was his experience that gave all of us the opportunity to understand the basic principles of abdominoplasty. Nevertheless, our patients hardly accept evident scars. It is for this reason that the concept of modeling the abdomen has radically changed since the introduction of liposuction techniques.

22.2 Anatomy

The anatomical characteristics of the abdomen are very important to take into consideration. The surface anatomy of the abdomen can de subdivided into the epigastrium or upper abdomen, the hypogastrium or lower abdomen, and the mesogastrium or midabdomen, which contains the periumbilical and waist areas (Fig. 22.1).

Some areas of the abdomen appear very difficult to defat and this is mostly because of the presence of numerous fibrous septa, especially in the waist area and in the upper abdomen. The upper abdomen is a very challenging area since the presence of this large amount of fibrous tissue can be responsible for unaesthetic postoperative wrinkles. Nevertheless, Scarpa's fascia does not exist in the upper abdomen and if too much fat is taken away from this area there is no possibility that this fascia, existing only in the lower abdomen, may alleviate the adherences of the fibrous tissue to the skin.

The back or dorsum is a very large area if we consider it from the scapular region down to the upper gluteal region. The muscular area of the back is vascular in the deep part near the fascia. There are two major areas where fat deposits occur in the dorsum. One is underneath the scapular region above the lower costal margin, in the bra area, and the other one is lower in the hip area.

22.3 Abdominal Liposuction

According to my experience, with the introduction of liposuction, original abdominoplasty is rarely required. Liposuction should not be performed when little fat is present, with large skin aprons or extended stretch marks, and in the presence of muscle diastasis. To those patients who are not good candidates for liposuction I propose a two-stage operation. The first stage is liposuction and the second stage a mini tummy tuck if, after 6–8 months, skin retraction is not satisfactory. Most of my patients appear to be happy only with the first stage. The abdomen in fact has excellent retracting capacities, especially in young patients. Today 90% of surgical abdominoplasties are treated with liposculpture.

The technique for the abdomen does not differ very much from that of other areas of the body. Liposculpture of this area can really change the silhouette of a person. There are areas in which care must be taken, such as the upper abdomen, where excessive defatting might result in rugosity after the postoperative edema has passed. This happens mainly in older patients with decreased skin elasticity.

The preoperative evaluation of the patient is very important. The patient should lie down and then lift the legs up in order for the abdominal muscles to be evaluated. Liposuction alone is not done if there is significant diastasis of the rectus abdominal muscles. Preoperative photographs are taken and the patient is marked.

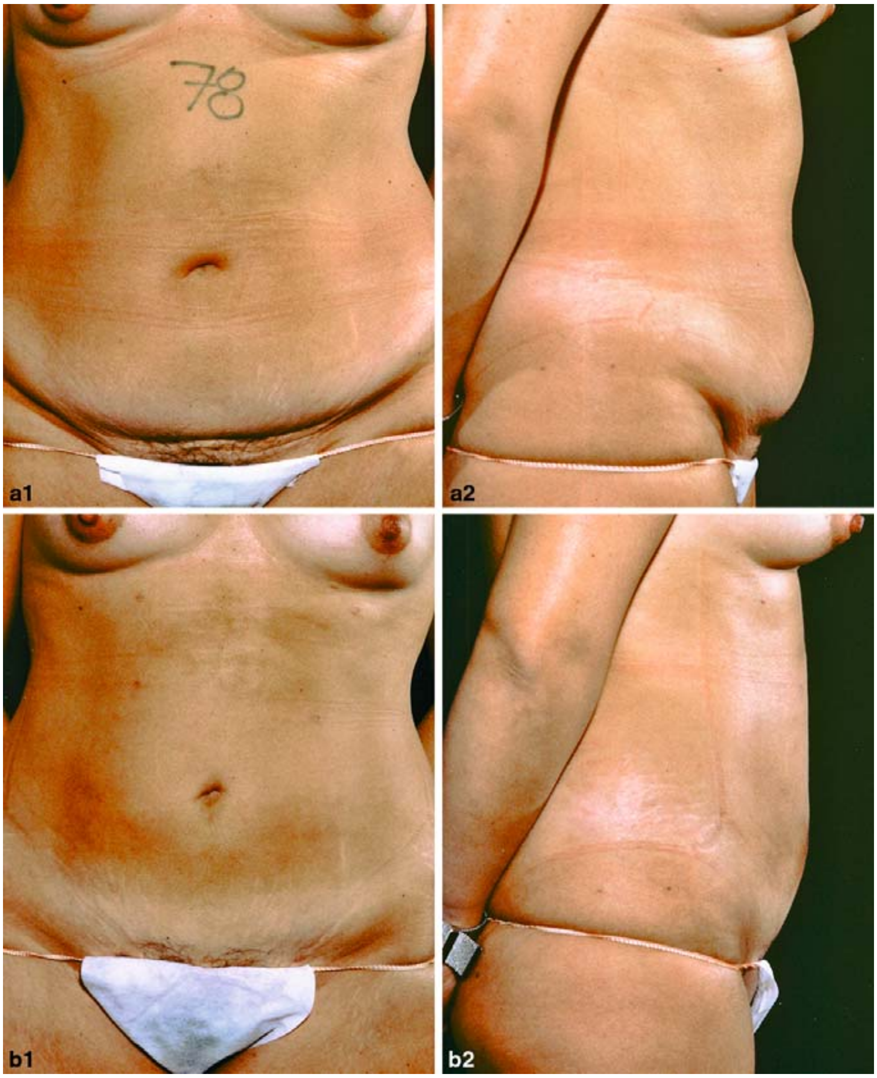

Fig. 22.1. a Preoperative patient. **b** Postoperatively following abdominal liposuction

In the operating theatre I explain to the patient how the orthostatic bed works and the anesthetist then starts sedating the patient. Liposculpture of the abdomen should never be made under general anesthesia. If muscle relaxation is present, intestinal perforation could occur. Moreover, the patient should be able to contract the abdominal muscles whenever asked to do so during the operation.

A modified tumescent solution is used with the same amount infused as will be removed. Real tumescent infiltration gives an excessive dislocation of the fat, making it very difficult to sculpt the body. After infiltrating, these areas are massaged energetically in order for the liquid to spread evenly.

The orthostatic bed makes it possible to work in a natural everyday position on the body of the patients. As usual, the major debulking is made in a slight Trendelenberg position, then the patient is placed in an orthostatic position where the force of gravity can no longer give false effects.

Tunneling is begun with my harpstring method. Generally four or five incisions are enough for the whole abdominal area. No importance should be given to the number of incisions made. The only important thing is to crisscross in the correct way. Tunneling should always be made in a vertical manner. Two incisions are suprapubic. From the left one I crisscross on the right side of the abdomen in a clockwise direction, and the opposite happens for the right incision. Another incision is placed over the umbilicus. From this incision I crisscross to the right and to the left. Other incisions can be placed under the breast so as to tunnel in the opposite direction. Of course different situations require different incisions.

It is important to always work on a wet surface in order to allow the gloved hand to appreciate what it is touching. I work with my left hand flat on the surface of the abdomen until I am concerned about the diminishment of the volume. Then I start pinching and rolling in order to evaluate the thickness of the remaining fat. A certain amount of subcutaneous fat should always be left. You should always feel unhappy at the end of your operation thinking that you could have taken away more. The important thing is what you leave not what you remove. Good and expert surgeons are only able to imagine what will be.

Because of the particular anatomy of the abdomen, I do heavier liposuction on certain areas of the abdomen in order to give a better silhouette to the patient. The midline between the costal margins contains a lot of fibrous tissue and fat can at times be difficult to remove, but when possible I take away more fat in that area than in the surrounding ones in order to give a depressed effect. I do this for patients that want an athletic abdomen similar to a culturist's one. Also, I remove more fat in the triangle above the mons pubis and beneath the umbilicus. This gives more roundness on the left and right sides of the lower abdomen, which gives it a very feminine appearance. Sculpturing the waist is also a very important aspect of abdominal liposuction. This goes along with liposculpture of the higher hips.

When the operation is completed, the operated areas are massaged with a steel tube. One of the tubes is smooth and the other is corrugated. The areas are in this way smoothened out. Later, 3M Reston foam is applied, which prevents bruising. Over Reston foam the patients wear two pairs of garments. One is two sizes larger and is the one that has to go over the Reston foam. Another one is only one size larger because it will easily fit over the other one.

After 4 days the patients begin massage sessions that will be for 2 months. Postoperative massages are very important for the abdomen because those fibrous areas will get very swollen after the operation and massage is fundamental in order for the postoperative edema to go away and to reduce the probability of permanent lumps.

Patients are told that they should never sit at a 90° angle for at least 1 month. This would increase the probability of having wrinkles on the skin surface that would take a lot of time to resolve (Fig. 22.1).

22.4 Liposuction of Flanks and Hips

The flanks are another very important area to take into consideration. They may be treated together with the lower abdomen or sometimes as a single procedure. Fat deposits in this area are a secondary sexual trait in males. It is frequent to observe these fat deposits even in skinny patients. The presence of fat in this area, especially for women, may be very unaesthetic.

Patients are marked and photographed in the usual way. Tumescent fluid is infiltrated in the same amount that we think we will remove. Tunneling should always be done in a vertical manner. The technique does not differ very much from that of other parts of the body (Fig. 22.2).

22.5 Liposuction of the Back

The back or dorsum is a very large area but excellent results can be observed after liposculpture of this area. It is usually done as a single operation and not combined.

In women, the bra makes the fat deposit look even worse. When fat is present in the back it tends to deposit in a "curtain manner".

The technique in general does not differ from that of other areas of the body except for certain points. In this case I use real Klein [2] infiltration by infiltrating twice as much as I think will be taken out. Four incisions are made. Two are underneath the area to be treated (one on the left and one on the right) and two are over the area to be treated. In this way the tunnels can be made in a crisscross fashion. The direction of the ribs must be followed and one should not tunnel perpendicularly to them. Care must be taken to stay away from the muscle since it is very vascular and we do not want excessive bleeding. This is the main reason why I infiltrate so much in this area.

The back is not an area I do in one single session. Patients are always told that they will need a second operation. In the first operation deep liposculpture is done and in the second procedure superficial liposculpture is done. This is an area where skin retraction is of the utmost importance. For this reason I consider it both an intervention of debulking and of superficial refinement. Superficial liposculpture gives the skin the opportunity to retract.

At the end of the operation the treated areas are massaged with a steel tube so that they can even out. I finally pinch and roll test the area in order to evaluate any irregularity. The wounds are sutured and 3M Reston foam is applied. The patients must start massage sessions on the fourth postoperative day. The massages have to be very deep. Since very little subcutaneous tissue will be left after the operation, if they do not undergo massage, adherences may come especially in the costal areas, after the postoperative edema has resolved (Fig. 22.3).

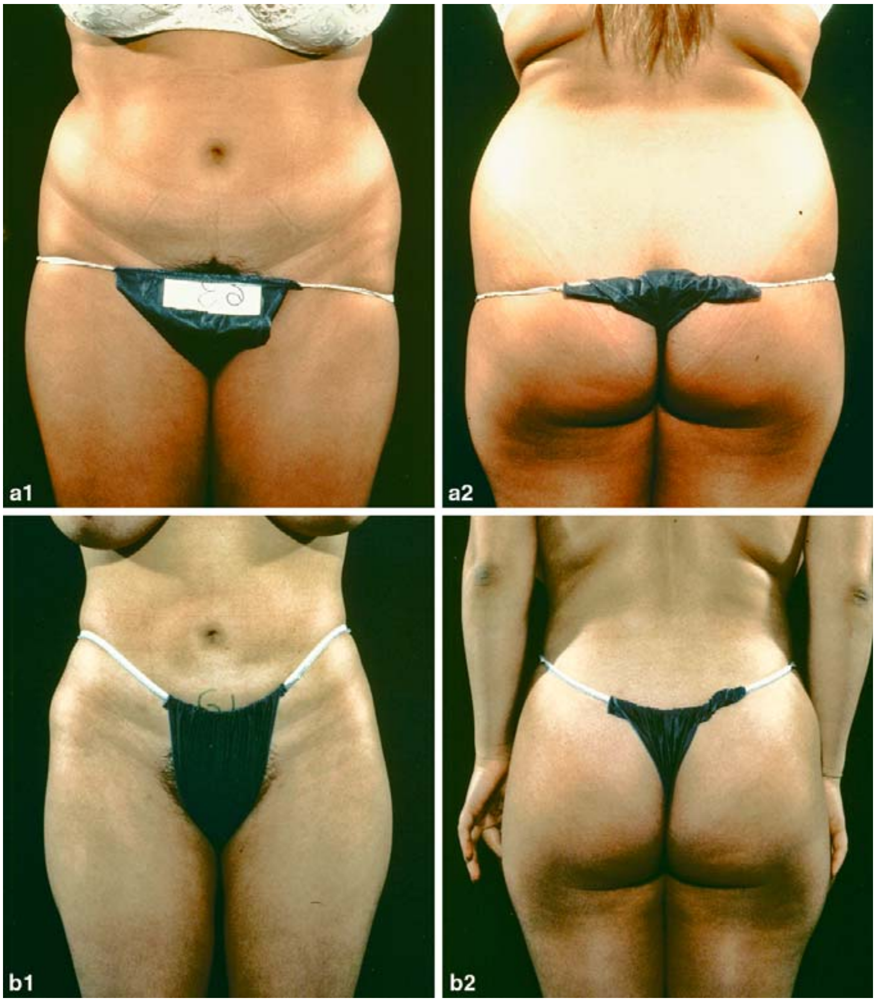

Fig. 22.2. a Preoperative patient. **b** Postoperatively following liposuction of the hips and waist

22.6 Liposuction of the Brachial Area

Another area that can be treated as being part of the trunk is the brachial area. Women really do not like fat deposits in this area. One incision is made under the axillary area and one near the elbow. Tunnels are made in the classical manner. The results for this area can be very satisfying.

It is very important in this area not to debulk excessively because of the skin relaxation that can occur. Patients should be instructed to do gymnastics after the operation.

22.7 Liposuction of the Mammary Area

The mammary region is also part of the trunk. In this region fat deposits are frequent in men and are called gynecomastia. True gynecomastia in which the mammary gland is hypertrophic must be distinguished from a false one in which the gland is normal and only fat is present. Before treating gynecomastia, it is very important to establish if it is a symptom of a disease. The presence of estrogen-producing tumors, hepatic cirrhosis, and even drug abuse may be responsible for gynecomastia. A complete hormonal screening should be prescribed for the male patient.

Before the advent of liposuction all gynecomastias were treated surgically. The results of these operations were not very pleasant and ended up in very irregular surfaces, hematomas, and also necrosis of the areolar complex. Liposculpture has eliminated a number of these complications. Liposculpture is indicated in all cases except in true gynecomastia. The gland in fact cannot be removed through liposculpture. When there is presence of both fat and gland, the surgical removal of the gland can be performed together with liposculpture or after several months in a second session.

The patient is marked and photography are taken. Infiltration is done with the modified tumescent

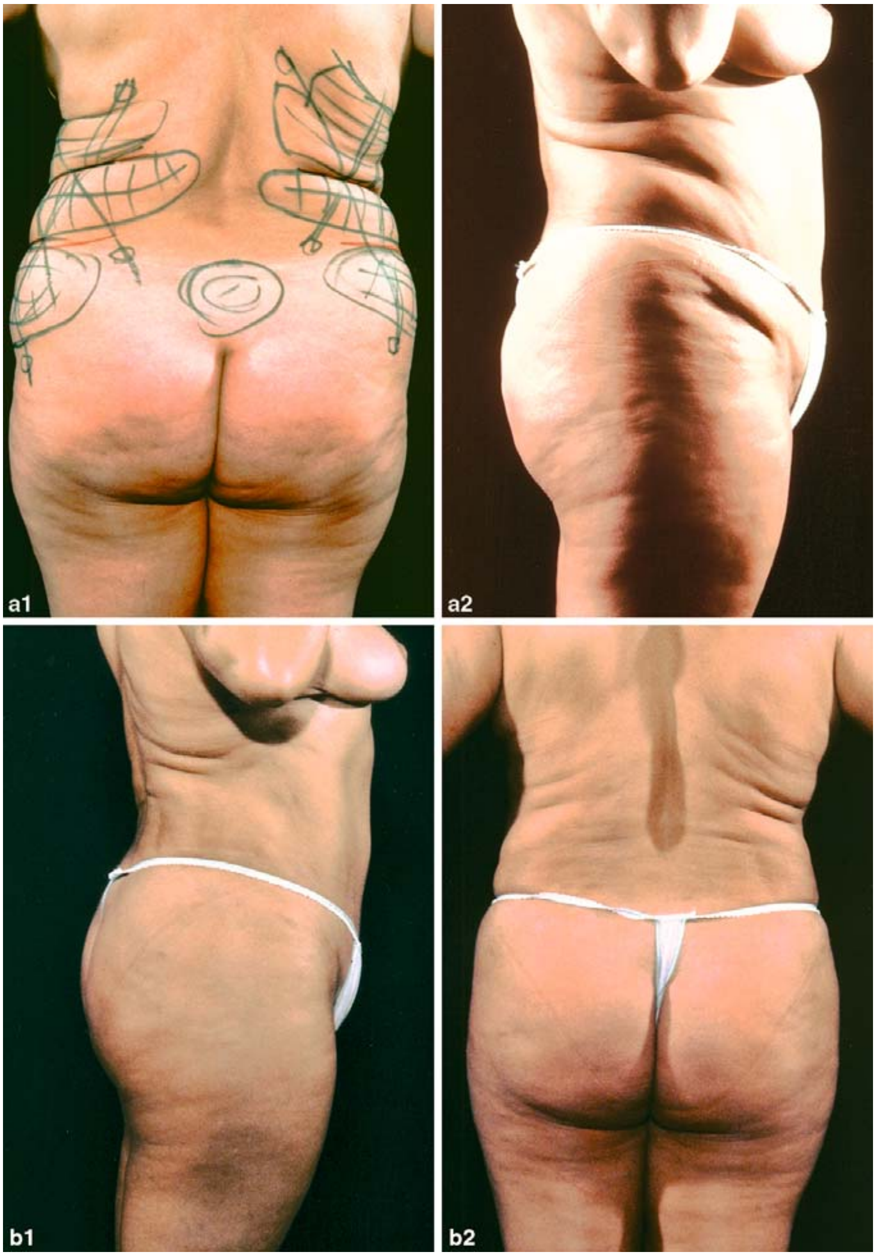

Fig. 22.3. **a** Preoperative patient. **b** Postoperatively following liposuction of the back

technique. Incisions are made in the sternal region, one on the left side and one on the right. In this way we can tunnel following the course of the pectoral muscles. If some gland is present, a periareolar incision should be made.

Reston foam and bandages are always applied after the operation and kept in place for 3 days.

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23 Liposuction and Dermolipectomy

Ivo Pitanguy, Henrique N. Radwanski, Barbara H.B. Machado

23.1 Introduction

Before the advent of modern plastic surgery, body contour alterations were reluctantly accepted and hidden under heavy clothing. Not until the second half of the last century did medical advances permit, for the first time, the surgical correction of contour deformities. Currently, the exposure of the body by revealing attire together with the desire to demonstrate fitness and youthfulness in an increasingly competitive society have created a stereotype model of slimness that is constantly reinforced by mass media and propaganda. This greater consciousness of the human form is further emphasized by the high value placed on physical beauty, especially as regards the female body, where social and professional success is often a consequence of attractiveness.

On the other hand, sedentary lifestyle and dietary excesses, associated with factors such as genetic determination, pregnancy, and the aging process, contribute to alterations of body contour that create a strong psychological motivation for their correction. Localized fat deposits and skin flaccidity are sometimes resistant to the sincerest effort in weight loss and sport activities. This ever-increasing request for contour surgery has been favorably met by safe anesthesiology and efficient surgical techniques, resulting in a high degree of patient satisfaction.

23.2 Technique

Correct diagnosis of contour deformities should include a detailed history of weight fluctuation, endocrinologic status, careful physical, and photographic inspection. The relationship between "content and container," that is, the amount of excess fat and skin flaccidity, is an important aspect that will determine between a procedure with minimal incisions, such as liposuction (also called suction-assisted lipectomy), and surgical resection of excess tissue (i.e., dermolipectomies). Finally, the patient's psychological motivation should be investigated in detail, in order to avoid expectations that are unacceptable or impossible to accomplish.

Whenever a dermolipectomy is deemed necessary, the position and extent of scars should be carefully described and demarcated. Explanation regarding the healing process helps patients understand how scars will become more acceptable over time. The possibility of combining procedures should be considered. Factors that determine the feasibility of operating on more than one anatomical region in a single operation include the patient's status (general health, age), anesthetic considerations (total amount of drugs, accumulative blood loss), and the correct training of the surgical team. In combined procedures, it is most important that the surgeon act as the leader in directing his or her assistants and nurses, so that each step is anticipated, with no loss of movement or time. The senior author has described this as an "orchestration" of the surgical team.

There has been an evolution of the different techniques for the correction of body contour deformities, as performed by the senior author in over 4 decades of experience [1–20]. While it is true that liposuction has attained a position of great popularity owing to its efficacy and safety when well-indicated, redundant skin and adipose tissue may only be removed by surgical resection. This is particularly true of secondary cases that have been initially treated with liposuction alone and are seen to have a poor aesthetic result.

23.3 Surgical Techniques

The number of indications for excisional body contour surgery has decreased substantially since the advent of liposuction in the late 1970s. For example, dermolipectomy of the trochanteric region as well as the medial thigh, which were relatively common, have become more limited. Nevertheless, this approach is still indicated in cases where significant skin flaccidity is present, either alone or associated with increased adiposity. On the other hand, there are a few cases in which we do not indicate aspiration, such as below knee level. Ultrasound-assisted liposuction, although shown to have good results in the hands of some colleagues, has not been adopted in our service.

23.3.1 Liposuction

Liposuction has proved to be an excellent technique in cases of moderate fat accumulation with no cutaneous flaccidity. This may be performed in many different anatomical regions simultaneously, in association with other procedures or by itself. In the gynecoid type of fat distribution, which is typical of the female patient, fat cells are actually hyperplastic, and accumulate on the lower abdomen, thighs, and buttocks. This explains why women have greater difficulty in mobilizing this type of adiposity. Suction-assisted lipectomy is particularly efficient in treating this form of lipodystrophy (Fig. 23.1).

Patients that present with accentuated lipodystrophy are informed that staged procedures will be planned in two or more sessions. An interval of at least 6 months between each session is considered ideal. This program avoids removing large amounts of fat, and minimizes metabolic, electrolytic, and hemodynamic alterations. Just as importantly, this staged approach permits a more gradual accommodation of the skin.

Demarcation of the areas to be treated is done preoperatively with then patient in a standing position and preoperative photographs are taken at the office from different angles, which will serve to guide the surgeon during the actual procedure. On the day of surgery the patient is marked and then lightly sedated before entering the surgical suite. After appropriate anesthesia, local infiltration is done with 0.25% lidocaine and epinephrine (1: 500.000), even if the patient is under general anesthesia. The amount that is infiltrated depends on how much is expected to be aspirated. The wet technique is indicated for small-to medium-volume aspiration, whereas the tumescent technique is reserved for removal of large quantities of fat.

The appropriate cannula is chosen and inserted through a stab incision in a natural crease. Pretunneling (passing of the cannulas with no vacuum) serves to establish the correct planes. Care should be taken to preserve connections between the subcutaneous tissue and the skin to avoid interrupting superficial innervation and vascularization, allowing for adequate lymphatic drainage. Therefore, superficial liposuction has to be done with moderation.

With the cannulas connected to the aspirator, smooth strokes are applied in a fan-shaped fashion, in different planes of the subcutaneous tissue. Inspection of the regions and palpation serve as guides to check for adequate and equal removal of adiposity. By introducing the cannula from a different incision, crisscrossing is established. A feathering pattern should be applied, so as to smooth the edges of the demarcation.

Fig. 23.1. a Areas to aspirate are exactly the same as the demarcation for the classic riding-breeches technique. Liposuction may be thus considered as a "closed riding breeches technique." **b** Result from a simple liposuction after 6 months for a 27-year-old woman

With experience, the surgeon will "feel" how much fatty layer should be left. This is approximately 1–2 cm (depending on the anatomical region) and serves to protect the overlying skin while avoiding unsightly depressions and adherence of skin to muscle. It is better to err on the side of less removal, than to have to proceed to immediate correction of irregularities with fat injection. In our service, the largest case has been the removal of 9.8 kg, from a patient weighing 83 kg. This was done under the tumescent technique.

In the postoperative period, fluid replacement is dependent on the preoperative status, the amount aspirated, and hematocrit in the first 24 h. The following routine has been established. Replacement is done with saline solution, Ringer's lactate, or glucose for small-to medium-volume aspiration. Plasma expanders may be indicated for larger volumes. In the patient that presents with a low red-cell count, blood replacement is utilized. This may be planned ahead, by either autologous transfusion or by hemodilution, which is done immediately before surgery.

Collection of autologous blood for transfusion is begun 30 days preoperatively by banking 600 ml of concentrated red cells in two stages (15 days apart) or 800 ml of whole blood, also in two stages. Hemodilution implies the removal of whole blood before surgery, with rapid infusion of Ringer's lactate or normal saline. This causes a decrease in blood loss in the aspirate and retains 400 ml of whole blood to be infused at the end of the procedure.

The patient is given large amounts of isotonic fluids in the first week postoperatively. Dermotony (mechanical deep massage) is begun after 10 days, to free fascial adherences and even out small irregularities. The use of compressive, elastic garments is continued from the immediate postoperative period through the first 2 months.

In a personal communication, Illouz made the following comments regarding liposuction:

> Although we are favorable to safe scientific innovations, many of the alterations that were done to the classical procedure have created more problems than solutions. I think that, to deviate from the classic, simple technique, one should be very careful, assuring that there are true advantages. Megaliposuction, which is the removal of more than 10% of the patient's body weight, should only be considered with great reserve. On the other hand, the infiltration of more than 1 to 1.5 times the amount expected to be aspirated may cause substantial hemodilution, with consequent hemodynamic effects. This is especially true if lidocaine is used.

23.3.2 Dermolipectomies

23.3.2.1 Trochanteric Dermolipectomy for Correction of Drooping Buttocks and Interfemoral Flaccidity

Prior to the advent of liposuction, this procedure was used for most cases of large trochanteric lipodystrophy and offered satisfactory results when well understood and executed. Although the treatment of choice is currently liposuction alone, in very large deformities this surgical technique associated with liposuction can result in a very satisfactory contour while maintaining well-hidden incisions. This is particularly effective for the treatment of interfemoral flaccidity and the heavy, ill-defined drooping buttocks. The patient must be properly informed of the placement of final scars and should actively participate in decision-making, understanding that there will be a definite enhancement of contour, while accepting the inevitable scars.

There have been many secondary cases of trochanteric lipodystrophy referred from other services that had been treated by liposuction alone and were more satisfactorily addressed by the dermolipectomy procedure.

With the patient in the standing position, the areas to be corrected are marked. The planned excision of skin and subcutaneous tissue corresponds to a fusiform area that extends laterally and upward toward the anterior–superior iliac spine and medially along the inner aspects of the thigh (Fig. 23.2). This incision may be extended to the inguinal region in cases of associated anterior crural flaccidity. The inferior segment of the demarcation falls in the gluteal crease.

The incision is carried out initially along the superior border of the demarcated area and the flap is lifted off the aponeurosis and undermined, including the lateral depression that is sometimes present. The inferior flap is then advanced upward in three vectors: superiorly, medially, and laterally (Fig. 23.3). The excess tissue is excised in segments, equally distributed, and adapted to its new bed. Recently, a smaller resection for the treatment of the drooping buttocks was performed, associated with liposuction of the flanks and trochanteric region. This technique can also be associated with liposuction of the inner thighs and the knee (Fig. 23.4).

Interfemoral flaccidity is corrected by dermolipectomy, placing the scar in the natural crease. Excessive tension on the flap must be avoided, especially medially, so as not to cause the pulling down of the labia majora. The resultant scar should be well disguised within the gluteal and inguinal folds (Fig. 23.5).

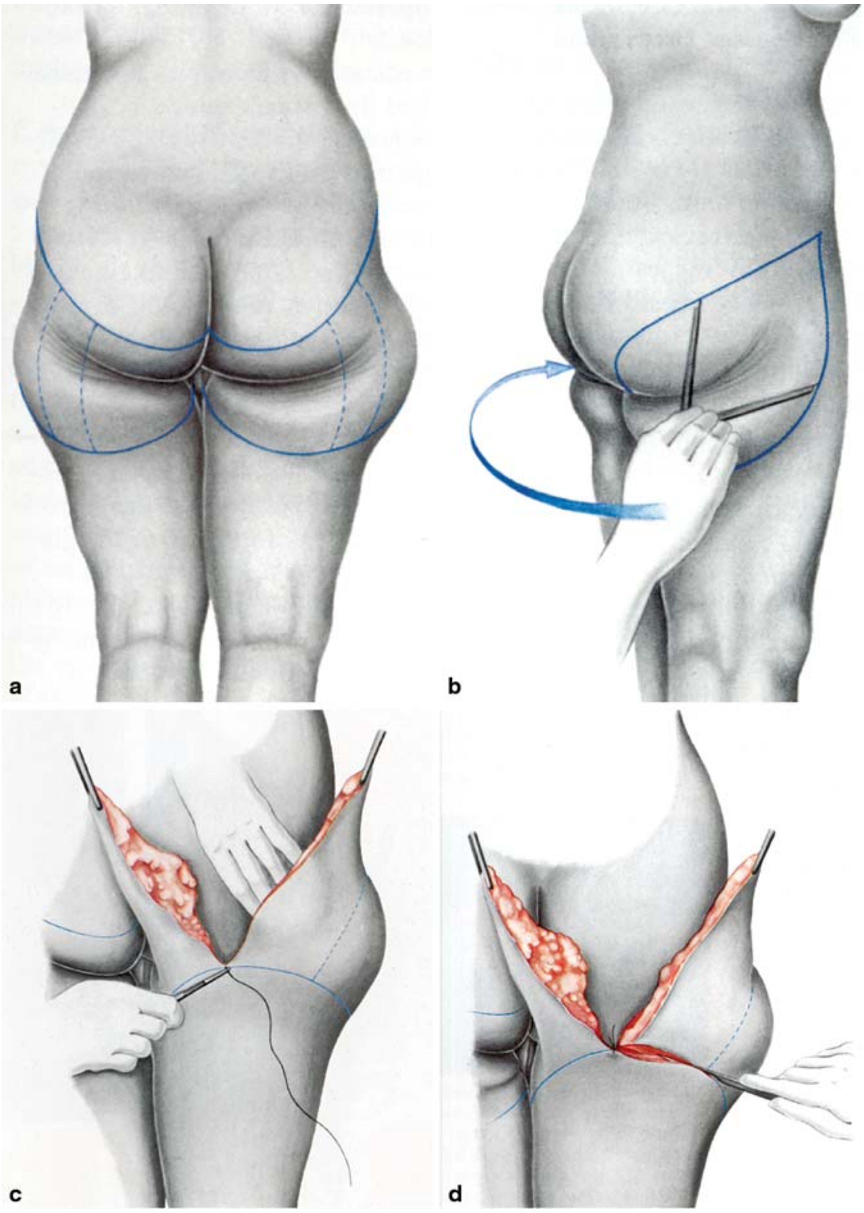

Fig. 23.2. Excision of skin and subcutaneous tissues in a fusiform area that extends laterally and superiorly toward the anterior superior iliac spine and medially along the inner aspects of the thigh

23.3.2.2
The Upper Limbs

Treatment of contour deformities of the upper limbs requires a very critical appraisal of the patient's complaints and expectations. The surgeon should be emphatic regarding limitations and possibilities of surgical procedures. A scar placed along the inner aspect of the arm is relatively visible when treating brachial lipodystrophies; therefore, resection of excess tissue is only indicated in very selected cases where the deformity causes a significant disharmony between the upper limbs and the patient's overall body contour. Liposuction has become the procedure of choice in moderate cases of fat accumulation on the posterior aspect of the arm, removing excess adipose tissue through minimal incisions.

Skin resection is warranted when the patient presents with visible looseness of skin secondary to the aging process or after considerable weight loss. An elliptical demarcation is done along the posterior and inner aspects of the arm, thus assuring that the final scar is placed at the least visible location of the upper limb, which is at the internal bicipital sulcus. Dissection of tissues is done in a posterior direction in order to bring the excess flap inward (Figs. 23.6, 23.7).

Some patients present with excess tissue that affects the elbow, the upper limbs, and the lateral aspect

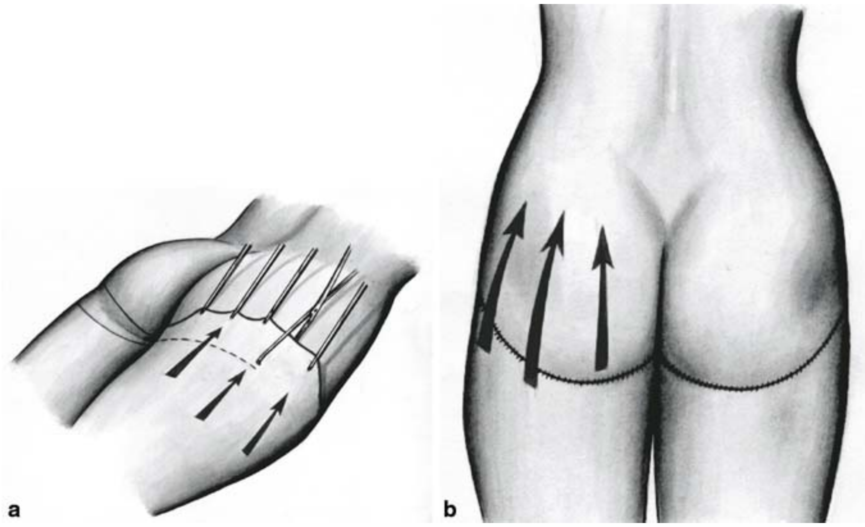

Fig. 23.3. The inferior flap is advanced superiorly in three vectors: superiorly, medially, and laterall

Fig. 23.4. a A 42-year-old patient had prior liposuction aspiration. **b** Contour was reestablished with dermolipectomy. Currently, femoral dermolipectomy is reserved for cases that present with excess skin, or in severe irregularity, as in cases secondary to liposuction

of the thorax. These cases are treated by a technique that was described in 1975, called a thoraco-brachial dermolipectomy [7]. The patient is examined and marked standing up and with the arms open so as to demonstrate excess ptotic tissue. A sinuous demarcation begins distally, at the elbows, and moves along the inner aspect of the arms, continues along the armpit, where it is "broken" by a z-plasty, avoiding scar retraction. The demarcation proceeds along the lateral aspect of the upper trunk and finishes at the submammary sulcus.

The final scar is more satisfactory with this sinuous demarcation than when compared with other techniques that employ straight lines, which risk developing a "bow-string" deformity along anatomi-

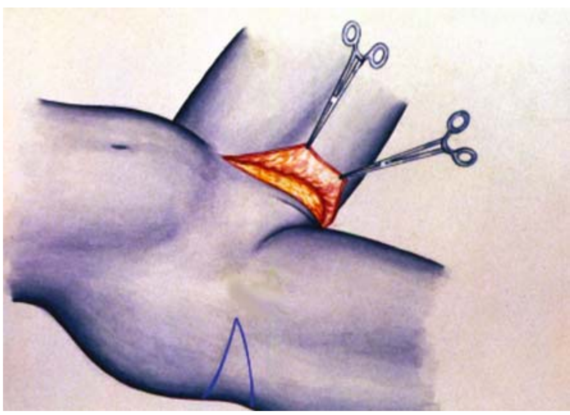

Fig. 23.5. The resultant scar from thigh lift should be within the gluteal and inguinal folds

cal creases with consequent unfavorable retractions (Fig. 23.8). Suction-assisted lipectomy has become a valuable adjunct to this procedure.

23.3.2.3 The Abdomen

Abdominal alterations may be summarized as cutaneous (redundancies, stretch marks, scars, flaccidity, and retractions), accumulation of subcutaneous tissue (lipodystrophy), and those affecting the musculo-aponeurotic system (diastasis, hernia, eventration, and convexity). Procedures have, therefore, been described to correct the integument (skin and loose subcutaneous cellular tissue), the aponeurosis, and the muscle structure. The ultimate goal of surgery is to achieve an aesthetic contour with acceptable scars and the return of full function of the abdominal girth.

A system of classification has been established to correlate between presenting deformity and surgical planning (Table 23.1).

In association with the classic procedure, liposuction has decreased the necessity for extensive undermining of the abdomen, thus contributing to a lesser rate of complications such as serosanguinous collection and flap ischemia. It should be emphasized that liposuction should be restricted to non-undermined areas. Two primary arterial plexi are responsible for the irrigation of the abdominal wall: (1) a subdermal superficial system and (2) a deeper, more profound musculo-aponeurotic system. Many blood vessels form anastomotic connections between the two levels, particularly in the periumbilical region. This vascular anatomy must be respected so as not to risk causing a decrease in vascularization of the abdominal flap.

The senior author's personal approach to abdominal deformities was described in 1967 [3], where attention to both function and aesthetics was emphasized. The functional aspect of abdominoplasties was deemed to be especially pertinent in the older, overweight, multiparous woman. The reinforcement of the abdominal wall, as proposed, was done by plication of

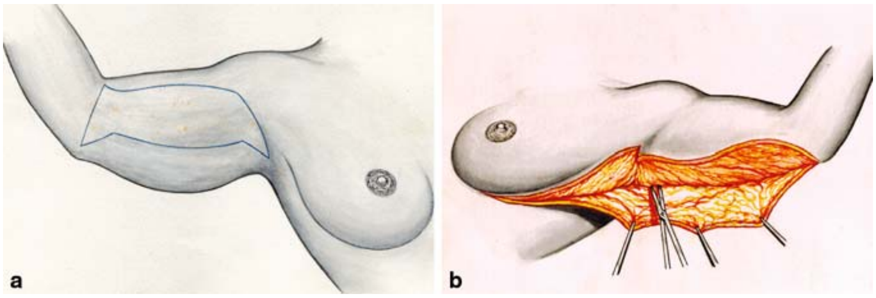

Fig. 23.6. Dissection in brachioplasty is performed in a posterior direction in order to bring the excess flap inward

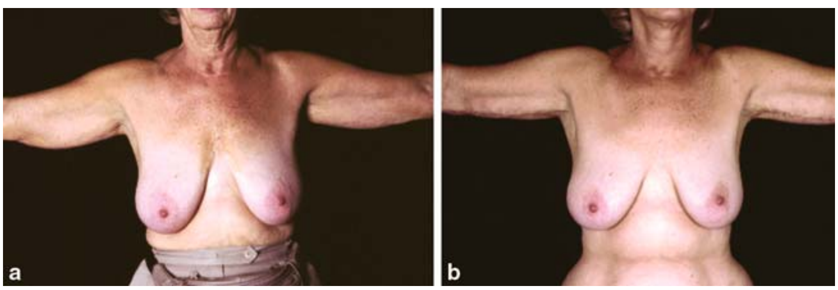

Fig. 23.7. a A 59-year-old patient with simple brachial flaccidity.
b Corrected by removal of an atypical ellipse of skin and subcutaneous tissue

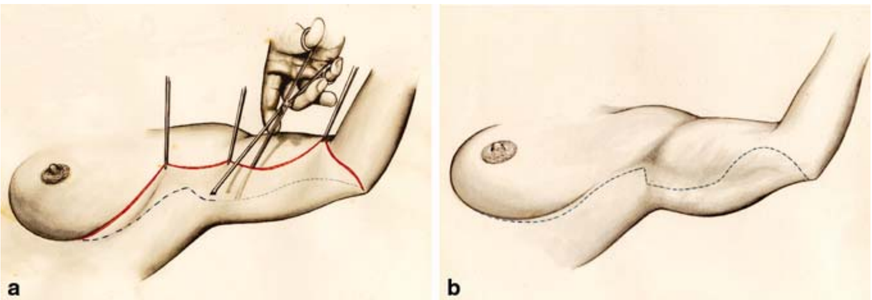

Fig. 23.8. The final scar should be sinuous

Table 23.1. Pitanguy's classification of aesthetic abdominal deformities

Type	Clinical presentation	Suggested technique
I	Abdominal lipodystrophy without skin flaccidity; absence of diastasis or hernia	Liposuction
II	Moderate abdominal lipodystrophy with diastasis	Mini-abdominoplasty or endoscopic abdominoplasty
III	Accentuated abdominal lipodystrophy with cutaneous flaccidity and excess; presence of diastasis; with or without associated scar	Standard abdominoplasty
IV	Skin flaccidity and/or lipodystrophy, with diastasis or eventration; associated scar	Atypical approach
O	Marked generalized abdominal lipodystrophy with absence of excess skin.	These patients are not ideal candidates for abdominoplasty, and should be prepared for surgery by strict clinical treatment to lose weight

the aponeurosis from top to bottom, without opening the fascia. A pleasing curvature was given to the waist, not by pulling on the skin, but by tension on the aponeurosis and the muscles.

23.4 Conclusions

The surgical treatment of body contour deformities is a constantly evolving art that seeks to improve individual alterations while maintaining an overall well-proportioned balance. Liposuction has revolutionized the surgical treatment of contour alterations by removing excess adiposity through minimal incisions. On the other hand, patients may still present with deformities that require a dermolipectomy, and planning must be based on sound surgical experience. More important than the technical procedure, however, are a correct diagnosis of the deformity and a thorough interpretation of the psychological and motivational structure of the patient. The real goal of body contour surgery is to reestablish the structural and psychosocial harmony of the individual, so that he or she may achieve a balance between his or her self-image and the environment.

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24 The Modern Lipoabdominoplasty

Jorge I. de la Torre, Luis O. Vásconez

24.1 Introduction

Current abdominal contouring procedures consist of suction-assisted lipectomy, dermolipectomy, musculoaponeurotic plication or some combination of these approaches. Ideally, this results in sufficient reduction of subcutaneous adipose tissue volume, maximum resection of excess skin and tightening of musculoaponeurotic laxity to create an aesthetic contour of the abdominal wall. As with all aesthetic surgical procedures, the goals of abdominal contouring surgery are to maximize the aesthetic outcome, reduce recovery and minimize morbidity.

24.2 History

The initial abdominoplasty procedures consisted of resecting a significant abdominal pannus. Kelly [1] (1899) described the use of a large horizontal midabdominal incision. A variety of incisions were subsequently described, but the lower abdominal transverse incision presented by Thorek [2] (1924) was the basis for the modern abdominoplasty incision.

The modern evolution of abdominoplasty as a contour procedure was described by Vernon [3] (1957). It included not only musculoaponeurotic plication but also transposition of the umbilicus. Subsequent refinements and modifications were proposed, including variation in the specific incision design, musculoaponeurotic plication technique and extent of dissection [4–6]. These techniques, however, are all limited because the contouring is achieved by surgical excision of tissue and closure, often under tension, which leave significantly visible scars.

Mini-abdominoplasty uses a relatively small transverse lower abdominal incision to permit limited resection of redundant infraumbilical skin in conjunction with aggressive liposuction of the abdominal wall. The modified abdominoplasty elevates a skin flap from the pubic region to the subcostal margin. The umbilicus is detached from the fascial midline, fat resection is performed sharply or with limited liposuction and the fascial midline is tightened both above and below the umbilicus. Standard abdominoplasty requires aggressive elevation of the upper abdominal flap to the level of the subcostal margin. It includes wide undermining of the superior flap, translocation of the umbilicus and repair of diastasis recti. Traditionally, liposuction has been avoided with aggressive undermining to minimize necrosis of the elevated abdominal flap.

In contrast suction-assisted lipectomy can provide dramatic contour improvement with minimally apparent scars. Early techniques in the 1960s, as described by Schrudde [7], utilized sharp curettage and suction. Kesselring and Meyer [8] (1978) introduced the use of strong suction. However, the most significant advance in body contour surgery may have been the introduction of the blunt-tip cannulae by Illouz [9]. Another significant improvement in the safety of liposuction came with the utilization of the "wet techniques" to infuse dilute local anesthesia with epinephrine to the operative field [10]. Additional modifications include the use of ultrasound-assisted liposuction by Zocchi [11] (1992), as well as laser-assisted liposuction and power-assisted liposuction [12–14].

While liposuction uses minimal incisions to provide improved contour, it does not address the redundant skin redundancy or muscle laxity. Concerns regarding disruption of the abdominal wall vascularity, limited liposuction in conjunction with the standard abdominoplasty procedure. The "marriage abdominoplasty" combines abdominoplasty with more conservative liposuction. As the traditional contour techniques were re-evaluated, new concepts regarding the safety of prudent combinations of liposuction with abdominoplasty resection emerged [15]. Liposuction abdominoplasty is now understood to effectively preserve the neurovascular supply of the abdominal wall, facilitate mobilization of the upper abdominal wall and improve aesthetic contouring [16]. In fact, some research has indicated that within 1 week of surgery there is no significant impairment of skin perfusion following suction-assisted lipectomy [17]. This allows a new paradigm in body contouring, to combine extensive suction-assisted lipectomy with sharp lipectomy and surgical abdominoplasty techniques [18–20].

24.3 Clinical Anatomy

The overall shape of the abdomen varies depending on the fat distribution and musculoaponeurotic constitution. The ideal body shape for women is narrow at the waist and wider at the hips, while in men it should progressively narrow from the chest to the hips [21]. Fat accumulation also differs between the genders [22]. Women demonstrate weight gain in the lower abdomen, hips and buttocks; in men fat accumulation occurs intra-abdominally and circumferentially around the mid-abdomen and flanks. While abdominal wall lipodystrophy can be contoured to obtained a desirable result, intra-abdominal adiposity will limit the level of improvement and should be recognized preoperatively.

The surface landmarks of the abdomen include the costal margin superiorly, the anterior iliac crest and the mons pubis inferiorly and the umbilicus. Located approximately midway between the xyphoid and the pubis, the umbilicus is the most prominent surface feature of the abdominal wall. In the youthful abdomen, the lateral border and inscriptions of the rectus muscles are visible as well; the umbilicus is hooded superiorly and tightly adherent to the deep fascia.

The subcutaneous tissue consists of superficial and deep fat, separated by Scarpa's fascia. The superficial layer is typically dense and fibrous in nature with what has been described as a superficial fascial system [23]. This pervasive system of connective tissue encases and shapes the fat of the trunk and extremities. Scarpa's fascia is a fibrous layer of connective and adipose tissue that forms a discrete layer in the lower abdominal wall. The deep adipose layer is loose with poorly organized septae [24]. It is disproportionate enlargement of this deep layer in the torso and upper thigh which characterizes fat accumulation even in thin women.

When planning abdominal contouring, careful consideration should be given to the three major vascular zones of the abdominal wall. The mid-abdomen is supplied by the superior epigastric and inferior epigastric arteries, which form the deep epigastric arcade in the region of the umbilicus. Perforators extend through the anterior fascial sheath to supply the overlying skin. The external iliac artery supplies the lower abdomen. The lateral abdomen is supplied by both the intercostal and subcostal arteries. The intercostal arteries originate from the thoracic aorta and extend to the internal mammary between the external and internal oblique. The superficial external pudendal artery, the superficial epigastric artery and the superficial and deep circumflex iliac arteries are branches of the femoral artery, which also contribute to the lower abdominal wall skin. The venous drainage system runs parallel to the arterial system. Subsequent consideration will be given to the blood supply to the abdominal wall as related to planning abdominoplasty techniques with particular regard to concomitant liposuction.

The abdominal lymphatic drainage is to the axillary lymph nodes above the level of the umbilicus. Below the level of the umbilicus, drainage is to the superficial inguinal lymph nodes. Disruption of the inferiorly directed drainage will result in postoperative swelling, just above the incision, which with time will resolve.

Innervation of the upper abdomen is predominantly from the intercostal nerve. Because both the nerves pass deep into the abdominal musculature and there is overlap of these dermatomes, it is unusual for patients to experience significant paresthesias in the mid and upper abdomen. Sensory abnormalities are commoner in the lower abdomen and pubis, inferior to any incisional disruption of the sensory nerves.

24.4 Patient Evaluation

The three key elements to consider when evaluating abdominal contour patients are skin quality, musculoaponeutic laxity and degree of lipodystrophy. With rapid weight gain or pregnancy, significant abdominal wall stretching can occur, leaving persistent skin excess and loss of elasticity. In addition, striae or stretch marks are visible where the dermis has been disrupted. Diastasis recti are often present: a weakness of the fascia is almost always identifiable in multiparous females. Moderate lipodystrophy typically results from hypertrophy of the existing adipocytes; however, with weight gain, adipocyte hyperplasia will occur [25]. This results not only in undesirable adiposity, but also in the formation of cellulite as the fibrous septae within the subcutaneous adipose cause changes in the reticular dermis indentations on the skin surface [26, 27].

Patients seeking abdominoplasty can be classified on the basis of the physical examination and the plan for operative management [28, 29]. Type 1 patients are usually younger, with good skin elasticity and minimal lipodystrophy and good muscle tone. Good results can be obtained with suction-assisted lipectomy alone. A type 2 patient has mild skin excess, a normal musculoaponeurotic layer and mild to moderate lipodystrophy, particularly inferior to the umbilicus. Minimal lower abdominal skin resection in combination with liposuction is effective for these patients. A type 3 patient has mild skin excess, lower abdominal laxity with diastasis of the recti and mild to moderate lipodystrophy inferior to the umbilicus. In addition to the skin resection and liposuction placation of the rectus sheath from the pubis to the umbilicus is required. A type 4 patient has skin excess, significant laxity of the musculoaponeurotic layer and lipodystrophy. Skin resection, liposuction and plication along the entire rectus sheath offers improvement but may require transaction of the umbilical stalk. A type 5 patient presents with severe upper and lower abdominal skin excess and laxity. Diastasis of the recti is severe and the patient is often moderately obese. Traditional standard abdominoplasty with placation of the rectus sheath and defatting is necessary.

24.5 Surgical Technique

24.5.1 Preoperative Treatment

Aesthetic improvement of the abdomen is achieved with a continuum of procedures ranging from liposuction alone to multistage belt lipectomy with repair of musculo-fascial defects. Modern abdominoplasty is a concept-oriented procedure to address lipodystrophy, musculoaponeurotic laxity and redundant skin (Fig. 24.1). It combines aggressive liposuction of the abdomen and flanks with dermolipectomy in the suprapubic region. Undermining is limited to the midline to allow placation of the fascia.

Preoperative evaluation and markings (Fig. 24.2) are made with the patient in the standing position. The anticipated area for skin resection is marked as are the areas for liposuction. Prior to induction of general anesthesia, lower extremity compression devices are placed and preoperative antibiotics are given. Once the patient is asleep and the Foley catheter has been placed, several small access incisions are made. Usually these are placed at the umbilicus, the top of the pubic hairline and laterally within the bikini or underwear line to minimize visible scaring; however, additional incisions are often used. Liberal placement of access incisions permits infusion of Klein's solution and facilitates fat aspiration with the greatest control to improve the contour while limiting irregularities and asymmetries. Standard Klein solution is infused into the areas of planned suction-assisted lipectomy and dermolipectomy. The infusion volume is 1:1 with the anticipated aspiration volume.

24.5.2 Suction Lipectomy

After allowing the epinephrine to take affect, liposuction is performed deep to Scarpa's fascia beneath the planned skin resection. Major contouring of the remainder of the abdomen is performed by suction-

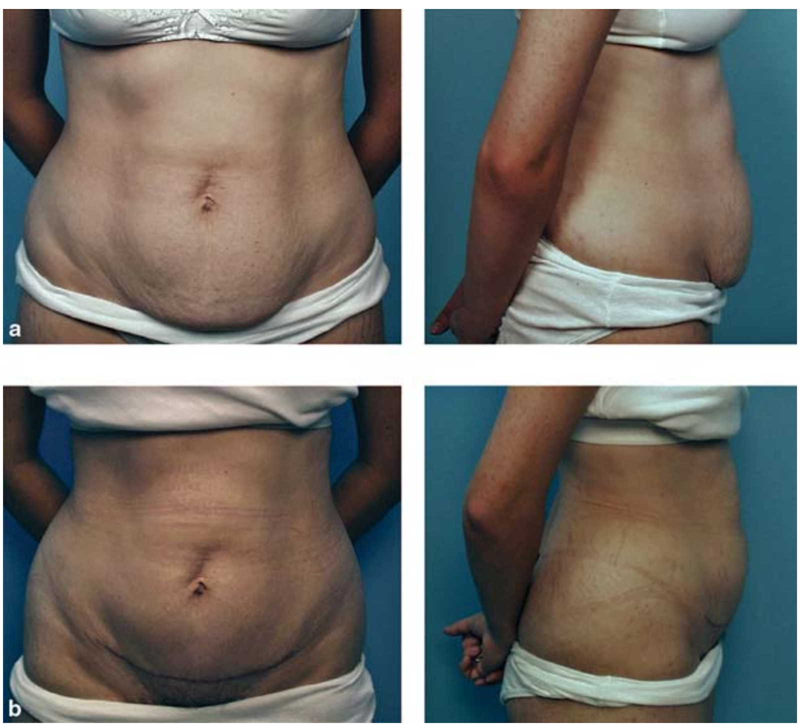

Fig. 24.1. a Preoperative lipodystrophy, musculoaponeurotic laxity and loose skin. **b** Postoperatively

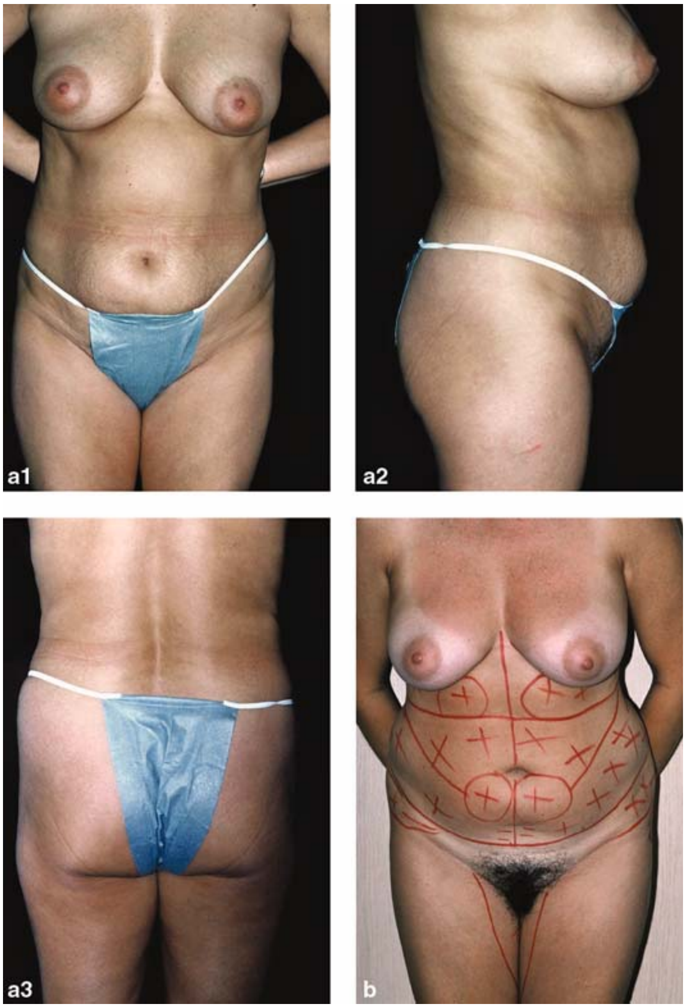

Fig. 24.2 . **a** Preoperative evaluation in the standing position. **b** Markings in the standing position

ing in both the deep and the superficial fat layers. A 4-mm cannula is typically used, with either the Luer-lock syringe system or vacuum aspiration. Aspiration volumes for the abdomen are usually between 2 and 4 l. If more than 4 l of fat is aspirated, in-patient observation is recommended. Once the result of the liposuction has been checked for irregularities and asymmetries and has been found to satisfactory, resection of the redundant skin is performed.

24.5.3 Dermolipectomy

The skin is incised with a scalpel along the preoperative markings. Sharp dissection is performed through the subcutaneous tissue continuing down through Scarpa's fascia. The infiltration of the Klein solution minimizes bleeding and permits rapid dissection with serrated Mayo scissors. With the incision complete to each lateral margin, the ends of the skin paddle are grasped with Kocher clamps and the segment is avulsed. Even when aggressive suction lipectomy has been performed some adipose tissue will remain deep into Scarpa's fascia. (Fig. 24.3) Additional deep contouring can be performed on the abdominal wall fascia using a flat cannula with the vacuum aspirator. However, to minimize the risk of seromas the fascia should not be stripped clean, but rather at least a fine layer of overlying soft tissue should be left intact.

24.5.4 Fascial Repair

Management of the fascia is of even greater importance when skin resection and undermining is limited. Dissection is performed sharply to elevate the subcutaneous tissue from the midline fascia, creating an area 4–5 cm in width. The use of a lighted retractor or an endoscope allows visualization of the diastasis and facilitates the fascial placation. This can usually be performed while preserving the umbilical attachment to the fascia.

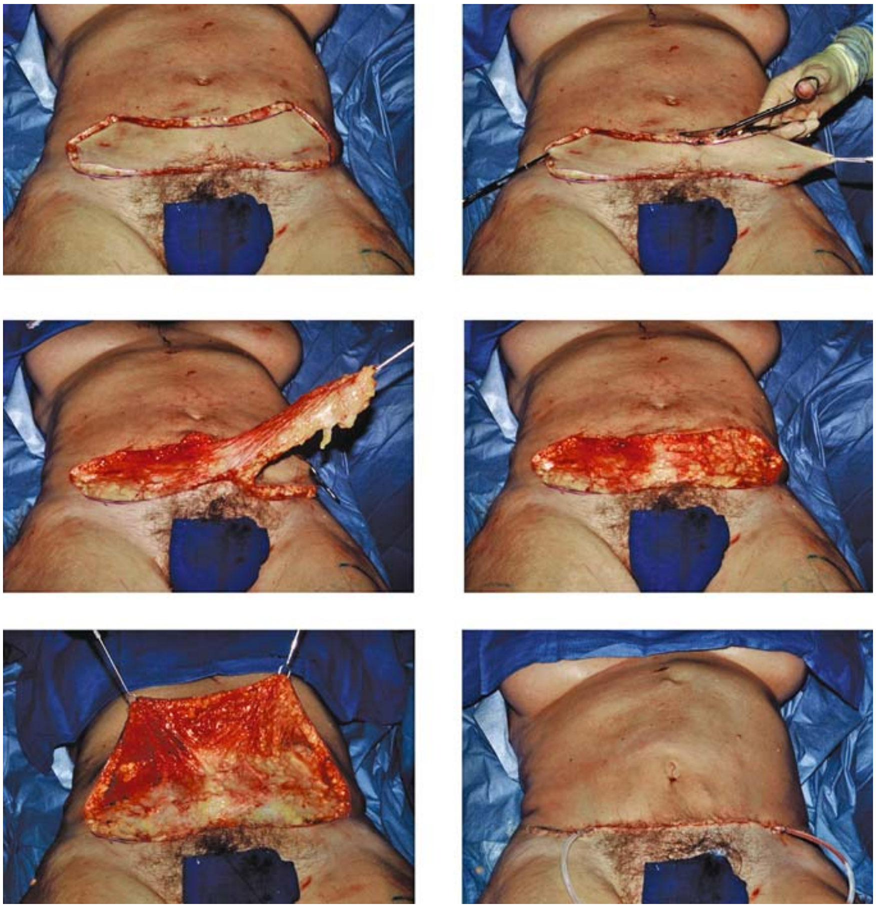

Fig. 24.3. Dermolipectomy

Correction of the diastasis is achieved by approximating the fascia at the medial border of the rectus muscles; however, additional tightening can be performed. The amount of additional tightening which will be tolerated can be evaluated by grasping the fascia with two Kelly clamps and approximating the margins. The fascia can then be marked with methylene blue to allow precise placement of the sutures, tapering the amount of planned plication at the cephalad and caudal limits. The midline is closed using several 0 Prolene simple interrupted sutures both above and below the umbilicus. Using interrupted sutures offers additional control over the degree of plication achieved. A running suture of 2-0 looped nylon is placed to imbricate the midline. The midline fascia can be plicated and imbricated from the level of the xyphoid to the suprapubic region.

When no undermining of the superior flap is performed, transverse plication of the musculoaponeurotic tissue can be readily performed within the area that has been exposed by dermolipectomy. The fascia is readily exposed and significant abdominal wall tightening can be obtained. Plication and imbrication is performed along a transverse line inferior to the umbilicus. Although this method avoids undermining the superior flap, it tightens the abdomen in a longitudinal direction. Although it will not correct rectus diastasis, it is however helpful to further emphasize the desirable contour of both the lateral and the anterior aspect of the lower abdomen.

24.5.5 Management of the Umbilicus

Plication around the location of the umbilical stalk may compromise vascularity of the umbilicus and should therefore be performed carefully or avoided. Placement of the plication can be discontinued just above the umbilicus and then restarted below it. Permanent knots should be buried using a smaller slow-absorbing suture such as Vicryl or polydioxanone. This avoids any palpable sutures in the thin tissue around the umbilicus.

The umbilicus usually remains attached; however, if additional exposure is required, it can be "floated." The periumbilical depression is re-created by using liposuction with a flat cannula 2–3 cm surrounding the umbilicus. If the umbilical stalk is long, tacking sutures can be used to attach the deep dermis of the umbilicus to the facial midline. If the umbilical stalk must be detached, use of landmarks, such as the iliac crest, is helpful to avoid resetting it too low.

24.5.6 Wound Closure

Wound closure is facilitated by the liposuction in the upper abdomen, which creates mobility of the sliding flap [30]. In addition, because the subdermal thickness of the upper flap is reduced the wound edges align properly and give an aesthetic closure. Staples are used to temporarily approximate the skin edges and ensure that no dog-ears are created. Closure is in layers including the superficial fascial system and deep dermal layers.

If any final touch-up contouring is required, it can be performed at this point prior to the subcuticular closure. If needed, closed suction drains can be brought out through the lateral aspect of the incision and secured with nylon sutures.

24.6 Postoperative Care

Immediately following the procedure, a light dressing and a compression garment are placed. This serves to hold the dressing in place without tape, decreasing edema, seroma formation and contour irregularities. Drains are removed when drainage is less than 30 ml per 24 h and the binder can be discontinued a few weeks later. Rarely is Fowler's position required, except for comfort. Ambulation is encouraged early and typically patients resume regular activities in 3–4 weeks. Activity restrictions are for comfort only.

24.7 Complications and Contraindications

Complications following modern lipoabdominoplasty can range from minor undesirable aesthetic outcomes to potentially life-threatening problems. In general, they occur less frequently than with the standard abdominoplasty [31, 32]. The most frequent undesirable outcome is contour irregularity secondary to liposuction, occurring in 10% of patients [33]. Careful cross-hatching and liberal access sites will limit this problem. The rate of seromas with standard abdominoplasty techniques is over 20%, while with the lipoabdominoplasty technique it is 2–4%. In addition, rates of hematoma formation, wound separation and wound infection are similarly decreased. Since the umbilicus is not reinserted the umbilical necrosis is almost non-existent. Postoperative skin necrosis has not been reported.

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Abdominal Liposuction in Colostomy Patients

Bernard I. Raskin

25.1 Introduction

The tumescent technique for liposuction is well established [1–5]. In this method as originally formulated by Klein [6], large volumes of dilute lidocaine anesthetic are infiltrated into the subcutaneous tissue and the fat aspirated is by a small cannula. The procedure can be performed without further anesthetic [3–5] or with supplemental analgesia as required [3–5], or with the patient fully anesthetized at the discretion of the surgeon. Mortality, while extremely rare, has been related to lidocaine toxicity especially when lidocaine is combined with other anesthetic or systemic medications [7] and pulmonary embolism [8]. However fatal and near fatal morbidity have resulted from necrotizing fasciitis [9] and cases involving intestinal perforation [10, 11]. Overall the paucity of major complications such as infection in abdominal liposuction with the tumescent technique is well documented [12].

Guidelines of care for liposuction have been well established by various specialties [1–5] although specifics on preoperative use of antibiotics are lacking. Most surgeons utilize broad-spectrum antibiotics preoperatively; however, the antibacterial effect of lidocaine may be important in infection prevention [13].

Because of the potential for infection by exposed bowel in the colostomy patient, it is unusual for surgeons to attempt cosmetic liposuction in those patients. The concern would be bacterial seeding of extensive areas of fat through the abdomen and flanks leading to severe infection.

25.2 Technique

The author has performed two liposuctions on a 50-year-old 66-kg woman with a 5-year history of a left abdominal colostomy due to traumatic cauda equina syndrome, who was in otherwise excellent health [14]. The first lipectomy was of the flanks, saddlebags, and knees. The patient was given 1 g cefazolin preoperatively and the colostomy site was covered with two layers of 3M Steri-Drape. The second layer of draping extended beyond the margins of the first layer. The ports were on the upper lateral buttocks and knees, and 2,300 ml of fat was removed. The procedure was completed without complications and recovery was uneventful. Several months later, an abdominal lipectomy for cosmetic purposes was performed as described in the following. Again, a preoperative broad-spectrum antibiotic was utilized, and the stoma was double-draped using a wide border with adhesive surgical draping with the second layer of draping extending beyond the first layer.

25.3 Procedure

Liposuction was performed under local anesthesia. The patient had very minimal fat in the abdomen and no complaints of stool leakage. The procedure was planned to effect a smooth transition to the area of the stoma. She was meticulously scrubbed with Betadine from the neck to the knees. The stoma and bag were covered with 3M Steri-Drape no. 1010, which is a plastic drape that adheres tightly to skin. A larger Steri-Drape was then applied over the first (Fig. 25.1). Gloves were then changed by all personnel. Cefazolin

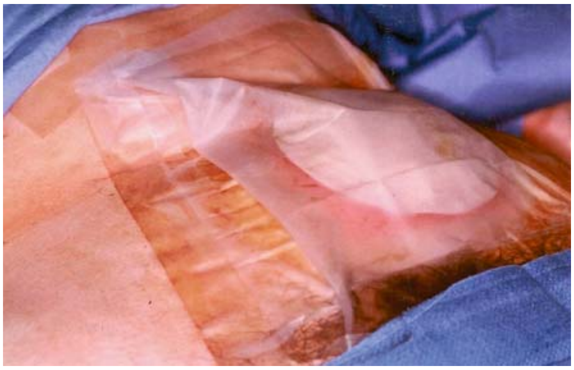

Fig. 25.1. Steri-Drape applied

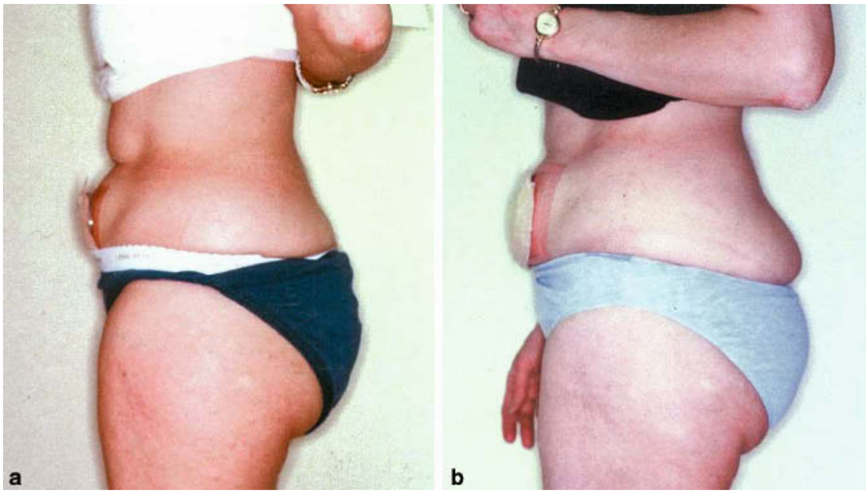

Fig. 25.2. a Preoperative patient with colostomy. **b** Postoperative patient following abdominal liposuction

(1 g) was given intravenously. Mild additional sedation and analgesia were accomplished with diazapam sublingual, a narcotic, and antihistamine intramuscularly. Small stab incisions were made in the right inguinal fold and right upper abdomen (her stoma was on the left). Klein formulation [6] (50 ml of 1% lidocaine, 12.5 ml of 8.4% sodium bicarbonate, 1 ml of 1:1,000 epinephrine in 1 l of normal saline) was infused with a total of 1 l. Because of patient anxiety, the immediate area of the stoma was not addressed. Conservative-tip cannulas (3- and 4-mm diameter) were utilized and 250–ml of fat was obtained. A volume of 250 ml of additional serosanguinous fluid was obtained. The postoperative course was uneventful. Although photographs were not dramatic, the patient was pleased with the result (Fig. 25.2).

The author utilized the tumescent technique, which allows the procedure to be completed under local anesthetic and takes advantage of the known antibacterial effect of lidocaine [13]. The technique is to double-drape with adhesive surgical draping extending widely beyond the stoma edge, with the second drape overlapping and extending beyond the first drape. Both bag and stoma are covered. However, the patient did not have a leakage problem compared with other reported patients.

25.4 Discussion

Use of liposuction for various other medical conditions is well established [15–23]. However, there are relatively few literature citations of abdominal liposuction in colostomy or urostomy patients. Samdal [24–26] reported treating eight patients with troublesome colostomies and urinary stomas with syringe suction assisted lipectomy under local anesthesia. Margulies [27] documented five additional cases of suction lipectomy of the abdominal wall to improve stomal function. These 13 cases involved localized suction lipectomy of the peristomal region for functional improvement of a leaking stoma, although Margulies reported aspirating up to 1,600 ml of fat in one patient. An article in the nursing ostomy literature [28] briefly describes a patient with liposuction around the stoma for stool leakage and indicated that the particular surgeon had performed the procedure on six other patients without further elaboration. There is only one article on cosmetic liposuction on a colostomy patient [14].

In Margulies' [27] series of five patients, the ages ranged from 13 to 47. In each case, appliance fit was hampered by body habitus, obesity, irregular folds, and scars. Two patients had ileal conduit urinary diversions. Three patients had end ileostomies for ulcerative colitis and Crohn's disease. The technique did not utilize tumescent anesthesia. In the series, a betadine-soaked sponge was placed in the stoma, the abdomen widely prepared, and a large transparent adhesive drape applied over the stoma and extending 6–8 in. (approximately 15–20–cm) from the stoma edge. Incisions were made outside the draped area, and the catheter was utilized in an undermining mode initially. Under direct visualization and palpation, fat was aspirated around the stoma. Patients were discharged the same day. Preoperative antibiotics followed by 5 days of supplemental oral agents were utilized, and binders were worn for 2–3 weeks. Two of the patients underwent subsequent sessions. There were no complications. The authors summarize by stating that complications are avoided with a widely prepared sealed field, preoperative antibiotics, and stomal palpation while aspirating. They recommend excluding patients with a parastomal hernia owing to risk of injury to the bowel.

Samdal's [25] discourse on eight additional patients did not describe specific measures to address infection prevention in his series. All patients were treated with a 4- or a 5-mm outer diameter cannula in the Fournier technique utilizing bullet-shaped tips. The procedures were performed under local anesthesia with 0.1% lidocaine and 1:1,000,000 epinephrine. Five of the patients were treated in hospital and three as outpatients. Prophylactic antibiotics were provided to six of the eight patients. Postoperative dressings were elastic tape for 1 week and a compression garment for two to three additional weeks. Seven of eight patients reported resolution of leakage or infrequent leakage less than once per month postoperatively. Samdal concludes that liposuction may correct stomal problems in selected cases, avoiding the potential morbidity of open revision. Caution is recommended when moving the cannula blindly adjacent to a stoma. Small surface irregularities that might be ignored in routine abdominal liposuction can ruin the functional result according to the authors of the study . They consider the syringe-assisted method to be superior in these cases.

25.5 Conclusions

Reports in the literature are few concerning abdominal liposuction in ileostomy or colostomy patients, but there have been no reports of significant infectious complications or intestinal perforation. The procedure appears safe. The recommendation is to vigorously clean the patient's skin from neck to knees, utilize the tumescent technique, which takes advantage of the antibacterial effect of lidocaine in buffered bicarbonate, inject an intravenous wide-spectrum antibiotic, and perform a wide double covering of the stoma site and bag with adhesive sterile drapes.

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Liposuction and Lipotransfer for Facial Rejuvenation in the Asian Patient

26

Tetsuo Shu, Samuel M. Lam

26.1 Introduction

The demand for cosmetic surgery has reached an all-time high in Asia. With the disproportionate influence of the Western media throughout the world, Asian patients often yearn to emulate the Occidental models in their countenance by undergoing plastic surgery. However, Asians who reside in the Orient maintain different aesthetic ideals that only at times converge with Occidental standards. For instance, a fuller upper eyelid and lower malar prominence run counter to Western conceptions of beauty. Furthermore, the Western surgeon who elects to operate on the Asian patient may attempt to extrapolate from his anatomic understanding cultivated from experience with Caucasian patients. However, the bony structure, soft-tissue distribution, and skin quality all differ radically from the Caucasian anatomy. If the surgeon can understand the unique aesthetic and anatomic features of the Asian patient, he or she can embark on a successful surgical intervention in the Asian patient who seeks plastic surgery. Cervico-facial liposuction and lipotransfer follow the tenets just outlined for the Asian patient. In this chapter, the authors will describe a methodology for liposuction and lipotransplantation that is designed for the Asian patient given the anatomic constraints and aesthetic objectives.

Liposuction has proven its efficacy as a useful tool for body recontouring and has assumed a prominent role in the plastic surgeon's armamentarium. In addition, cervical liposuction has also become integral to facial rejuvenation with or without a concomitant cervico-facial rhytidectomy. Autologous fat transplantation has met with greater circumspection in professional circles. Many plastic surgeons have concluded that lipotransfer is an ineffective endeavor, as all the transplanted adipose tissue is bound for complete resorption over time. Accordingly, many techniques have been advocated for fat transplantation that have sought to maintain the viability of the fat cells after transplantation, including centrifugation, washing, and microinjection, to name a few. However, controversy has persisted, and the popularity of adipose transplantation has waned somewhat. The authors would like to revive interest in this technique and to expound upon a surgical technique that has demonstrated value after 23 years of clinical experience and to explain the philosophical underpinnings for this method.

26.2 Asian Anatomy and Aesthetics

The Western surgeon must appreciate the subtleties that define the Asian face before he or she undertakes any kind of incision-based surgery or dermatologic resurfacing.

The underlying bony structure of the Asian face differs dramatically from that of the Caucasian face. The forehead and brow region exhibit a narrow expanse and flat contour, with a posterior inclination superiorly. The temple region may appear more hollowed owing to the relative protuberance of the zygomatic arch. The orbits are shallower by virtue of both a less recessed bony orbital cavity as well as a fuller eyelid. The midface tends to be flatter, as the malar bone exhibits less convexity. Conversely, the lower face is more convex than that of the Caucasian face owing to the relative maxillary-alveolar projection and lower mandibular recession.

Greater accumulation of adipose is present in the malar region in the Asian patient, which upon descent accentuates the nasolabial fold at times even more prominently than in the Caucasian patient. However, the submental area tends to have less adipose accumulation in younger patients, as compared with Caucasians; but this difference markedly declines as Asians mature and acquire a greater amount of submental fat. Despite this progressive accretion of submental fat, the underlying platysma muscle is half as likely to be dehiscent in the midline and to exhibit the characteristic anterior platysmal banding as in Caucasian patients.

The overlying skin is also thicker and more resilient in the Asian patient, which may obviate the need for a concomitant rhytidectomy after liposuction. A predilection for pigmentary discoloration and hypertrophic scarring in Asian skin should make the surgeon always wary about any kind of incision. The senior author has developed a method of incision camouflage and skin protection that markedly reduces the risk of these adverse outcomes, as will be thoroughly explained.

Although Asians often desire a more open eye, i.e., a wider palpebral aperture, that resembles the Caucasian eye, a hollowed eye may look unnatural or impart an aged appearance. Overexuberant fat resection from a blepharoplasty or double-eyelid surgery may lead to this hollowed orbital appearance. Lipotransfer to the sunken upper lid may restore one's ethnicity or rejuvenate the upper lid. However, the lower-lid region is generally a poor area for direct fat transfer, as any redundant skin can lead to a herniated lower-lid appearance. The temporal concavity that is accentuated by the relative zygomatic curvature in the Asian patient is also an area that some patients desire correcting. Autologous fat transplantation offers hope to address this problem. Although the malar region is typically hypoplastic in the Asian patient, very high cheekbones may not always be a favorable, aesthetic trait. When convex malar bones are combined with prominent mandibular angles, a prevalent feature in some Asian countries, the patient may appear to have a very boxy face that can be interpreted as masculine and aggressive. However, a very flat midface may communicate a washed-out, expressionless look and reinforce ethnic facial features; therefore, the surgeon may elect to undertake liposuction or lipotransfer depending upon the anatomic configuration and the patient's desires. Both facial liposuction and lipotransfer constitute unusual requests in the West.

26.3 Adipose Anatomy, Histology, Physiology

Obesity prevails in the West, as a result of a generous consumption of unctuous food products. The Western diet has increasingly plagued much of Asia, with the construction of golden-arched outposts in every conceivable location. Albeit still considerably less needed in the Japanese archipelago, body liposuction is becoming a much more popular option to attain the svelte physique celebrated in the media. This section will explain the senior author's research on adipocyte physiology and explain how that knowledge has impacted surgical technique.

The location and type of fat differs from individual to individual and is largely influenced by genetic factors. Dietary habits only exacerbate this predisposition toward obesity. Adipocytes proliferate in number until adolescence, after which time further increase in fatty deposition arises from hypertrophy of existing fat cells. Hyperplasia is only implicated in the rarer cases of morbid obesity. Once fat cells are surgically evacuated, they will not return. The remaining fat cells, however, may continue to expand in size given dietary influences. The primary target of liposuction is reduction in the number of adipocytes and not overall weight loss. However, weight reduction may arise as a consequence of improved energy consumption rate and better response to diet and exercise.

Two principle types of adipocytes predominate in the body: "fatty" and fibrous fat cells. The former tend to exhibit an oilier, more liquefied form, and are less ideal for lipotransfer. The fibrous fat cells are more solid and compact on gross inspection and are favored for autologous transplantation. Histologically, they appear to be more compressed signet-ring cells than the fatty type. After lipotransplantation, histological evaluation confirms that a greater population of fibrous than fatty adipocytes exists. This condition may arise owing to the greater viability of the fibrous variety or represent transformation of the fatty to the fibrous type.

The senior author's technique for liposuction harvesting and transfer has yielded consistent results in facial and breast augmentation over the past 23 years. Liposuction harvesting, or straightforward liposuction, should be carried out with a 3-mm blunt cannula outfitted with a side port and that is connected to a wall suction device. After the fat has been removed, it should be strained with iced normal saline through cotton gauze until dry (as will be explained in greater detail). This atraumatic technique ensures maximal fat preservation for transplantation. Centrifugation removes the nutritive elements, e.g., collagen, that assist in fat survival, and it subjects the fat to unnecessary traumatic injury that reduces the likelihood of fat viability. Successful lipotransfer technique is contingent upon two factors. First, the pressure of the delivery should not be excessively high, as the combination of a small needle or cannula and a large syringe may fragment intact adipocytes and impair survivability. Second, the fat should be injected into the recipient site in a constantly moving radial fashion, moving from a deeper to a more superficial plane. This type of surgical delivery permits the fat to be distributed evenly throughout the host bed and to have maximal contact with the surrounding nutritive native tissue. Placement of a large aliquot of fat in a discrete location will promote resorption, as the surrounding nutrition cannot penetrate into the depth of the transferred fat. The bolus of transplanted fat will likely degenerate into a macrocystic entity or develop undesirable calcification. Selection of fibrous fat cells only for transplantation will also increase the yield.

If all these tenets are adhered to, 50–60% of the transplanted fat will survive and persist indefinitely; therefore, overcorrection should be the objective in lipotransplantation. Repeat augmentation can be judiciously undertaken after a 3-month period. Histological studies confirm that grafted adipose tissue undergoes neovascularization in the host bed after a 4-week period, a process that is mostly completed by 2–3 months. Once vascularization has occurred, the transplanted fat will remain for perpetuity. Biopsies taken at 1 year after transplantation confirm graft viability, which is corroborated by photographic documentation. Furthermore, conventional plain radiography reveals no adverse cystic degeneration or development of unwanted calcifications.

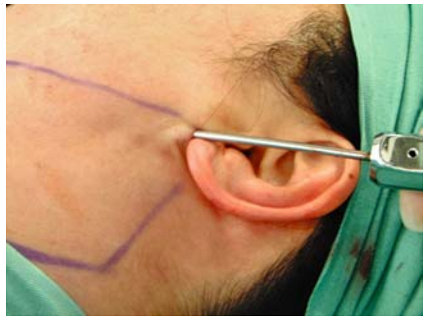

Fig. 26.1. Cervico-facial liposuction is performed with a cannula inserted through the lobular-facial junction after tumescent infiltration

26.4 Surgical Technique

26.4.1 Facial Liposuction

Like body liposuction, the tumescent technique is advocated for removing facial adipose deposits. The entire face and neck region is prepared with chlorohexidine solution. After intravenous sedation with Ketamine and a mild tranquilizer, the tumescent mixture of normal saline and 1% lidocaine with 1:100,000 epinephrine in a ratio of 4:1 is infiltrated into the subcutaneous tissue with a 25-ml syringe and a long 22-gauge needle. The injection technique follows a radial pattern, fanning across the cheek down into the submental region, or across the intended area of liposuction from a point at the lobule–cheek interface. After infiltration of the tumescent/anesthetic solution, the skin should be relatively tense and somewhat blanched in appearance, typically achieved after infiltration of 20–25 ml into the each side of the face and 10–15 ml into the neck per side.

A stab incision with a no. 11 Bard-Parker blade is undertaken again at the lobule–cheek interface, and Metzenbaum scissors are used to dissect a small pocket of 1–2 mm in dimension at the incision site. A 3-mm liposuction cannula, not attached to wall suction, is introduced through the incision and passed in a radial fashion through the deeper subcutaneous plane from the facial to the cervical region in the intended area for liposuctioning (Fig. 26.1). This undermining will facilitate uniform and uncomplicated liposuctioning. The cannula is then connected to the wall suction device in order to begin liposuctioning.

The non-dominant hand should tent the skin upwards and guide the passage of the liposuctioning cannula, as the dominant hand controls movement and direction of the cannula. The cannula should be passed in a radial fashion from the deep subcutaneous plane eventually to the more superficial plane, all the time rotating the cannula. The senior author uses a proprietary liposuctioning cannula that permits freehand rotation of the cannula around a rotating bezel located at the base of the cannula. The non-dominant hand should always register the amount of thickness remaining in the skin flap and deeper tissues to gauge when to terminate the liposuction procedure. At the end of the procedure, the stab incisions are not approximated with any suture but left to close by secondary intention. A 4×4 gauze is used to roll out any remaining blood under the flap, which is expressed through the stab incision before a bulky pressure dressing is applied and retained for 48 h.

A submental incision is avoided in the Asian patient, as this may predispose toward unfavorable healing. The lobule–cheek interface provides the least conspicuous point of entry for cervico-facial liposuction as well as optimal access to the face and neck regions. No more than 70% of the total fat should be removed so that adequate skin contraction can occur. Removal of greater than 70% may leave behind some loose skin that fails to contract and adhere to the underlying soft tissue. In an individual who is older than 50 years of age, a more conservative estimate of 50% of fat should be removed owing to the poorer elastic quality of mature skin unless a concomitant rhytidectomy is planned to remove the excess skin. Liposuction alone with consequent skin adherence may provide the benefit of a mini-facelift.

Unlike the thinner Caucasian skin, Asian skin is thicker and more resilient; therefore, a rhytidectomy that may be recommended for a 50-year-old Caucasian may be unnecessary in an equivalently aged Asian. Clearly, skin elasticity should be assessed prior to surgery in order to determine the best course of action. The cheek is an area that is more technically difficult to achieve uniform liposuctioning, and only 30% of the total adipose tissue should be removed.

Care should be taken to assess flap thickness and uniformity as the procedure is undertaken.

26.4.2 Autologous Facial Fat Transplantation

The quality and quantity of fat removed from the face is often insufficient for lipotransfer to other regions of the face. There is a higher concentration of connective tissue in the cervico-facial region that makes a great proportion of the contents removed during liposuction worthless for transplantation. Therefore, body liposuction is advocated to remove adequate fat tissue for transfer to the deficient facial zones.

The abdomen tends to be a reliable source of generous adipose tissue, particularly in the more corpulent patient. The medial, anterior, and posterior hips are another source from which adipose may be procured, especially in the thinner individual. The point of entry should be within a natural skin crease or other acceptable concealed site, e.g., within the umbilicus and at the groin or buttock crease. A small plastic protector that the senior author has designed should be mounted at the liposuctioning cannula entry site and secured to the skin in order to minimize unnecessary cutaneous trauma. All of these precautions are warranted in the Asian skin, which is prone to hyperpigmentation and hypertrophic scarring. The same technique is advocated for body liposuction as for facial liposuction. If only a minor amount of adipose is required, e.g., to fill in the hollowed upper-lid region, then a syringe with a handheld suction can be used to remove smaller quantities. At the end of the procedure, the area that has undergone liposuction should have a compressive dressing applied for a 1-week duration, and the patient should maintain limited activity for a 10-day period.

Once all the fat has been harvested into a sterile suction canister, the fat must be processed for transplantation. Cotton gauze is placed over the mouth of an empty pitcher and the fat placed atop the gauze. Iced normal saline solution is poured over the fat in order to strain the excess blood and poor-quality fat through the gauze into the pitcher. A spoon can be used to swirl the mixture to expedite passage of the saline through the gauze (Fig. 26.2). The gauze is then wrapped around the fat and squeezed by hand to remove the excess saline (Fig. 26.3). The entire process is repeated several times until the fat achieves a pasty, solid consistency and assumes a yellow-to-orange color (Fig. 26.4).

Fig. 26.2. The harvested adipose tissue is strained through two cotton-gauzes with saline

Fig. 26.3. After most of the saline has been filtered through the cotton gauze, the cotton gauze is picked up and the remaining saline is squeezed through the gauze

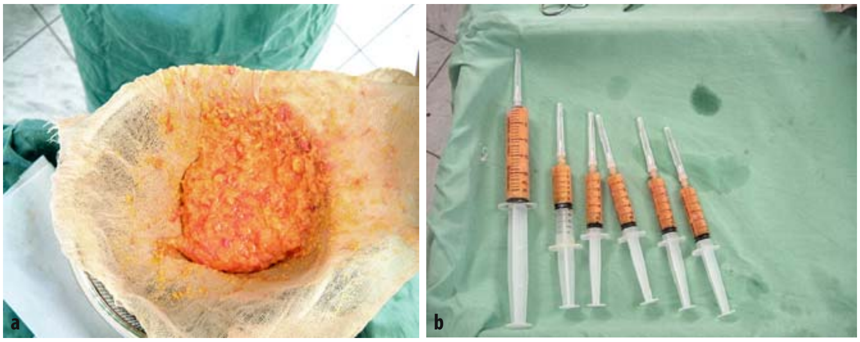

Fig. 26.4. The harvested fat has been dried and has assumed a yellow-to-orange color ready for transplantation

The fat can be placed into 1-, 2.5-, or 5-ml syringes depending on the intended area for lipotransfer. The 1-ml syringe outfitted with an 18-gauge needle is ideal for upper-lid, temporal, frontal, and nasolabial-fold augmentation; whereas the 2.5- or 5-ml syringe outfitted with a 2-mm cannula is preferred for larger volume transfers into the cheek and possibly the frontal and temporal regions. The 2.5- or 5-ml syringe should not be equipped with an 18-gauge needle, as the increased pressure from a larger syringe into a smaller needle may traumatize the adipocytes excessively.

The patient should receive proper intravenous sedation before fat transplantation, as no local anesthesia should be infiltrated into the recipient sites. Local anesthesia hinders accurate assessment of the amount of fat that should be transferred and should be avoided. Unlike for liposuction, the cannula or needle need not be rotated as the fat is injected. Furthermore, the fat should only be injected during withdrawal of the needle or cannula so that a uniform distribution may be achieved. For the upper lid, the 18-gauge needle attached to a 1-ml syringe is inserted inferior to the lateral extent of the eyebrow and passed medially into the subcutaneous plane (above the orbicularis oculi), with injection during withdrawal (Figs. 26.5, 26.6). The needle should pass in a radial fashion to promote even fat allocation. Typically, a total of 2–3ml of fat is required per side. In a postblepharoplasty, the surgeon should tent the skin upwards to avoid inadvertent postseptal injection. For the nasolabial fold, the 1-ml syringe and 18-gauge needle can be passed along the nasolabial fold entering first from the inferior end of the fold then the superior end following a deep-to-superficial order of injection. Radial injection is not indicated in this situation, as all the fat should be deposited immediately along the fold or slightly medially. A 2-mm cannula attached to a 2.5- or 5-ml syringe should be used to inject the fat into the malar and/or submalar regions from a stab incision at the lobule–cheek interface. The same technique for liposuction should be used for lipotransfer, with the exceptions that no tumescent injection is used, the flap need not be undermined first, the cannula need not be rotated, and the injection should be made only during withdrawal. Otherwise, the radial, deep-to-superficial cannula movement should be emulated. The forehead can also be infiltrated to achieve a more uniform appearance using a 1-ml syringe with an 18-gauge needle. Finally, the temporal region can be restored with fat infiltration in a manner similar to lipotransfer to the cheek, starting, however, from

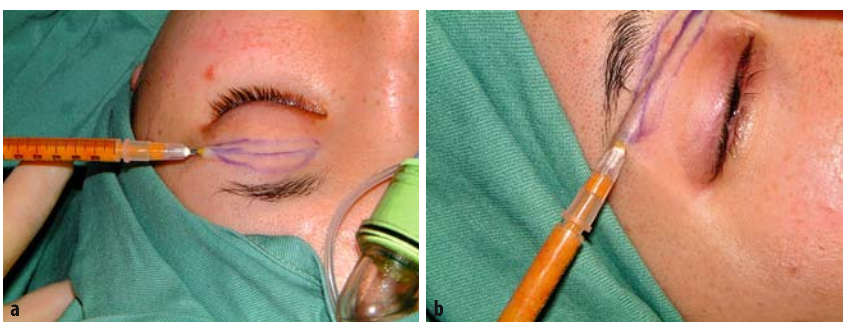

Fig. 26.5. Eyelid fat injection using an 18-gauge needle and a 1-ml syringe

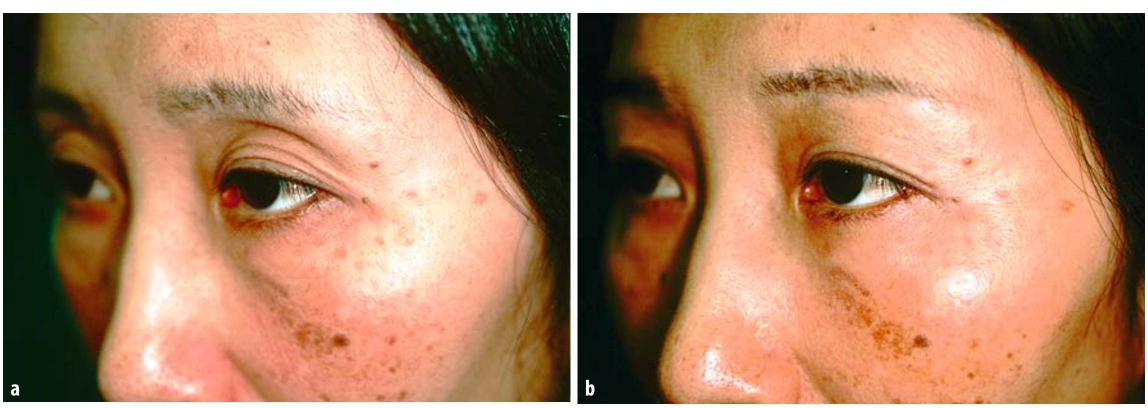

Fig. 26.6. a This 48-year-old female patient exhibits an aged sunken-eye appearance. **b** Thee years postoperatively following a single session of lipotransplant to the upper-lid region

the hairline just above the helical crus. The surgeon is cautioned to stay in the subcutaneous plane at all times to avoid possible, but unlikely, facial nerve injury. An important step after fat transplantation that should not be overlooked is molding the transplanted fat between fingers to ensure a more uniform distribution. The fat can be pinched between two fingers and gently massaged until the contour feels smooth and even.

26.5 Conclusions

Facial liposuction and lipotransfer have proven to be reliable and consistent techniques for facial rejuvenation in the Asian patient. If the anatomic and aesthetic qualities of the Asian face are understood, then the intended surgical result can be achieved. Clearly, the principles of liposuction and lipotransplant can apply to all ethnicities, nationalities, and races, given the proper understanding and experience with each particular background.

Acknowledgement Portions of this work are reprinted from Shu and Lam [1] with permission from the *International Journal of Cosmetic Surgery and Aesthetic Dermatology*, Mary Ann Liebert, Inc.

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1. Shu. T., Lam, SM: Liposuction and lipotransplants for facial rejuvenation in the Asian patient. Int J Cosm Surg Aesth Derm 2003;5(2):165–173

Microcannula Liposuction

Bernard I. Raskin, Shilesh Iyer

27.1 Introduction

Liposuction surgery is unique in each surgeon's application of technology in pursuit of artistic results that satisfy both patient and surgeon. All surgeons observe and study other successful practitioners and incorporate style and artistry into their own special blend based on technical training, background, specialty, and the technology they wish to integrate into their practice. Since each patient has different anatomy, emotions, and expectations, liposuction approaches will vary.

This chapter explores, defines, and reviews microcannula liposuction surgery. The emphasis is on the use of microcannulas with tumescent anesthesia such that the entire procedure can be performed under local anesthesia without intravenous sedation or general anesthesia. Much of this chapter emphasizes techniques that enhance performance of the entire liposuction while the patient is awake. The emphasis on a method that is inherently more time consuming may appear as an oxymoron to many surgeons, especially those that would never consider performing liposuction on a conscious patient.

Yet microcannulas have inherent advantages as part of the surgical tools to enhance artistry and have applications throughout liposuction. The authors bring a diversity of experience to this chapter and hope surgeons will develop an appreciation of the application of microcannulas to their individual technique. For example, one of the authors (S.I.) completes all liposuctions utilizing solely microcannulas and local tumescent anesthesia. The other author (B.I.R.) depending on patient preference and other considerations performs procedures with tumescent local anesthesia or intravenous sedation/general anesthesia combined with tumescent infiltration using small microcannulas depending on the specific patient.

Microcannulas offer unique features such that all surgeons should be conversant with their applications. For surgeons performing virtually all procedures under sedative anesthesia, microcannulas with local tumescent anesthesia offer a simple, efficient, inexpensive approach to small touch-ups that can be accomplished in an office setting. For surgeons choosing microcannulas, the authors believe they will see an improvement in overall smoothness and a reduction in skin deformities and irregularities, with superior symmetry and artistic proportion.

27.2 Background and Origins of the Microcannula Technique

During the early days of liposuction, large-diameter cannulas were often employed to aspirate unwanted fat [1, 2]. These cannulas were more traumatic and tended to remove larger amounts of fat with each stroke [2, 3]. They were often used under general anesthesia or intravenous sedation and frequently produced significant postoperative pain and a long recovery time [3]. With the advent of the tumescent anesthesia technique, patients began to be treated entirely under local anesthesia [4]. The concept of microcannula liposuction evolved logically and Ilouz [1] first reported utilizing cannulas of 2.5-mm size on the face in 1984. Dermatologists began utilizing smaller and less aggressive cannulas as surgeons attempted to diminish discomfort in the conscious patient undergoing tumescent liposuction, minimize bleeding, and enhance safety [1, 5–7].

In conjunction with the development of tumescent anesthesia by Klein, a gradual preference for smaller, less aggressive cannulas has emerged [2]. Many liposuction surgeons prefer microcannulas smaller than 3 mm for all procedures in contrast to macrocannulas, which may measure up to 6 mm or greater [7]. These microcannulas offer a number of advantages over larger cannulas in that they can be used to remove small amounts of fat and meticulously sculpt tissue in a highly controlled fashion. This is especially advantageous in areas such as the face, neck, cheeks, inner thighs, and knees. Microcannula liposuction has become the standard approach for many practitioners in combination with the tumescent anesthesia technique [7].

27.3 Microcannulas, the Tumescent Technique, and Hemostasis

The tumescent technique developed by Klein involves the infiltration of a highly dilute lidocaine solution with epinephrine into the subcutaneous tissue prior to lipoaspiration. The concentration of the lidocaine usually falls in the range 0.05–0.1%, while the concentration of epinephrine is usually in the 1:2,000,000–1:1,000,000 range [4, 8]. Details of tumescent fluid pharmacology can be found in Chap. 10.

Tumescent infiltration of a dilute lidocaine–epinephrine combination into the fat confers two major advantages. First, in part owing to vasoconstriction and in part owing to lidocaine's lipophilic action, much higher doses of lidocaine can be used compared with the traditional 7 mg/kg that is considered to be the upper limit when 1% lidocaine is directly infiltrated in the skin. In the tumescent technique, there is a slowly absorbed depot effect from the subcutaneous tissue that allows up to 35–55 mg/kg lidocaine to be used. Slow absorption ensures that toxic serum levels of lidocaine are not attained [3, 4].

Second, because of the vasoconstrictive effects of epinephrine, profound hemostasis is achieved [3, 9]. This enables the use of microcannulas, which are potentially more traumatic to vascular structures than larger cannulas. While large macrocannulas generally produce more overall trauma to the subcutaneous tissue and fibrous septa compared with microcannulas, the smaller cannulas have the potential to produce more vascular trauma and hemorrhage. This is because for any given volume of fat removed, the surface area of the wound is larger with microcannulas. However, the tumescent fluid's vasoconstrictive effects provide significant hemostasis such that microcannulas can be safely used [4].

27.3.1 Microcannula: Definition

Microcannulas are defined by Klein [4] as having an inside diameter of less than 2.2 mm. This equates to the inside diameter of a 12-gauge needle. However, 10-gauge cannulas with an inner diameter of 2.7 mm are also manufactured and many practitioners consider cannulas less than 3 mm to represent "microcannulas." These microcannulas are made of hypodermic stainless steel and typically have a thinner wall than standard liposuction cannulas. This thin wall creates a delicate cannula such that manipulation and utilization of the cannula is different than with typical macrocannula liposuction. Structural limitations impact the aperture shape and size. In contrast to Klein's definition, many surgeons clinically define microcannulas as 3 mm in size or smaller. Many 3-mm inside diameter cannulas have a somewhat thicker wall typical of more standard cannulas. This results in a proportionately larger outside diameter with a stronger wall that allows for a longer cannula and thereby fewer incision sites for aspiration ports.

27.3.2 Microcannula Clinical Aspects: Advantages and Disadvantages

Microcannula liposuction has been tested and applied as part of the tumescent technique for liposuction under local anesthesia [4]. Use of microcannulas in the "wet" or "superwet" methods of liposuction or for liposuction under general anesthesia has not been evaluated, although presumably microcannulas would be effective.

Microcannulas typically remove less fat with each pass, resulting in a technique that requires some adjustment on the part of surgeons who may otherwise anticipate removal of large volumes quickly. However, removing small volumes with each pass confers significant overall controlled access to the fat compartment. Use of microcannulas allows both deep and superficial layers to be addressed with a reduced risk of skin deformity compared with use of larger cannulas. Removing fat from the superficial layers ultimately results in a greater amount of fat removal overall because larger cannulas cannot safely access superficial areas adjacent to skin without risk of contour irregularities. Microcannulas also have the advantage of less disruption of fibrous attachments that connect skin to underlying muscle, reducing the potential for loose skin [4].

For surgeons, microcannulas offer easier penetration into fibrous areas with reduced force [10]. Less muscle strength is required, diminishing elbow and shoulder stress and potentially decreasing repetitive injury problems for the surgeon. In areas where arm position or posture may be suboptimal, the ease of moving microcannulas through the tissue reduces surgical effort and minimizes physician exhaustion on longer or larger procedures. While microcannula liposuction requires more time, the physical component is considerably less tiresome overall, reducing fatigue at the completion of even challenging cases. Furthermore, the multiple ports utilized allow for positional comfort for the surgeon since he or she spends less time working with aspiration ports that may be in an uncomfortable position or that require liposuction with the non-dominant hand.

Even surgeons who do not regularly utilize microcannulas may in fact find them useful. As noted previously, certain areas such as the neck and cheek are treated with lowest risk utilizing microcannulas, removing minimal fat deposits to achieve a sculpting effect [11]. The periumbilical area is another preferred spot. This region is often quite uncomfortable even with complete tumescence. Application of microcannulas in this area is highly effective in minimizing discomfort. Areas such as the inner thighs often require minimal fat removal and at are at risk for contour irregularities without the use of microcannulas. The medial knee fat pad is also best sculpted with the microcannula technique.

Another major advantage of the use of microcannulas is the reduced risk of scarring at cannula entry sites. Often, more entry points are utilized but these incision sites are very small and the amount of additional scarring is minimized. In practice, these 1–2-mm wounds heal promptly without sutures and with excellent cosmesis [4].

Disadvantages of microcannula liposuction include the potential for overaggressive liposuction resulting in skin depressions. Although it is true that small amounts of fat are removed per stroke, with improper surgical technique, large amounts of fat may ultimately be aspirated, resulting in depressions. This risk is less, however, than with the use of larger cannulas. The microcannulas are fragile and more easily damaged during surgery or cleaning, resulting in greater expense for replacements. As noted already, more incisions are required, which can result in noticeable marks or dyschromia in prone individuals. Surgical procedures require more time with the microcannula technique in tumescent liposuction. Finally, nursing staff must be more attentive in cleaning as microfragments of fat can clog the small apertures [12].

Importantly, the surgeon must constantly be attentive to the relationship of the aperture and the underside of the skin when working superficially. Since microcannulas are often directed superficially, it is imperative that the surgeon be aware of the particular aperture utilized since some of these cannulas have apertures on all sides. The apertures must always be pointed away from the overlying skin to avoid damaging the underside of the dermis and if cannulas with apertures on all sides are being used, the cannulas must not contact the underside of the dermis. Cutaneous necrosis can result from excessive injury to the dermis [4, 13].

27.4 Cannula Nomenclature and Design

Microcannulas smaller than 3 mm are manufactured from hypodermic needle tubing. Both the size and the tip design are important in these cannulas. Because of the small internal diameter, microcannulas smaller than 3 mm are referred to in "gauge" rather than millimeters. Smaller "gauge" refers to larger diameters (Table 27.1). For instance, a 12-gauge cannula is larger than a 14-gauge cannula. However, there appears to be some variance in the actual internal diameter measured in millimeters depending on the reference. For accuracy, it would be best if the internal diameter size is specifically and consistently defined among practitioners and manufacturers. Klein [4] notes two different sizes for 12-gauge cannulas, 2.2 and 2.15 mm. Furthermore, in jewelry manufacturing, 12 gauge has an internal diameter of 2.05 mm [14]. In the medical industry, the established standard for 12-gauge hypodermic cannulas is an inside diameter of 0.088 in. (or 2.23 mm) manufactured from type 304 stainless steel (KMI Kolster Methods, Corona, CA, USA, personal communication). Table 27.2 lists medical industry standards for hypodermic stock for various gauges. While clinically the actual size may not impact outcome, there is a 15% difference in surface area of the 12-gauge cannulas between the upper and lower diameter sizes as determined in the aforementioned references. This size variation begins to blur the difference between different gauge sizes and therefore blunts the clinical accuracy in the operative report and between each physician practicing the procedure. In clinical practice, many physicians and vendors consider a 10-gauge cannula to be similar to a 3-mm cannula although the surface area difference between the cannula is almost 20%.

Aperture is the next important aspect of microcannulas. One common design features multiple small apertures along the cannula near the distal tip. These apertures are circumferential and care must be therefore

Table 27.1. Microcannula gauges and correlating diameters [4] in mm

Gauge	Diameter
10	2.7
12	2.2, 2.15, 2.05
14	1.6
16	1.2
18	0.84
20	0.58

Table 27.2. Hypodermic medical industry standard sizes, in inches (KMI Kolster Methods, Corona, CA, USA, personal communication)

Gauge	Inside diameter	Outside diameter
12	0.088	0.109
14	0.068	0.084
16	0.053	0.065
18	0.045	0.055
20	0.030	0.037

be taken when working directly adjacent to skin. Commonly these are referred to as "Capistrano" cannulas (Fig. 27.1) [4]. Another cannula type demonstrates apertures directly along only one side of the cannula and is designed so the surgeon is always knowledgeable about aperture location. The common nomenclature for this type is the "Finesse" cannula (Fig. 27.2). In the authors' experience, cannulas designed with multiple circumferential apertures are surprisingly effective at removing a considerable volume of fat. Cannulas with apertures only along one side are less efficient in fat removal, but safer when working near the skin and in areas where conservative liposuction is required. All microcannulas are blunt bereft of aggressive tips common in larger cannulas. A few manufacturers produce the bulk of cannulas for many of the better recognized brands (KMI Kolster Methods, Corona, CA, USA, personal communication).

27.5 Cannula Care

Microcannulas require additional attention because the small size and multiple apertures render them susceptible to residual desiccated debris, which is often not easily removed and may become adherent [4, 12]. The authors initially soak cannulas in germicidal solution immediately after use and then rinse them. The cannulas are then repeatedly flushed with enzymatic cleaner under pressure with a 30-ml or larger syringe. Surgical brushes designed for this purpose are then used to vigorously clean the inside of the tubing. The cannulas are then again flushed with an enzymatic agent under pressure and are then placed in an ultrasonic cleaner, rinsed with distilled water, and autoclaved.

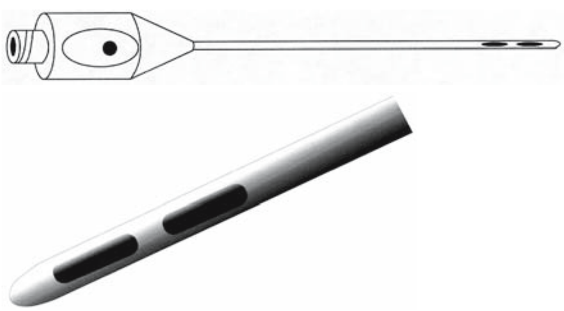

Fig. 27.1. Finesse cannulas

Fig. 27.2. Caspistrano cannula

27.6 Preoperative Evaluation

Consultation prior to surgery is an important aspect of liposuction surgery. Areas of treatment are established and a decision made as to whether more than one liposuction session is required on the basis of the amount of fat to be removed and the anticipated tumescent fluid volumes to be used. Clear goals and realistic outcomes and expectations should be emphasized. The health status of the patient, including relevant history, medications, and drug allergies, should be known in advance of performing the surgery. Additionally, routine preoperative serum laboratory values should be checked.

On the day of surgery, all medications are reviewed to ensure that no medications that interact with lidocaine metabolism are being taken. The patient's weight is obtained to calculate the amount of lidocaine that will be infiltrated based on the 35–55-mg/kg upper limit [2, 9]. At this time, any ancillary medications that will be utilized, such as clonidine, lorazepam, or meperidine, may be administered. Further information on lidocaine pharmacology and ancillary medications used during liposuction can be found in Chap. 10.

Before the patient is taken to the operating suite, detailed topographical markings are completed to designate the areas where infiltration of tumescent fluid and subsequent liposuction will be performed. Generally, concentric circles are used with denser markings indicating areas where more lipoaspiration will be performed. Peripheral areas should be marked for feathering to allow maximal blending and even contouring. Markings also include port sites, so the entire procedure is planned in advance of tumescent fluid infiltration. Aspiration ports must be closer than the length of the cannula since the procedure requires that aspiration of the fat be overlapping from multiple port sites. Usually, we make the distance between the ports sites about half the length of the cannula. Not all port sites are actually incised intraoperatively, but the authors strongly recommend anticipating and marking the maximum number needed in advance.

27.7 Tumescent Anesthesia Infiltration Technique

The tumescent technique has been refined such that minimal analgesia or additional sedation is required. The areas to be treated are tumesced with the standard combination of lidocaine, epinephrine, and bicarbonate in normal saline. The usual tumescent mixture is 500 mg lidocaine (50-ml bottle of 1% plain lidocaine), 1 mg epinephrine, and 10 mEq sodium bicarbonate in 1 l of normal saline resulting in a 0.05% lidocaine concentration [4, 15]. This concentration can be enhanced to 0.075, 0.1, or even 0.15% depending on the areas being treated and the total lidocaine dose and tumescent fluid volumes anticipated.

Different concentrations of lidocaine are chosen depending on the area and volume required. For example, infusing a neck can be performed with higher lidocaine concentrations, where considerably less total fluid is required. This contrasts with the abdomen and flanks, where significantly larger volumes of tumescent fluid are required, making use of higher concentrations potentially problematic, especially when total lidocaine dosing approaches the upper limit of 35–55 mg/kg.

Fluid is perfused until the tissue is swollen and moderately distended and has a fully tumesced feeling [16]. The skin should have a firm edematous quality and may demonstrate pallor and may be slightly cool. Overinfiltration may actually render the lipoaspiration more difficult. Typically the infiltrated volume is on the order of 2:1 or 3:1 fluid to aspirate [4]. A period of 15–30 min should elapse to allow maximum anesthesia [17]. Thus, the surgeon may wish to sequentially tumesce areas to be sculpted and then return to the first area to begin aspiration.

27.8 Lipoaspiration with Microcannulas: General Principles

Because microcannulas are designed to be thin walled, they are more delicate and bend easily. This bend of the microcannulas increases with cannula length and higher cannula gauge. Owing to cannula flexibility and bend, movement in a straight line is necessary. These cannulas cannot be utilized to lift or move tissue. To redirect the cannula, it should removed until just the tip remains under the skin and then redirected. The cannulas are not designed to be forced through areas of dense resistance. In that case, a smaller-diameter or shorter cannula should be chosen. Microcannula liposuction should be a smooth process, with the cannula slipping between fibrous septa without imposing excessive traction through resistant tissue.

Microcannula liposuction is a two handed procedure, with one hand squeezing and gripping the tissue to immobilize and compress fat and the other gently moving the cannula through the tissue tunnel created. Liposuction will not occur with a stationary cannula and minimal fat is aspirated without a hand grasping, pinching, compressing, or otherwise immobilizing tissue. The fat compartment should not move back and forth with the cannula but must remain stationary for efficient liposuction to occur. A fully tumesced compartment with increased tissue tension has less tendency to move as the cannula traverses the area. Therefore, tumescence of the area is important for microcannula liposuction to be fully effective [17].

Care should be taken to avoid repeatedly pushing the hub into the skin in order to avoid tissue trauma that could result in dyspigmentation [18]. Change in cannula direction occurs by withdrawing and redirecting the microcannula. The compressing hand can also move the fat around between strokes by manipulating the fat vertically or laterally. When using a cannula with holes on only one side, small rotations between strokes allow more complete aspiration.

The key surgical technique is the concept of multiple aspiration sites and the fanning pattern between incision sites [4]. A pattern of tunnels thus radiates from each adjacent incision site. There is overlap, interdigitation, and intersection of the various tunnels from multiple incision sites (Fig. 27.3). Thus, the incision sites are close enough such that overlap from adjacent aspiration sites occurs during the liposuction procedure. It is important to remember to remove only limited amounts of fat from each incision site

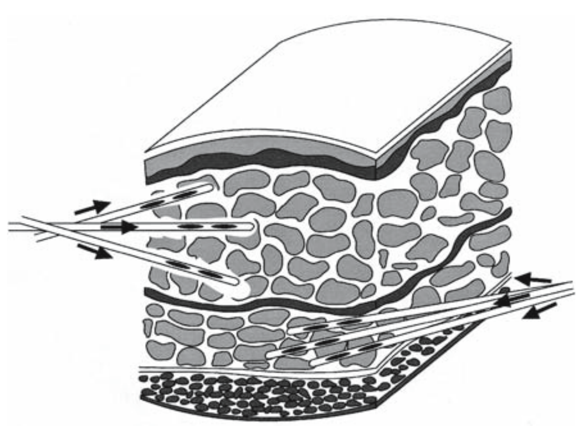

Fig. 27.3. Tunnels overlap, interdigitate, and intersect from multiple incision sites

before moving onto the next site and eventually returning to the original site to continue the process.

The procedure requires use of multiple aspiration sites over an area sequentially with repeated aspiration from the same port on several occasions throughout the liposuction [4]. A fanning technique of liposuction is employed with anywhere from five to 25 strokes from each port, all at the same depth. The surgery involves small removals from any incision site so that fat is uniformly taken throughout the field. The process is then repeated several times from the various aspiration sites until an end point is reached. Continually switching aspiration sites affords the surgeon the opportunity to achieve a smooth and uniform result. Fat is thus removed in small sequential steps in that 10–20% of fat is removed uniformly over the entire area, such as the abdomen, with each series of passes. The procedure is continued until the desired clinical end point is attained.

The deeper fat is approached first. Once the deeper fat has been addressed from all the aspiration ports, the process is repeated in the middle depth of the fat pocket and finally the various ports are utilized for aspirating the more superficial level of fat [13]. It is essential to address the deeper compartment first [4]. A cleavage plane at the muscle level must be established in order for accurate liposuction to occur. Clinically, only a small amount of liposuction at the deepest fat level adjacent to muscle is needed for establishing the desired cleavage plane and the initial cannula strokes establish that cleavage plane. If this cleavage plane is too superficial, then the surface hand squeezing the tissue will only be working with mobilized tissue above that cleavage plane and the deeper fat will be obscured and not removed, ultimately producing suboptimal results. After the deep and superficial compartments have been appropriately aspirated, microcannulas are used to feather the periphery. This enhances symmetry and blending to produce optimal skin contouring.

Liposuction of the most superficial aspect of the subcutaneous compartment must be completed carefully to avoid damaging the undersurface of skin [13]. Injury to the dermis may injure the skin's vascular supply, resulting in cutaneous necrosis and undesirable sequelae such as ulceration, scarring, and dyspigmentation. Liposuction cannulas should not scrape the dermis. When working at the most superficial compartment, cannulas with apertures on the underside only should be utilized.

It may seem counterintuitive, but the initial stages of the liposuction procedure should be accomplished with the smallest cannula. These are less uncomfortable than larger cannulas [17]. The larger microcannulas can then be utilized subsequently. The concept involves creating extensive tunnels with the smaller cannula and then enlarging those holes with a larger cannula. In this concept developed by Klein in utilizing the smallest cannula first, the emphasis is on maintaining uniformity throughout the procedure by gradually working up to the larger cannula [4]. When larger cannulas are used first, it is more difficult to direct the small cannula into new pathways, whereas larger cannulas follow the least-resistance direction by entering existing holes. Using the smallest size first avoids the issue of excess liposuction occurring in discrete locations resulting in irregularities that may be visible and difficult to completely even out. Furthermore, the smallest microcannulas are most effective initially in the fibrous areas such as periumbilical, upper abdomen, male breast, male flank, and back.

27.9 Special Considerations in Choosing Microcannulas

Details of utilizing microcannulas in various anatomic areas are discussed in the remainder of the chapter. In general, larger cannulas should be used when debulking large fat volumes in the deeper planes, while smaller cannulas can be used in the more superficial plane where fine contouring is required. In treating the deeper fat planes of the flanks, saddlebags, and abdomen, 10–12-gauge cannulas are frequently utilized. Fourteen-gauge cannulas are probably the most versatile in our experience and fit through a small 1.5-mm skin opening with little residual scarring. In fibrous areas such as the periumbilical area, breasts, and abdomen, 16-gauge cannulas are effective in fenestrating the fibrous tissue. Subsequently, a larger 12- or 14-gauge cannula can be introduced. Determining when to introduce larger cannulas is a clinical decision. Often, less resistance is noted after repeated sweeps through an area, prompting an empiric trial of a larger size. Finer cannulas, including the 16-, 18-, and 20-gauge cannulas, are the instruments of choice in treating more delicate areas on the lower face such as the nasolabial region. Twenty-gauge cannulas are extremely fragile and must be handled with care. Surgeons may prefer lightweight aspiration tubing for more precision when using the smallest cannulas.

27.10 Microcannula Liposuction by Anatomic Area

27.10.1 Upper Abdomen, Lower Abdomen, and Male Flanks

Preoperatively, patients should be evaluated for the presence of visceral fat, which cannot be lipoaspirated. If present, patients should be forewarned that the final postoperative contour may not be flat unless the visceral fat is addressed through diet and exercise. Additionally, skin tone and anticipated retraction must be assessed. Often, a significant amount of retraction is obtained through liposuction alone such that excision of redundant skin is not required. The presence of deeper fascia, such as Scarpa's fascia in the abdominal region, promotes tissue retraction [19, 20]. Once healed, if excess skin is noted, abdominoplasty can be considered at that time. The abdomen should also be evaluated for the presence of hernias, which pose a risk for bowel perforation if present.

The upper and lower abdomen are considered distinct areas but are often treated together. It is essential that the upper abdomen be evaluated in conjunction with the lower abdomen in the preoperative evaluation. If excess adiposity is noted, especially in the area of the epigastric and supracostal fat pads, the upper abdomen must also be treated or it may persist as overhanging fat which is aesthetically undesirable. The supracostal fat pads must be flattened. Extra attention should also be paid to the periumbilical region. Thorough aspiration of the fat in the periumbilical region is essential to produce a flat abdomen. As this area may be more fibrous and tends to be more sensitive, thorough tumescent infiltration is essential.

Incision sites are generally placed in the suprapubic region and the upper lateral abdomen. These sites should be placed with some degree of asymmetry to produce the most inconspicuous postoperative result. An additional entry site in the umbilicus is often helpful and is well hidden once completely healed. In patients with a pannus, the incision sites should be placed below the pannus so proper drainage during the postoperative period can occur. If the entire pannus is not flattened completely and the incisions are placed too high, fluid may collect in the pannus and develop into seromas.

The abdominal area may be more fibrous especially in those individuals who exercise this area frequently. It is often advantageous to initiate lipoaspiration with a 14-gauge cannula, which passes more easily through fibrous bands and septa. Once tunnels are created, a 12- or 10-gauge cannula can be easily used. A gentle stroke must be used and the tip of the cannula should always be monitored to prevent passage of the cannula under the subcostal structures into the thoracic cavity.

In male patients, the flanks or "love handles" can be treated in the same session as the abdomen. To access this area, the patient is placed on his side and the fat pockets can be accessed by incisions placed at the posterior aspect. The incision in the suprapubic area utilized for abdominal liposuction can be utilized to approach the flank region from the anterior perspective in addition to any entrance point more posteriorly. Aggressive liposuction can be performed in this area to thoroughly remove the excess fat pockets utilizing larger cannulas such as the 12-gauge Capistrano or the 10-gauge Finesse cannula.

27.10.2 Suprapubic Liposuction

The suprapubic area is a site about which patients infrequently complain but is satisfying to patients once addressed. A suprapubic mound may make the penis appear less defined and suprapubic fat extending onto the labia majora may be problematic for women, causing disfiguration. Furthermore, this area may appear more pronounced after abdominal liposuction.

The site is effective for microcannula liposuction because this area requires sculpting around the base of the genitals and extension frequently into the labia majora on women. Further, women prefer a "mound of Venus" and thus, careful sculpting of the suprapubic area is required. The procedure is carried out in the fashion as described earlier in this chapter with overlapping interdigitating lipoaspiration from multiple aspiration ports. Microcannulas are utilized to creatively sculpt the tissue to the desired end point rather than to achieve a simple debulking. Fourteen-gauge Finesse cannulas are recommended. Excessive liposuction should be avoided and a layer of fat should remain in place to avoid palpable pubic bones. Significant ecchymoses and edema are common postoperatively in this area after both suprapubic and abdominal liposuction [21].

27.10.3 Female Flanks and Waist

Female patients often seek contouring of the flank region in the upper back especially when bulges are produced secondary to compression by clothing. The back and upper flank areas are especially fibrous and generally require significant time to treat although ultimately only small amounts of fat may be removed. However, this is a satisfying area to treat for both the patient and surgeon as shapely contouring can result. The flank area is usually treated in conjunction with the waist and hips. When treated as one unit, this is an area that can dramatically alter the shape of the female contour 21].

It is best to approach this area initially with a 14-gauge Capistrano cannula to break through the fibrous tissue with ease. Later stages of the procedure can be performed with the 12-gauge Finesse or Capistrano cannulas. In general, the back has more potential for scarring so incision sites are minimized and placed as far laterally as possible. In this area, it is important to be conscious of avoiding symmetric placement of incision sites bilaterally. The patient is treated lying on her side but rotated slightly anteriorly. In this position, the fat pockets can be lifted with the non-dominant hand and adequately aspirated. To effectively provide the patient with a harmonious female contour, the waist is also often simultaneously treated. This area is usually comprised of significant amounts of fat, which can be removed with 12-gauge cannulas.

The female flanks and waist are usually treated in a single session, with the whole unilateral lower back area being treated one side at a time. Once both sides have been treated, the patient can be placed in the prone position for final blending of the whole back region. A 12-gauge Finesse cannula can be used to treat the mid back and cross the midline for optimal blending of both sides of the back.

27.10.4 The Buttocks

Microcannula liposuction of the buttocks avoids many of the complications that heretofore prevented surgeons from contouring this region. With larger cannulas, asymmetry and irregularities result not uncommonly. However, an entire buttocks region can be addressed with the microcannula technique, although a conservative approach is required [4].

Buttocks fat is relatively devoid of significant vascular or neural structures and overall there is a general homogeneity to the fat. There are, however, fibrous septa within the fat known as ligaments of Jacque affording a supporting structure that in the youthful buttock maintains the normal visually pleasing configuration.

The horizontal infragluteal crease is a confluence of multiple fibrous connective tissues connecting to the fascia distally and buttocks tissue superiorly. The various septa insert into the deep dermis of the crease defining the inferior boundary of the buttocks. This confluence is known as the ligaments of Lushka [4]. The combination of the two sets of ligaments serves to elevate the buttocks from above and support the structure from below. Over time the suspensory ligamental structure stretches, resulting in a drooping buttock. With obesity local additional accumulations of fat seems to occur, causing a bumpy quality to the surface.

With microcannulas, all areas of the buttocks may be treated, including the "banana roll" inferiorly. This affords the opportunity to sculpt the buttocks region, which is often viewed as part of a complex involving the hips and lateral thighs. Microcannulas allow for careful sculpting and feathering of each of the important areas to avoid sharp cutoffs. With macrocannulas, some reduction in volume can occur, but areas such as the medial gluteal regions are typically left untreated and contouring the upper lateral buttock-flank border becomes problematic. These areas are comfortably addressed with the microcannulas.

The patient is positioned prone with the buttocks slightly elevated. The entire process proceeds with an emphasis on maintaining symmetry, uniformity, and smoothness. Superficial liposuction should be avoided in the buttocks region [4]. The benefit of microcannulas is that fat is taken in all directions from multiple ports, reducing the problem in macrocannula liposuction of grooving or telltale irregularities. Gradual uniform reduction is the intent with fanning, intersecting, and interdigitating patterns of strokes, usually five to 25 from each port before proceeding to another port. The entire buttocks region is accessible, including the previously worrisome "Bermuda Triangle," which is a triangle in the center of the buttocks extending from the infragluteal crease to the superior buttocks cleft. The only area that should be avoided is the infragluteal crease because of problems with asymmetry and irregularity. Even with microcannulas, dimpling can occur. To avoid this, the lipoaspiration must be deep, leaving a thick layer of fat undisturbed beneath the skin.

The banana fold represents a problem area that must be addressed extremely conservatively to avoid causing a secondary buttocks crease. Liposuction of the banana fold should be considered as an effort to conservatively improve the area rather than to aggressively remove the fat in its entirety. Clinically, to avoid a secondary crease, a residual but diminished banana fold should be present postoperatively. To avoid disruption of supporting structures, Klein [4] advocates cannulas be directed at 45° from the horizontal. As stated already, the infragluteal crease should be avoided as asymmetry and irregularity can result and the benefits are small.

The buttocks region must be treated conservatively overall. Excessive liposuction can cause a ptotic unsightly result. Klein [4] states that a maximum of 30–50% of the fat should be removed. The authors prefer the more conservative 30% figure. Whereas size may matter, in actuality the intent should be a smooth, natural, well-proportioned end point.

27.10.5 Microcannulas in Axillary Hyperhidrosis

Topical regimens and oral medications have remained the conservative approach to treat axillary hyperhidrosis and are effective for many patients. Newer surgical approaches have been described, including treatment with Botox®, which has been approved by the FDA for this purpose. The results with all of these treatment modalities, however, are often transient. Microcannula liposuction is a minimally invasive and low-risk modality with the potential for a reasonable permanent clinical remission of this significant lifestyle and quality-of-life issue.

The starch iodine test defines the involved area. The area of hyperhidrosis is not always defined specifically by the hair distribution; it may occur in only a small area or may be present in the entire axilla. After being prepped in a sterile fashion, the involved areas can be treated. Only a few distant incision sites are needed at the periphery of the hyperhidrotic area placed closely enough to allow the normal interdigitation and crisscrossing of the microcannula technique. Because of the small volume of tumescent fluid and the limited area, a higher lidocaine concentration such as 0.1 or 0.15% may be chosen. In this region, the anesthesia is infused superficially and in contrast to liposuction in other areas, the *peau d'orange* skin effect is the desired end point. Waiting 15–30 min after infiltration is needed for maximum anesthetic and vasoconstrictive effect.

Anatomically, the sweat glands are found at the base of the dermis and in the most superficial levels of the fat. Therefore, liposuction here is performed very superficially and, as such, can only be accomplished with a microcannula. Any larger cannula would be tissue-destructive and counterproductive. Swinehart [22] recommends the 12-gauge Finesse cannula (apertures only on one side of the tubing) but keeps the aperture directed upward adjacent to the dermis in contrast to the normal technique of directing the apertures downward. Because of the slight curve of the cannula tip, the apertures do not directly contact the dermis when using this cannula as long as the surgeon is careful. Two or three crisscrossed patterns are initially performed. Swinehart then advocates using the Capistrano cannula with circumferential apertures to rasp lightly against the dermis and remove or destroy sweat glands. The ultimate goal is removal of eccrine sweat glands and not fat, reflecting the superficial nature of the procedure.

Multiple tunnels with conservative liposuction being performed in multiple directions are required. Care must be taken to avoid leaving a large area of dermis unsupported by vascular structures. It is preferable to return for a second procedure rather than risk developing substantial necrosis of the dermis. Patients are warned that final results may take months with this procedure so touch-up efforts should be delayed [22].

27.10.6 Perioral and Nasolabial

Senescence may cause hollowing of the central cheeks with accentuation of remaining fat in the nasolabial folds. Correction of these irregularities may contribute to a more refined, pleasant facial contour but these areas can only be addressed with microcannulas. Often, the amounts to be removed are so small that syringe-assisted lipoaspiration is effective [23]. Areas that can be aspirated include the malar fat pads, meilolabial folds, marionette lines, and jowls [24–26]. Ideal candidates for facial liposculpture demonstrate early aging with good elasticity and skin tone. This can be tested with the snap test, in which the skin is pinched and retracted and then returns quickly to normal contour.

Preoperative markings should be made with the patient in the sitting position. The most important underlying structure of which the surgeon must always be aware is the marginal mandibular branch of the facial nerve as it traverses the mandible. Remaining in the superficial plane while aspirating in this area is mandatory. Tumescent anesthesia is infiltrated using a 0.1–0.15% lidocaine concentration. The syringe-and-needle method may be chosen for infiltration rather than an infusion pump. Proper tumescent infiltration will magnify the tissue but not distort tissue landmarks. This concept should help surgeons decide on the appropriate infiltration end point. Aspiration ports are carefully selected to be hidden in the lateral nasal ala, oral commissures, smile lines, or crow's feet.

In this procedure, the superficial fat compartment is the target treatment zone. The authors prefer utilizing a 16-, 18-, or 20-gauge Finesse-style cannula that may be connected directly to a syringe or fine tubing attached to vacuum suction. One hand should grasp and pinch the areas to be suctioned, while the dominant hand is used to pass the cannula parallel to the direction of the fold being aspirated. Frequent assessment is required because only minute amounts of fat need be extracted and feathering of adjacent areas is important. Rolling the skin between the fingers allows for assessment of the tissue fat aspirated. This procedure is primarily a superficial liposuction of a very small fat compartment and, as such, the smallest effective microcannula should be chosen. It is not necessary to rotate through cannula sizes as may be done for other compartments such as the abdomen. Furthermore, use of only a few aspiration ports may be all that is required on the cheeks, jowls, or malar fat pads. The use of multiple crisscrossing interdigitated tunnels is not as necessary as in other areas. Finally, this procedure should be performed in a conscious patient in the sitting position for more accurate end-point determination.

The end result is dependent on skin retraction over the site, so only a modest volume reduction needs to be attained. Aspirated fat should then be considered for fat transfer into adjacent atrophic areas.

27.10.7 Neck and Jowl

Liposuction of the neck and jowls can be performed with the machine-assisted or syringe-aspiration technique. Conservative removal of the jowl area is necessary but the neck can be more completely treated. The standard tumescent fluid is infiltrated until tumescence occurs utilizing a 0.1 or 0.15% lidocaine concentration. The treatment area in the neck should be limited to the area between the sternocleidomastoid muscles bilaterally. Rapid fat removal in the jowl can leave an unsatisfactory result owing to over-resection. The use of extremely small microcannula (18 or 20 gauge) will help prevent this complication. In contrast, thorough fat removal in the neck enhances skin retraction, revealing a significant clinical result.

The neck is best approached through a crisscrossing pattern of microcannula liposuction. This is accomplished by ports in the submental region and infra-auricular sites bilaterally providing adequate interdigitation of lipoaspiration. Most of the fat is located at a superficial level immediately under the skin. Care should be taken to avoid traumatizing adjacent and deeper anatomic structures. Aspiration of the neck should be performed with the usual grasping and pinching of the skin to avoid penetration through a dehisced platysma and damage to deeper structures. Potential complications include damage to the marginal mandibular branch of the facial nerve, persistent edema, damage to the platysma resulting in asymmetric facial movements, and trauma to the salivary glands.

The submental site should not be utilized as a port for accessing the jowls because damage to the marginal mandibular branch of the facial nerve may occur where it crosses the mandible. Jowls should be accessed from the infra-auricular site. A 20-gauge cannula can also be utilized to aspirate the jowl immediately inferiorly, which provides the crisscrossing needed and leaves an almost invisible residual scar. The neck and jowls are delicate areas that require microcannulas to avoid skin contour irregularities and prevent damage to adjacent structures [11, 27].

27.10.8 Outer Thighs and Hips

The outer thighs of women are also known as the "saddlebags" in the vernacular. This area often represents an isolated fat pocket that is effectively treated by liposuction (Fig. 27.4). The adjacent cosmetic units, including the hips and buttocks, must also be evaluated and treated if needed to achieve optimal contouring. Frequently the hips, outer thigh, and buttocks are treated in a single session. The patient should be marked preoperatively while standing and viewed from the front. This will ensure that the peak point of the outer thighs can be identified.

The outer thighs must be carefully treated to avoid contour irregularities. Meticulous attention must be maintained to ensure that enough fat is removed to produce a therapeutic effect, keeping in mind that excessive liposuction can produce indentations and depressions. The bulk of fat removal should occur in the deeper planes and superficial liposuction should be avoided. The area to be treated is teardrop-shaped, pointing distally where feathering into the distal lateral thigh occurs.

One high-risk area that is susceptible to depression is the area of the bulge that forms above the greater trochanter of the femur. The bulge is augmented when the leg is outwardly rotated and adducted (Fig. 27.5). If ag-

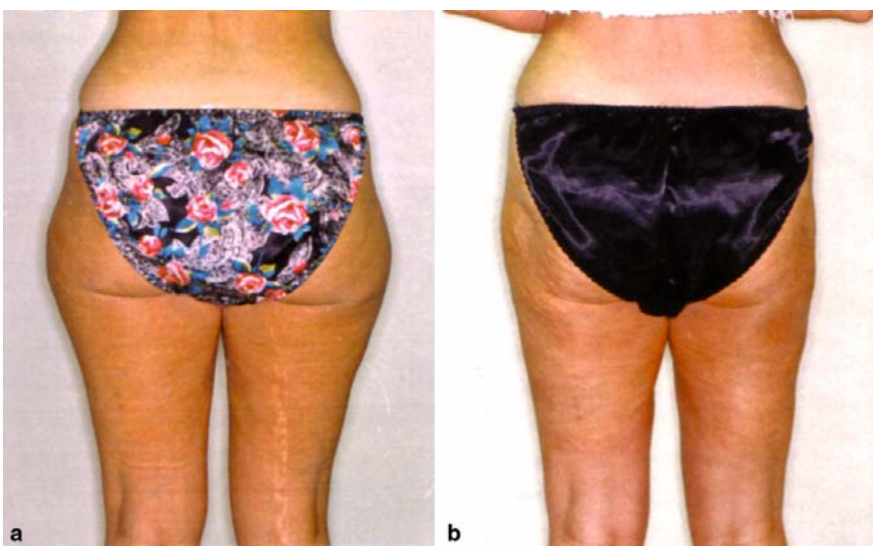

Fig. 27.4. Outer thighs are effectively treated by liposuction: **a** preoperatively; **b** postoperatively

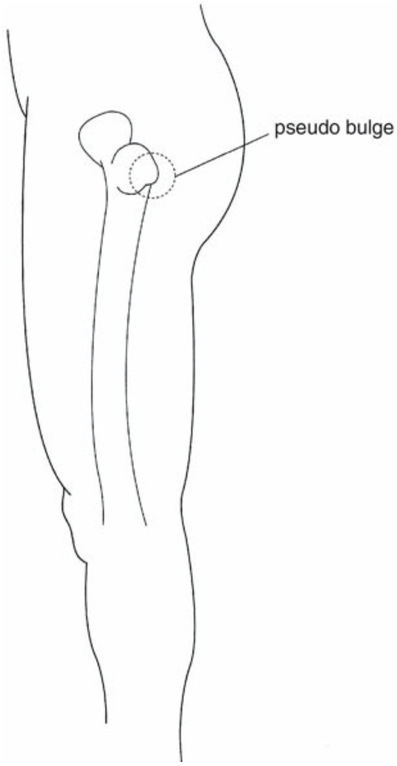

Fig. 27.5. The bulge above the greater trochanter is augmented when the leg is rotated outward and adducted, which may result in a depression from aggressive liposuction

gressive liposuction is performed to flatten this bulge, it will actually produce a depression when the patient returns to the anatomic standing position; hence, intraoperative positioning is of paramount importance. The leg must be inwardly rotated and adducted to move the greater trochanter and remove the overlying bulge. If this positioning is not maintained, an indentation will occur over the greater trochanter. As patients are awake during the tumescent technique of microcannula liposuction, they can be positioned appropriately during the surgery. This is a major advantage of the tumescent technique. A triangular pillow (Thigh Midline, HK Surgical) may be placed between the thighs to ensure appropriate positioning [4].

Three incision sites are made in the supero-posterior, supero-anterior, and infero-posterior positions correlating with the 2, 8, and 10 positions on the face of a clock. Less aggressive cannulas, usually 12- or 14-gauge Finesse cannulas, are preferred to gradually remove fat and sculpt the tissue evenly. The end point of liposuction in this area can be determined by visualizing a flat contour when the lateral thighs are viewed at eye level. Tactile evaluation through pinching of the tissue is also helpful in learning the end point of treatment of the outer thighs.

The hips often contain copious amounts of fat that if left untreated will result in a less-than-desired outcome. When treating the hips, it is essential that the liposuction be performed initially in the deeper planes. The surgeon can then move more gradually to the more superficial planes. Without adequate removal of the deep fat in this region, a persistent bulge will occur. When treating the hip, the cannula entry sites should be placed on the supero-posterior aspect as well as inferiorly to ensure adequate fluid drainage postoperatively.

27.10.9 Inner Thighs

The inner thighs often require only very conservative lipoaspiration to achieve the desired outcome (Fig. 27.6). This area is often a problem for patients not only owing to contour irregularity but also to chronic rubbing and irritation. By removing small amounts of fat, appropriate contouring can be achieved and rubbing of approximated tissues can be eliminated. This anatomic area has less elasticity and is especially prone to divots and dents if excessive or superficial liposuction is performed. In general, it is advisable to aspirate only the deep fat with minimally aggressive cannulas such as the 12- or 14-gauge Finesse cannulas [4].

Access to the inner thigh is best attained with the patient lying on his or her side with the contralateral thigh flexed upward. Incisions are placed at the anterior and posterior aspects of the inner thigh in this position. An additional entry site can be placed more distally in the mid thigh to provide access from multiple directions for cross-hatching. It is important to treat and feather distally into the mid-thigh region and treat the medial knee if needed to produce a smooth contour of the inner medial leg.

27.10.10 Arms, Calves, and Ankles

These are areas many surgeons decline to treat owing to potential problems yet each is amenable to the microcannula technique. The goal on the upper arms is to remove as much fat as possible yet preserve the immediate subdermal fat plane and avoid trauma to the skin; thus, microcannulas are considered the cannulas of choice because of the need to avoid the immediate subdermal area. Larger cannulas carry the risk of penetrating into undesired regions, rapidly removing fat before the surgeon realizes that the cannula is not properly placed, thereby resulting in tracking, dimpling, and puckering.

In the properly selected patient, skin contraction on the arms can be substantial and significant contour improvements can result (Fig. 27.7). Incision

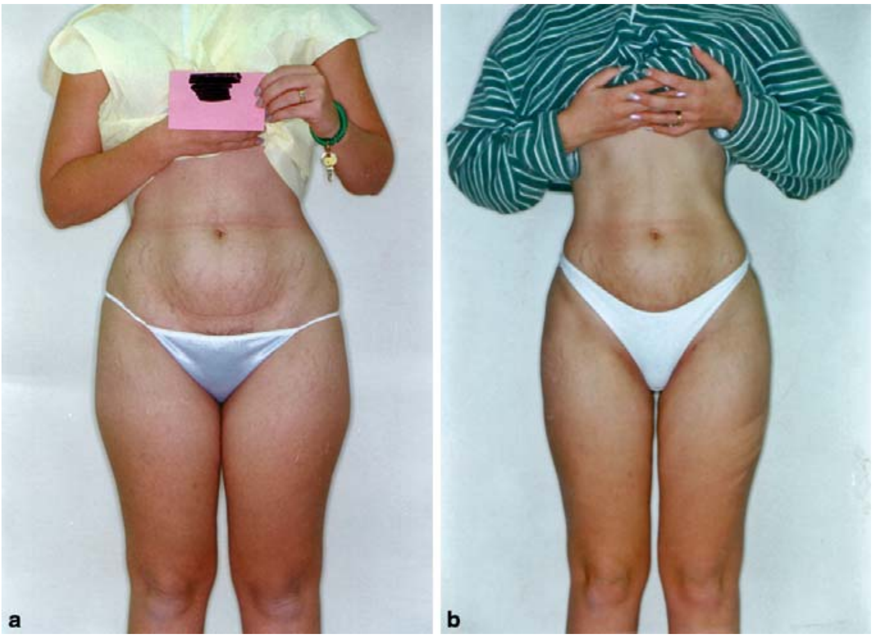

Fig. 27.6. Inner thighs often require conservative lipoaspiration: **a** preoperatively; **b** postoperatively

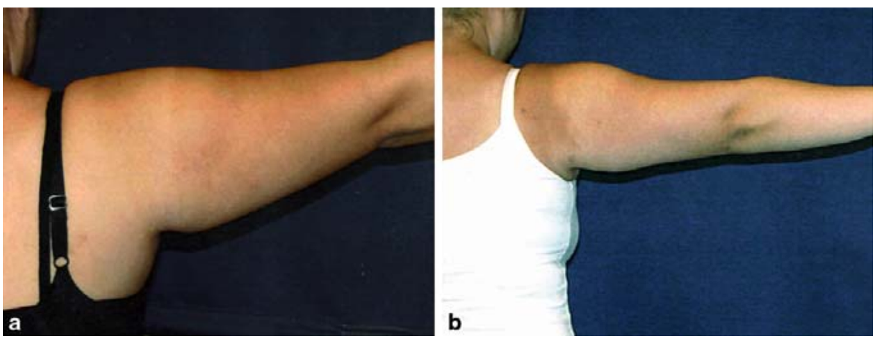

Fig. 27.7. Skin contracture of the arms can be substantial and significant contour improvement can result: **a** preoperatively; **b** postoperatively

sites are placed at the elbow and the scapular region. The bulk of lipoaspiration should occur on the posterior aspect of the arm with long strokes using a 12- or 14-gauge cannula. Lillis [28] emphasizes that multiple incision sites with extensive interdigitated cross tunnels results in the desired thorough even fat reduction. Compression postoperatively is important but the patient should be forewarned that a significant amount of distal edema may occur.

Calves and ankles are similarly treated. The challenge in treating these areas is determining if there is fat present and how much needs to be removed. That decision is beyond the purview of this chapter, leave it be said that sometimes a firm area that clinically appears devoid of fat indeed is suffused with the same. In contrast to liposuction of the arms, the legs are addressed circumferentially, sparing the immediate pretibia. This is a challenging area because the natural contours of the lower extremities are uneven and rounded. The main task to be achieved in this region is even fat removal both from the individual extremity and from the contralateral limb. Again, this makes the microcannula the instrument of choice both in sculpting and in a slow steady fat removal, which reduces the risk of contour defects. Furthermore, microcannulas allow for feathering with the more superior portion of the tibia. As with the arms, small cannulas, non-aggressive tips, and multiple interdigitating tunnels facilitate a satisfactory low-risk approach. Lillis [28] describes the use of 12- and 14-gauge Klein cannulas or a 2.5-mm standard cannula. The one technical difference in this area is that grasping and pinching can be difficult and is often not necessary as the fat is already compressed and relatively immobile. Postoperative swelling can be problematic and a compression hose and leg elevation are necessary.

27.11 Postoperative Care

Ports are typically left open with the microcannula technique [29]. Significant drainage may occur for up to 72 h and may be blood-tinged. Immediately after the procedure absorbent pads are applied. These may be abdominal pads or even women's absorbent pads, which are inexpensive and easy to change. A compressive elastic garment is applied which provides support and helps contour the skin during the retraction phase in the time following the liposuction. Heavy compression garments have been found to be unnecessary and possibly counterproductive.

Patients generally return to normal function quite quickly with the microcannula technique. The prolonged anesthesia effect of tumescent liposuction confers a comfort previously unknown in liposuction surgery in the immediate postoperative period. In general, patients prefer a few days rest but not uncommonly return to work within days. We have had patients return to work or go on vacation within a day or two of abdominal liposuction owing to the less traumatic nature of microcannula liposuction with tumescent anesthesia.

Skin retraction is a slow process that occurs over weeks [19]. Edema may persist for 2 months or longer and patients must be counseled that the final result may not be apparent for 2 months or longer. Occasional touch-up procedures may be needed but should be delayed at least 2 or 3 months after the initial procedure. Some surgeons recommend up to a 6-month delay [13].

27.12 Complications

Problems of surface irregularity are significantly reduced with microcannula liposuction. One of the authors (B.I.R.) was trained initially with "standard" larger cannulas and noticed a reduction in contour problems and irregularities after changing to microcannulas. The risk of intraoperative hemorrhage is quite low with this technique in part owing to cannula size and in part owing to the vasoconstrictive nature of epinephrine when adequate tumescence occurs [4]. There is a low rate of infection with tumescent anesthesia that may be due to the beneficial antibacterial aspect of lidocaine (see Chap. 10 for a more complete discussion). Scarring is generally minimal with the microcannula technique, although possible pigmentary alteration at the ports may occur.

Complications specific to the tumescent technique may result from the large volumes and amounts of lidocaine infiltrated. Edema and ecchymoses may result and may be especially noticeable in dependent areas.

Liposuction safety has been an issue since a 1999 article reporting five deaths in patients undergoing a form of tumescent anesthesia [30]. However, when liposuction has been performed by pure tumescent anesthesia in the conscious patient, there have been no recorded deaths [3]. Moreover, studies of tumescent liposuction under local anesthesia on large numbers of patients have identified an extremely low rate of any serious adverse event (see Chap. 10) [31].

27.13 Conclusions

Microcannula liposuction offers the surgeon extraordinary control of the fat compartment with a significant reduction in contour irregularities. There is reduced surgeon fatigue and stress. The risk of surface irregularities is significantly reduced. Microcannula liposuction reduces patient discomfort and allows for a more complete procedure with diminished need for sedation or additional analgesia. Facilitation of liposuction in fibrous areas is considerably enhanced with microcannulas. In sculpting delicate areas such as the cheek, microcannula liposuction remains the method of choice.

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Superficial Liposculpture: Rationale and Technique

Robert F. Jackson

28.1 Superficial Liposculpture

The most important cosmetic surgical development in the past 25 years has been liposculpture. Introduced in the 1970s by Giorgio Fischer and further developed by Yves Gerard Illouz and Pierre Fournier, the technique has been improved and has totally changed the way cosmetic surgery is practiced today [1]. There are two types of fat removal with aspiration. One is liposuction, which is the removal of fat through aspiration of localized deposits of subcutaneous fat. The other is actual body contouring or liposculpturing using both removal of the deep localized areas of fat and liposuction of the superficial layer for better draping of the skin to utilize contracture for a more aesthetic result. The original concept of liposuction had substantial limitations related primarily to excess skin, loss of elasticity and surface irregularities [1–4].

The field of liposuction surgery is indebted to Marco Gasparotti [5] who in 1989 introduced his technique of superficial liposculpture. It always seems that the job of the cosmetic surgeon is to sculpture the patient. Twenty years of experience performing liposuction has convinced me that I need to be able to work superficially as well as in the deeper plane if I am to obtain optimum results. As I start this discussion it is extremely important that one understand the distinction between sculpturing in the superficial layer and damaging or injuring the dermis. Fournier, one of the fathers of liposuction and mentor of many liposuction surgeons practicing today, states, "What you take is not as important as what you leave."

Gasparotti's technique involves deep removal of fat and subdermal removal of fat. His theory is that the subdermal removal of fat increases the postsurgical contracture of the skin to produce a smoother result. In areas such as the abdomen this approach has allowed substitution of liposuction for formal abdominoplasty or panniculectomy. Unfortunately, in the hands of unskilled surgeons total removal of the fat between the dermis and the underlying muscle and fascia can result in significant deformities and irregularities. As I teach the art of liposuction I instruct my students that defects on the operating table will be defects forever.

The superficial layer of fat is a distinct layer approximately 1–2 cm beneath the skin. There is a definite learning curve in liposuction surgery and to find this layer takes some practice. If one suctions too close to the dermis permanent defects will occur. If large areas are removed in the deep layer only, significant contour irregularities will result. The advent of the tumescent technique of liposuction has further enhanced our ability to safely contour the body and protect the dermis while still being able to carry out superficial liposculpture.

The safety of liposuction as we know it today has occurred owing to Jeffrey Klein and his contribution of the tumescent technique. My personal technique of the use of tumescent infiltration will be presented later in this chapter.

Gasparotti in his original theory felt that by properly thinning the superficial subcutaneous tissue one could use the properties of retraction or contracture and support of the skin to function in a dynamic way to obtain the desired contour [6]. Initially this technique was proposed for flaccid skin. Through the years, the technique has been utilized in all facets of body contouring. Contracture has given us the ability to hold and improve the sculptured results.

Contrary to the original concept of liposuction in which we were taught to stay deep, the superficial technique of liposuction revolutionized our ability to create a new body form. As Gasparotti noted in his text of superficial liposculpture, the skin is an active structural dynamic contributor to the body contouring procedure, not just a passive element in the operation [6].

Though the technique I use may differ in method, the goals of the procedure are similar to those of others who subscribe to the use of superficial liposuction.

28.2 Technique of Liposuction Combining Both Superficial and Deep Sculpturing

My personal technique of liposuction is constantly evolving as new modalities emerge that allow me to improve my results and enhance patient safety. The term "the art of medicine" is nowhere more evident than the field of cosmetic surgery. Liposuction is definitely based on scientific medically sound principles but the optimal results depend on the eye to visualize and the skill to artistically create the desired symmetry and contour. In liposuction surgery personal preference may be a combination of one's artistic style in combination with technical changes. In the process of our learning curve we will incorporate the methods of other colleagues and also develop our own individual skills.

28.3 The Surgical Candidate

The ideal patient for liposuction has been described as a young person with excellent skin tone and localized areas of fat. I, however, have performed liposuction on patients from the age of 14 through 84 with excellent results. Many of these patients did not appear to have good skin texture and actually appeared to have significant flaccidity. Following superficial liposuction, often through contracture, once the localized fat has been removed the skin becomes firm and a more aesthetic appearance is achieved. Liposculpturing will vary with the localization of the fat, the flaccidity of the skin and the underlying musculature without a lot of regard to the age of the patient.

A discussion of the ideal liposuction patient must include the fact that in most instances obesity is not an indication for liposuction. Elective procedures, especially cosmetic procedures, must always have patient safety as a number one core concept. There are many guidelines that state that in most patients up to 5,000 ml of supranatant fat can safely be removed using the tumescent technique [7, 8].

The ideal candidate, therefore, is a patient who has localized areas of fat that he or she wishes to have removed to give the perceived contour that they desire. Liposuction can be performed safely on most patients. Since this is an elective procedure the patient should be ASA class I or II and occasionally class III. I would personally avoid class IV anesthesia risks for liposuction.

The criteria that one uses in conventional liposuction is expanded and modified when choosing the patient that will benefit from superficial liposuction. Substantial results can occur when one debulks and minimizes the overlying skin flap. The use of superficial liposuction expands the patient population and includes some individuals that would have been considered unacceptable in our original liposuction criteria. A combination of superficial liposuction and occasional lipoaugmentation can give remarkable results.

28.4 Anatomical Considerations

There are conceptually three layers of subcutaneous fat. Practically we only work in two layers. There is a thin layer of fat attached to the deep dermis. To attempt to remove this layer of fat will result in injuries to the dermis and significant contour and surface irregularities. The severest of these complications is full-thickness dermal necrosis.

The superficial layer of fat is a layer of vertically oriented fat cells arranged in columns. This layer of fat is just beneath the reticular dermis as opposed to the intradermal or apical layer of fat. The superficial layer of fat is a compact, dense type of fat that is well organized with fibrous septa. A discrete sheet of fibrous fascial tissue separates the superficial layer of fat and the deep layer of fat. Superficial fat can be found throughout most of the body. It is much thicker in such areas as the abdomen, hips, thighs and buttocks. Below the knee and elbow the deep layer of fat phases out and only the superficial layer remains. In these areas one needs to modify his or her liposculpture technique. It is in the superficial layer that one needs to learn to work to do the final sculpturing that will allow the art of the technique to evolve.

The deep layer of fat, which is the only fat we originally removed in the early days of liposuction is more areolar, looser and arranged with a haphazard type of septae. The deep layer of fat is more prominent in pari-umbilical, para-lumbar, gluteal-thigh, and lower abdomen areas. As the deep layer of adipose tissue extends laterally from the abdomen to the flanks or midriff and distally over the lower extremities it gradually attenuates and essentially disappears, with its fascia merging with the superficial muscle fascia. This leaves only the superficial layer of fat in these areas. The superficial layer also becomes very thin. Care must be taken when carrying out liposuction in those areas with only superficial fat. The pattern of fat distribution is to a large degree genetic. In general, the pattern of distribution of lipodysmorphia in the female (gynoid) fat is most commonly deposited in the lower trunk, hips, upper thighs and buttocks. In men the deposition is evenly around the trunk, a thickness around the torso, in the upper abdomen and the male breasts (pseudo-gynecomastia).

The deep layer has to be reduced and modified to change genetic conformations. To hold the changes requires superficial liposculpturing.

28.5 Preoperative Evaluation

The preoperative workup should include a complete history and physical examination. Liposuction surgery is an elective procedure and for that reason patient safety is the number one concern. Attention should be directed to any previous surgical complications. Bleeding and/or clotting problems should be addressed. The physical examination should be complete and special attention should be given to the possibility of hernias, flaccid musculature, excess skin and previous surgical scars.

The laboratory evaluation that I presently use is extensive. If the patient has not had a complete hematologic workup within the 12 months preceding the proposed procedure I order a complete blood count, a basic metabolic screen, an EKG for patients over the age of 40, and a chest X-ray. I also order a partial thromboplastin time, a prothrombin time and a bleeding time.

As part of the informed consent I instruct my patients to stop taking any aspirin or non-steroidal anti-inflammatory agents. I also have them stop taking any herbal medicine. Patients are strongly encourage to stop smoking and all smokers sign a form that they have been well informed of the risks of continuing to smoke.

28.6 Surgical Technique

The original Gasparotti technique of liposculpture was mainly performed with the syringe technique using a beveled end-holed cannula [6]. Another important part of his technique included replacement of the autologous fat in certain superficial areas to improve surface contour. My modification of this technique includes aspiration of some of the fat with the syringe to be used for the correction of defects. The bulk of my procedure, however, is carried out with the use of the vacuum pump. To accomplish superficial liposuction I have used the ultrasonic technique of liposuction, routine liposuction and today I mainly use mechanically assisted liposuction. The cannulas I use at the present time include a multiple-holed cannula, a spatula-tipped one or two-holed cannulas and a ventral three-holed cannula. I will describe the cannulas in further detail later in the chapter.

Any vacuum pump used for aspiration that can generate negative 1 atm of pressure is acceptable. Traditional cannulas of the multiple-holed, spatula-shaped and the Saylan type are my choices for superficial liposuction. I tend to use the Mercedes cannula and other more aggressive cannulas in the deeper fat to debulk. In the late 1980s Klein introduced the small microcannula technique with excellent results. For most procedures the largest cannula that I use is 3.0 mm in diameter. For finesse the cannulas are even smaller in diameter. The exception is occasionally a 4.0-mm one-holed flat spatula that is used to remove very deep fat in the midriff, paralumbar area and the area below the brassiere line (an area I refer to as “bat wings”).

It is recommended that those who are just beginning the use of superficial liposuction use routine liposuction only. Until you get the “feel,” the syringe technique might be preferable. As your skill improves you can switch to the aspiration pump. I presently use the mechanical reciprocating device. In my hands I believe it is easier to sculpture with the reciprocating cannula.

28.7 Preoperative Preparation

The patient initially is marked in the upright position using permanent markers. Marking the patient in the upright position is important because in most cases the lipodysmorphia that we are trying to correct is very gravity dependent. Once the markings have been made the fat will move with the skin. Each surgeon develops his or her own marking technique. My technique is to draw topographically much as one would draw a topographic map (Fig. 28.1). Approximately 1 h prior to surgery the intravenous (i.v.) fluid administration is started and preoperative antibiotics are given. My personal preference, if there are no allergies, is 1 g of Kefzol or Ancef. Other antibiotics could be substituted if there are allergies to the cephalosporins. The patient is prepped with Betadine. If i.v. sedation or general anesthesia is used, it is administered prior to the prepping. In cases of pure tumescent local anesthesia we still use the i.v. and the preoperative antibiotics. Sterile ace wraps are used from the feet to the knees if there is no anticipated liposuction of calves. This is helpful to prevent venous stasis and also allows us to move the patient in a sterile manner. The patient is then placed in the appropriate position.

Tumescent infiltration is then accomplished using the Klein pump. There are other modifications of this pump and they are perfectly acceptable. The tumescent fluid used includes normal saline (0.9%) and 50 ml of 1% lidocaine per 1,000 ml of saline and 1 mg

Fig. 28.1. Topographic marking in the standing position

of epinephrine per 1,000 ml. For the pure tumescent technique with no i.v. sedation or general anesthesia the concentration of lidocaine is increased to 100 ml of 1% lidocaine. The concentrations of lidocaine are 0.05 and 0.1%. However, the more appropriate specification is 500 mg of lidocaine in 1,000 mg per liter. According to Klein, the current recommendations for tumescent liposuction totally by local anesthesia is 500–1,500mg of lidocaine per liter and 0.65–1.0 mg of epinephrine per liter of normal saline [9]. The addition of 12.5 mEq of sodium bicarbonate will decrease the pain associated with infiltration of the tumescent fluid.

28.8 Superficial Liposculpturing Steps

The procedure is then performed using the syringe for harvesting fat for later grafting. I use the Coleman needle for this portion of the procedure. This fat is decanted and placed in syringes for later use. My present technique does not include washing or centrifuging the fat.

The serum and fluid are discarded after the fat has risen to the top. The oil layer on the very top can either be aspirated or absorbed in a sterile gauze wick. Once as much fat as is felt to be needed has been obtained, liposuction is performed in the deeper fat in the routine manner using the vacuum pump. The one area in which I first work superficially is the inner thigh.

28.9 Liposculpturing of Various Body Areas

Superficial liposuction can be performed in most areas of the body. The level at which to work, according to Luiz Toledo of Brazil, depends on the region, the problem and the skin tone [10].

28.9.1 Abdomen

The abdomen is the area of the body most commonly treated by liposuction. Both sexes have a thinner more athletic torso as one of their primary goals. The abdomen is one of the areas that beginning liposuction surgeons choose for their initial cases. Unfortunately, the abdomen can be one of the most difficult areas to achieve optimal results. When evaluating a patient for liposuction the distinction should be made between omental or visceral fat and fat in the subcutaneous tissue. We must explain to them that liposculpturing cannot change their contour if the bulk of their fat is visceral or omental. The application of the Matarasso classification is useful when evaluating the abdomen (Table 28.1).

The aesthetic appearance, however, can be altered with liposculpturing. For most class IV cases liposuction is initially performed and then abdominoplasty is done after a few months. The reason for this is often the extent of the abdominoplasty can be reduced and occasionally the necessity for abdominoplasty may be unnecessary. In type III cases, liposculpture and a crescent-tuck abdominoplasty are combined with or without rectus plication. It is important to examine the patient in the standing position and evaluate for rectus laxity, diastasis recti and hernias. The patient should also be examined in the diving, sitting and supine positions with the head elevated. By using these positions one will be able to determine the excess fat to be removed as well as the presence of diastasis recti and/or muscular laxity.

Using the Klein pump, infiltration of the tumescent fluid is accomplished. The amount of fluid injected is equal to the amount of aspirate removed. With routine or mechanically assisted liposuction aspiration is initially performed in the deeper planes first. It is extremely important to know exactly where your cannula is at all times. The opposite hand from the one moving the cannula must always be in contact with the tip of cannula. This can be accomplished with the hand in the flat position or by use of the pinch maneuver around the cannula. It is also important that the cannula remains parallel to the skin and underlying musculature at all times. Once the deeper fat has been reduced then one can move superficially.

In the deeper planes the 3.0–3.7-mm cannulas are usually used. Occasionally, in the very obese abdomen, a 4.0-mm cannula is utilized in the deeper planes. The routine cannulas used are of the multiple-holed, ventral three-holed and the Saylan semispatula three-holed type. Presently, I am performing mechanically assisted liposculpture. It is important to note that once the abdomen has been reduced in the deeper planes smaller cannulas up to 2.0 mm are used to carry out superficial liposuction. The depth is controlled very carefully by the operator in order to thin the superficial layer. The end point of superficial liposuction has been accomplished when there is a small uniform amount of fat around the cannula and a smooth even feel and appearance of the skin. One can lift the cannula or carry out the pinch test to evaluate this depth. Once superficial liposuction has been accomplished one can feel the deeper fat to determine if further deep liposuction is required. The ideal result will be a smooth abdomen free of bulges or indentations.

The upper abdomen presents a different challenge when compared with the lower abdomen. The fat in the upper abdomen is contained within a significantly denser, more fibrous matrix. If this upper abdominal fat is not removed the patient will be left with a heavy upper abdominal fat pad that will yield a sagging upper abdomen with bulges that are unattractive. In this area liposculpture must be carried out in both the superficial and the deep planes taking care to work over the costal margins. The maneuver that I use in this area is to push down on the ribs and elevate the cannula just under the subcutaneous tissue being very careful to note that cannulas are over and not under the costal margin (Fig. 28.2).

To prevent unattractive fibrous attachments that can produce a pleating appearance, the crisscrossing radial pattern of liposuction initially described

Fig. 28.2. Liposuction in the superficial plane. Note the surgeon pressing down on the ribs to prevent inadvertent thoracic perforation

Table 28.1. Matarasso abdominal classification

Category	Skin	Fat	Musculofascial system	Treatment
Type 1	Minimal laxity	Variable	Minimal flaccidity	Liposuction or ultrasonic liposuction
Type 2	Mild laxity	Variable	Mild lower abdominal flaccidity	Liposuction plus miniabdominoplasty
Type 3	Moderate laxity	Variable	Moderate lower and/or upper abdominal flaccidity	Modified abdominoplasty with rectus plication
Type 4	Severe laxity	Variable	Significant lower and/or upper abdominal flaccidity	Standard abdominoplasty

by Dolsky [11] and Fournier is required. My personal technique is to use the multiple-holed small cannula and to follow this with a one-holed small, flat spatula.

The fat around the periumbilical area is resistant to removal but must be removed to prevent the "donut" appearance of residual fat around the umbilicus. For safety of the patient and to prevent intra-abdominal perforation through an undetermined hernia it is important to place the index finger of the opposite hand in the umbilicus. This maneuver will prevent inadvertent perforation as well as help define the fat that needs to be removed in this area.

The final part of the sculpturing procedure of the abdomen is the compression, which I feel gives support and allows for contracture during the postoperative phase. Postoperative care is very important for the final result. Foam compression is presently used in addition to the girdle-type garment and an abdominal elastic binder. Foam is used for the first 4 days and then just the garment and the binder.

28.9.2 Lateral Thigh, Trochanteric Area, Hip and Buttocks

It is necessary to describe these body sections as a complete unit rather than as separate areas. Women in particular tend to have subcutaneous fat deposits on the high hip and lateral thigh, often resulting in a disproportionate size problem when buying clothing. Many patients will report that they have to buy clothing of one size to fit their chest and a larger size to fit their hips and thighs. Some patients appear complaining that their problem is their buttocks, their "saddlebags" or possibly their "thunder thighs." It will be the surgeon's responsibility to create the curves and decrease the volume of the appropriate areas, which may not be the patient's perception.

The surgeon who is performing liposuction on this area must evaluate the woman from the waistline to the knee. The optimum result will only occur if the surgeon can conceptually perceive the postoperative shape. To help delineate the desired contour one needs to know the maximum concavity in the convex curve that makes up the hip and lateral thigh. This area is the maximum gluteal depression. An easy way to evaluate that depression is to have the patient laterally abduct the leg in the standing upright position. As a part of my marking technique I mark this depression. This depression is the distal extent of the high hip and the proximal extent of the lateral thigh. As one performs the liposculpturing surgical procedure one must realize that the convex curve and round feminine derriere one is attempting to accomplish requires reduction of the subcutaneous fat in both the lateral thigh and the high hip area until they are confluent with the original concavity between the two areas. To achieve the best results, the hip and the lateral femoral area need to be treated during the same operative procedure.

Women tend to gain weight around the hips with age and pregnancy. Many feel this is the beginning of the aging process and are anxious to have this area reduced. It should be noted to remove the fat in the high hip especially in the deeper planes the surgeon needs to note that the fat is oriented in a more superior plane than the fat of the lateral thigh. This area is one of the more forgiving areas of the body and superficial liposuction is usually not required. Deep liposuction will usually give excellent results in this area. Most of the time the skin in this area is quite thick and it contracts nicely. For patients who have flaccid skin and excessive fat in this area, superficial liposuction might be required, with the results always being controlled by constantly evaluating irregularities with the free hand. One needs to develop a concavity in this area that blends into a convex curve at the hip.

28.9.2.1 Technique

There is no area of the body where the surgical markings are more important than in the gluteal trochanteric lateral thigh area. The disproportionate areas of fat deposits are altered when the patient is placed on the surgical table. The patient has to be marked in the standing position and the markings need to be followed when the patient is lying on the surgical table. To obtain optimal results, the surgeon will need to conceptualize the perceived postoperative result. I use a topographic type of marking with more circles in areas that will need more suction. As mentioned earlier, the delineation of the high hip requires the knowledge that the deeper fat lies slightly superior and medial to the horizontal. The superior margins blend up and into the back, whereas the inferior margin stops at the maximum gluteal depression. Once this area has been marked, the lateral thigh and posterior thigh to be included in the resection should be marked. Obviously the body is not symmetric and the markings will be slightly different on the two sides of the body. A technique described by Gasparotti whereby using the palms of the hands and pushing inward achieves the desired contour. This maneuver will better help to visualize the end result [12]. Areas of depression that may require lipoaugmentation are marked in a different manner (I will often place an "F" for fill inside these circles). It is important to evaluate the amount of fat that will be removed and note it. This will help during the procedure when the tumescent fluid may have altered the contour slightly. I then begin to draw a line starting at the waistline making the appropriate concave and convex curves to simulate the new figure. While still standing the patient is then marked on the anterior surface of the waist, hips and thigh (Fig. 28.3). This is important because when the patient is lying down it is easy to remove too much fat from the anterior lateral thigh and leave an unsightly depression.

Posteriorly one of the most important landmarks has been described as the Gasparotti or G point. This is the area of the junction of the buttock with the lateral thigh. It begins at the thigh–gluteus junction superiorly and phases out as the subcutaneous fat of the lateral thigh inferiorly tends to blend closer to the underlying fascia. To achieve the appearance of a longer leg as one sculptures, a slight depression is created in this area. This will give roundness to the buttocks and visually lengthen the leg [6].

28.9.2.2 High Hip

The high hip or iliac crest area is forgiving but one must avoid overresection. In most cases deep liposuction will be sufficient in these areas unless a patient has flaccid skin. The fat here is normally easy to remove because it is not very fibrous and comes off quite easily. The skin is fairly dense with a rather thick dermis. It is rare that superficial liposuction is needed here. In patients with significant flaccidity of the skin and large flanks, superficial liposuction may be required, with the results always being controlled with digital manipulation and palpation to avoid irregularities.

The surgeon needs to make a smooth transition between the hip, the buttocks, the lateral thigh, the back and the waist. One must remember the high hips have a concavity that blends into the convexity of the lateral thigh.

The incisions used are trochanteric and sacral and, since small incisions are performed with a no. 11 blade or the very smallest 1.5–2.0-mm skin punch wherever access is needed. It is important to be able to create the desired contour and for that reason incisions are placed wherever needed. The deeper fat will need to be removed in a slightly superior medial plane. The cannulas that I use here are the multiple-holed, ventral three-holed and the one- and two-holed spatula of 3.0–3.7 mm. If superficial liposuction is required then the smaller 2.0–3.0-mm cannulas are used.

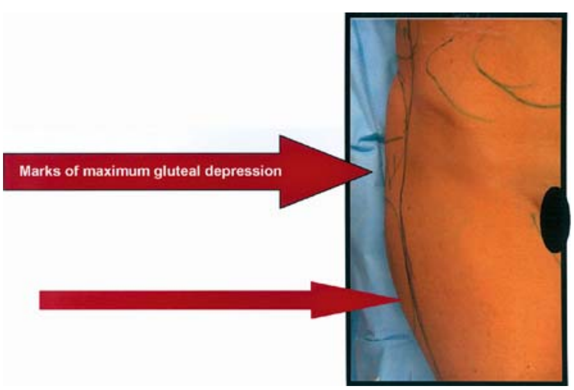

Fig. 28.3. Vertical line demonstrating outline desired. The anterior margin is also defined

28.9.2.3 Lateral Thighs

One of the areas most requested for liposuction is the lateral thigh. Unfortunately, the lateral thighs are one of the most unforgiving areas of the body. The lateral thighs are very susceptible to irregularity especially if there is a significant amount of skin flaccidity. The superficial technique has significantly improved results that can be obtained in the lateral and posterior thigh. The use of autologous fat grafting and liposhifting [13] may be required to obtain optimum results. Sculpturing of the lateral thighs needs to be blended into the hips, buttocks and waist to resculpture the lateral figure from the waistline to the knee (Fig. 28.4).

At least two incisions are required. Usually one is made over the greater trochanteric area and another below the distal margin of the proposed reduction. I, however, do not hesitate to make small stab wounds with a no. 11 blade or puncture wounds with a small 1.5–2.0-mm skin punch if needed to obtain better access. If the procedure is done with the patient in the prone position, one must be very careful to avoid the commonest complication of lateral thigh liposuction, which is depression that occurs because too much superficial fat is removed from the lateral femoral skin.

The subcutaneous infiltration of the tumescent fluid is then carried out. Overinfiltration is indicated in this area especially if there is flaccidity. I try to determine the amount of fat that will be removed during the preoperative marking period. This will help indicate the amount of tumescent fluid to be injected. In this area, it is my opinion the tumescent infiltration should be carried out until there is a firmness and slight "orange peel" appearance to the tissue. This will help stabilize the tissue during the liposuction phase.

After 12–15 minutes one can normally began the procedure. Prior to surgery, determination is made of the amount of fat, if necessary, that will be needed for later augmentation or filling of depressions to yield the round attractive feminine shape. Fournier often teaches his students to use syringes to determine the amount of fat needed to fill defects. He will take a 60-ml syringe and lay it in the defect to determine the amount of fat needed to fill that area. In some manner

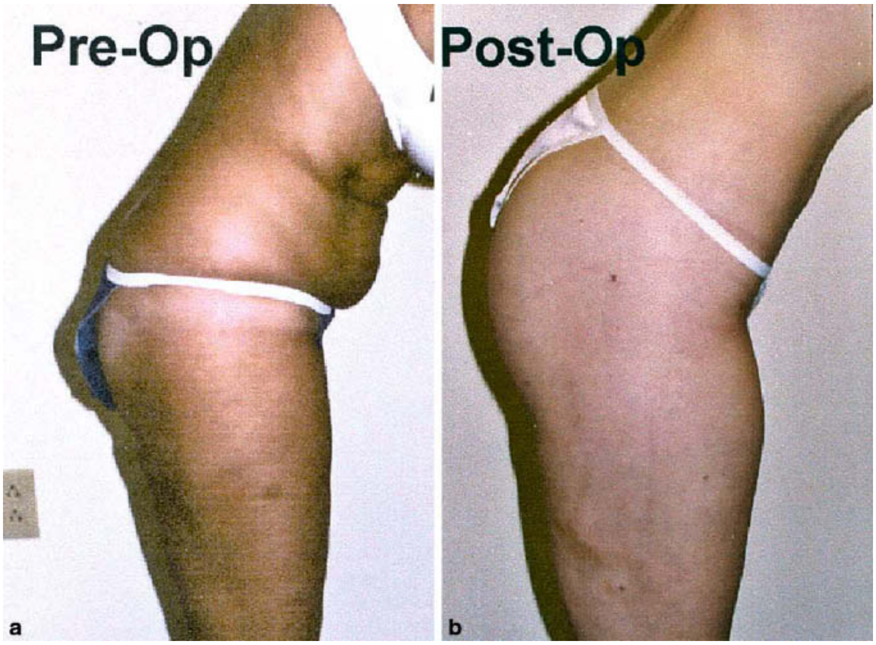

Fig. 28.4. a Preoperative 52-year-old female patient. **b** Postoperatively showing flattening of the abdomen, skin retraction and appearance of longer legs from contouring of the hips and thighs

one needs to determine the amount of fat that will be needed for corrections of the depressions.

Either the 10-ml or the 60-ml Luer-lock syringe with a small amount of saline and Coleman needles are used to harvest the fat for later use. I attempt to obtain at least 2–3 times the amount of fat I believe will be required. The deep phase of liposculpture is accomplished first. At the present time I use the oscillating mechanically assisted device. The cannulas presently used are the multiple-holed, ventral three-holed and the one- or two-holed spatula. The tunnels are made in a crisscross fashion but always in the vertical plane. Vertical tunnels tend to contract in the horizontal plane, whereas horizontal tunnels will contract vertically and leave waviness and irregularity. It is important to remember that you are creating round planes so be careful not to flatten the thighs. The marks that were made earlier serve to show depressions and elevations. As these elevations are reduced sculpturing must be continued very evenly, constantly using your hand in a flat position, and your eye to identify where there are irregularities. Moving to the superficial plane, refinement is carried out using small 2.0-mm or smaller cannulas.

The Gasparotti area is sculptured as a part of this unit in such a manner to create a very slight depression. The suction in this area is made around the lateral thigh–buttocks junction in such a way to create roundness and not a flattening. Superficial liposuction in this area helps with contracture of the skin in such a way to elevate the buttocks to hold the resection.

For the "banana roll," the area just below the inferior gluteal crease, one must be extremely careful. The liposuction below the gluteal fold can yield a dropping of the buttocks and create a worse or even a double banana roll. One needs to work deeper laterally until the desired reduction has been achieved and then work around cautiously underneath the buttocks in the superficial plane. Fine cannulas are used and slow conservative resection is accomplished by constantly palpating and molding with the non-operative hands. This will usually give the desired result and reduce the size of the inferior gluteal crease. In the lateral thigh and posterior thigh, fine irregularities are handled with the Toledo "pickle fork" cannula.

The postoperative care includes foam padding and a compression girdle. The foam padding presently used is either Reston foam or similar padding that you can buy at the local upholstery store and sterilize in your office. Topifoam can also be used. The foam is cut in a manner to provide supporting compression to hold your sculptured results and the girdle is then placed. The garment and the padding are left in place until the fourth postoperative day. Following removal of the garment and the padding the patient is placed back in the garment only. She will wear the garment 24 h per day removing it only to shower for the first week. At the end of the first week she will return to the office for external ultrasonic therapy if it is necessary. The garment will then be worn for the second week 18 h per day and for the third week 12 h per day. Ultrasonic therapy will be continued as needed for irregularity and ecchymosis.

28.9.2.4
Buttocks

Many patients will come for consultation stating that their "butt" is too large. Most of the time the enlargement is in the posterior high hips and lateral thighs that give the impression of a larger buttocks. This can be reduced with attention to the lateral thighs with the contouring described earlier in this chapter (Fig.28.5). A triangle with its apex at a top of the inner gluteal crease and each base point at the midpoint of the inferior gluteal crease on either side is considered "no man's land." Suction in this area can lead to a flattening of the derriere and masculinize the female figure. Lateral to this area one can mold the buttocks with fine cannulas in the deep area only. Superficial liposuction should not be done to this area. Small irregularities that are present preoperatively can be corrected with fat grafting.

28.9.3
Back

The area just below the brassiere line or the area just below the scapula often has a transverse roll of fat that is disconcerting to many of our patients. For purpose of practicality this can be considered as a single subcutaneous layer of fat with no area of deep fat. This fat is fibrous, making penetration difficult in this area. For that reason the mechanically assisted cannula works well. One needs to be very aggressive to remove most of the fat to get good contraction. This is one area in which ultrasonic liposuction works well. Generous tumescent infiltration helps to elevate the tissue for a more complete reduction. In our hands using finer cannulas and graduating to larger cannulas makes resection easier. Patience is required but good results can be achieved (Fig. 28.6). There may be multiple rolls below the scapula down to the waist-

Fig. 28.5. **a** Preoperative 27-year-old female patient. **b** Postoperatively showing apparent lengthening of the legs and reduction of the saddlebag deformity

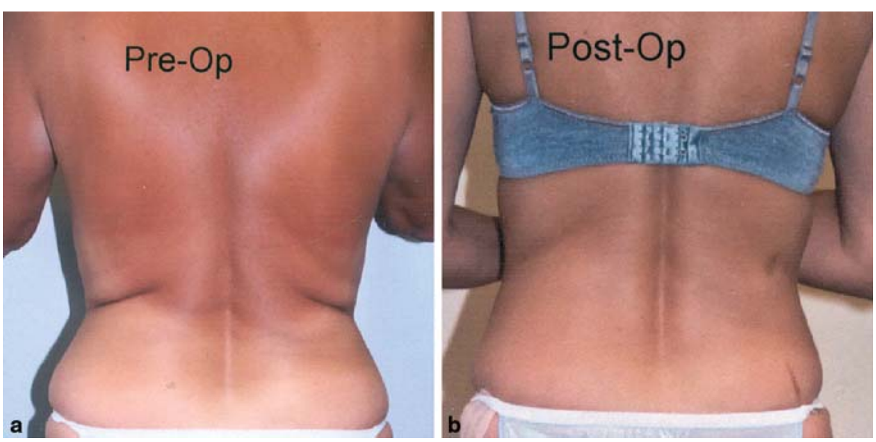

Fig. 28.6. **a** Preoperative patient. **b** Postoperatively following aggressive liposuction to the back

line. Each should be marked and aggressively treated to give the patient a smooth posterior appearance and a concave waist. Since the skin is quite thick in this area, superficial liposuction should be done.

28.9.4 Medial Thighs

The loose areolar fat and the very thin skin of the inner thigh makes this one of the very difficult areas to treat without leaving "divots." It is easy to overresect because this fat does not contain much fibrous tissue. The markings are important, delineating the highest point of fat and the margins to be reduced. After the tumescent fluid has been introduced the technique I presently use is to begin working superficially and gradually working to deeper areas. Only small up to 2.0-mm cannulas with ventral holes should be used by those unaccustomed to working in this area. I presently use a multiple-holed cannula that I had custom-made. The maneuver used is to move in the superficial plan initially and as the cannula is removed to press the tip angle slightly deeper. In this manner the fat can gently be reduced in a smooth fashion. The incisions used for this are just below the distal marks and in the suprapubic area. When reducing the inner thighs from the posterior approach, most of the posterior fat can be reduced through an incision in the inner thigh at the mid-portion below the marking.

Positioning is important and one must be very careful if suctioning with the legs in a "frog leg" position. It is very easy to overresect if one is not careful. For this reason most of the resection should be done with the assistant holding the leg straight and slightly adducted. (Fig. 28.7) The surgeon can then work from the inside of the leg, constantly feeling for any depressions or irregularity. Do not overresect in the mid thigh area or one will leave a bow-legged appearance. Blend the upper medial thigh into the mid thigh.

The fit of the garment is important in order to mold the inner thigh. The garment must come all the way to the inguinal crease. The skin of the inner thigh is extremely thin and the garment could cause a depression. I use foam padding under the garment. This seems to help considerably in preventing these depressions. External ultrasound postoperatively helps smooth minor irregularities.

28.9.5 Medial Knees

The skin is very thick in the knee area and superficial liposuction is not really required to obtain good results. I recommend a straight leg position. Phase the resection of the knee into the mid thigh without a "step-off." Most patients have a small area that will need to be reduced on the medial side just below the knee to obtain the nicest result. The amount of fat removed is minimal but the results are often quite impressive.

28.9.6 Lower Leg

Basically there is one layer of fat in the lower leg and it is mainly concentrated in the medial and posterior portion of the leg. Incisions just below the posterior popliteal crease give access and are well hidden. I address the inner calf first and then move to the posterior area. By using incisions at either end of the popliteal crease crisscrossing can be accomplished and vertical suctioning carried out. A roundness or fullness of the mid calf is the desired look; therefore, rarely is liposuction required in this area. In some cases lipoaugmentation may be indicated for a fuller mid calf. The distal calf and ankle can be done with small incisions made laterally and medially slightly above and behind the lateral and medial malleolus. Suction can be done superiorly and inferiorly from these incisions. Liberal use of tumescent fluid will be needed and suctioning should be fairly superficial. During the postoperative period the patient may have a significant amount of swelling. I use foam pads and stockings with 30–40-mmHg pressure on the ankles and calves when both are sculptured. Foam pads are cut and positioned to mold the ankles. If only the ankles are sculptured the elastic ankle supports purchased at a pharmacy work quite well.

28.9.7 Arms

One of the disconcerting aspects of aging in women is the so-called pendulous or sagging arm. Many

Fig. 28.7. Straight leg position is important. The assistant supports the leg during the procedure

women owing to genetics, age and weight gain accumulate fat in a disproportionate manner over the posterior dependent area of the arm. The fat is usually distributed in the lateral, medial and posterior portion of the upper arm. Exercise will not remove or reduce the volume of fat in this area. Rarely is liposuction required in the anterior or volar aspect. The goal of the liposuction surgeon is to reduce the bulk of fat in this area without creating a masculine appearance. Uniformly decreasing the subcutaneous fat over the lateral, medial and posterior surfaces yields a thinner arm. Decreasing the weight of the fat from the skin of the arm allows for contraction.

The thicker "sagging" upper arm gives the appearance of obesity; therefore, most women desire a thinner, more youthful arm. Liposculpture can yield excellent consistent results. One must be careful to sculpture the arms in a manner to complement the rest of the female figure. Extremely thin arms in some women will be disproportionate. Liposuction of the arm can be easily approached with the arm bent with two small 1.5-mm punches just above the posterior elbow medially and laterally; and a third incision in the posterior and axillary crease. If the anterior axillary fat pad needs to be reduced as well, another punch incision can be made in the anterior axillary crease.

During the tumescent phase pretunneling can be accomplished. This will help prevent overresection during the liposculpture portion of the operation. For the arm I use mainly two very small cannulas up to 2.0 and 2.5 mm. The direction of the suction is a crisscrossing pattern parallel to the long axis of the arm. Multiple tunnels with small cannulas will uniformly decrease the volume without over resection. After the deeper fat has been removed I switch to a very small 2.0-mm one-holed flat spatula-type cannula to free the fibrous septa and allow smooth contraction of the skin.

With experience the tumescent infiltration very closely equates the aspirate. As one area of caution, there is frequently a small 15–35 ml distal fat pad near the elbow close to the area of the surgical access punch wounds. If this is not removed, there will remain a sagging look at the elbow.

Many patients will also have prominent axillary fat pads. Occasionally they are found in patients who are thin. Fat pads seem to worsen with age. By elevating the patient's arm at a right angle with the elbow bent one can easily palpate the fat and delineate it from the underlying muscle. Tumescent infiltration and liposuction with small cannulas and liposculpturing in a uniform manner can reduce this area and yield a smooth blending into the axillary upper arm that is aesthetically pleasing.

I have found the arm and axillary area to be one of the most satisfying liposculpturing procedures for both myself and my patients. Postoperative care for the arms is mainly elastic sleeves with compression pads posterior and over the axillary area. These are worn for 24 h per day for the first week and then 12 h per day for the second week.

28.9.8 The Male Breast

The male breast is a common area of requested liposuction among men. In the adult man enlargement of the breast is usually the result of localized deposits of subcutaneous fat with normal or slightly increased glandular breast tissue. This syndrome is known as pseudo-gynecomastia. It is the responsibility of the surgeon, however, to rule out true gynecomastia, which is an excessive amount of glandular tissue. The surgeon also must rule out neoplasm. Though it is rare, carcinoma of the breast does occur in men and has a poor prognosis. Unilateral enlargement of the breast requires an extensive workup to eliminate carcinoma. A mammogram should be accomplished and probably a biopsy would be indicated.

Some of the causes of gynecomastia include thyroid hormone, many of the antihypertensives, anabolic steroids, estrogens, spironolactone, alcoholism, marijuana usage, digitalis and testicular and adrenal tumors. A history needs to be taken and workup completed to determine the etiology of the condition. The breast tissue is normally located just beneath the nipple areolar complex and can often be palpated. The subcutaneous fat of pseudo-gynecomastia is less distinct.

With a combination of the tumescent technique of deep and superficial liposuction excellent results can be obtained in pseudo-gynecomastia and significant reduction of glandular tissue in other types of gynecomastia. The patient should be warned that occasionally not all of the breast tissue can be removed and an open, small, simple mastectomy may be required in association with the liposuction procedure.

The technique of liposculpture requires knowledge of the anatomy of the breast and the subcutaneous fat associated with it. The breast needs to be considered a skin appendage and attached to the nipple areolar complex. The fat in this area is very fibrous and if one is doing this procedure under pure tumescent anesthesia I recommend slightly higher concentrations of 0.1–1.5% lidocaine (1,250–1,500 mg/l) and 1 mg/l epinephrine. Because this area is more fibrous, there is sometimes more difficulty removing the fat. This increased density also causes more discomfort for the patient during the procedure.

As in other areas, I use topographic markings to indicate the thickest distribution of fat and the point on the breast that has the highest elevation from the chest wall. The marks are made with the patient in the standing position. Good communication is needed between the patient and surgeon. Some patients want an absolutely flat chest, others aesthetically would prefer a slight amount of breast tissue left behind.

The tumescence tends to make the tissue less dense and cannula penetration much easier. Using purely local tumescent anesthesia, I begin the procedure with spinal needles and then switch to the "garden-spray"-type infiltrator.

If the patient is under general or i.v. sedation then the infiltration will be completed using the small garden-spray-type cannula. I use this cannula to carry out pretunneling.

Liposuction is begun with the multiple-holed cannula, 2.0–2.5 mm in diameter. The smaller cannulas help remove fibrous fat. If there tends to be a significant amount of glandular tissue I will use more aggressive "candy cane" or even basket-type cannulas. Superficial liposuction is necessary in the male breast after the deeper fat has been removed. For this it is safer and more efficient to switch to the small spatula with either one or two ventral holes. One needs to do significant superficial clearing of the subcutaneous fat to help with contracture (Fig. 28.8). Blending is extremely important and will sometimes require liposuction out into the anterior axillary fat pad.

My personal preference is to leave all of the incisions through which the liposuction has been accomplished open for drainage. The patients are placed in a compression garment, either an elastic vest or a binder. Foam padding, Reston foam or Topofoam, is used to further compress the breast. Compression is mandatory in this area to prevent excessive ecchymosis. Carefully done, liposculpturing of the male breast gives aesthetically pleasing results and excellent patient satisfaction.

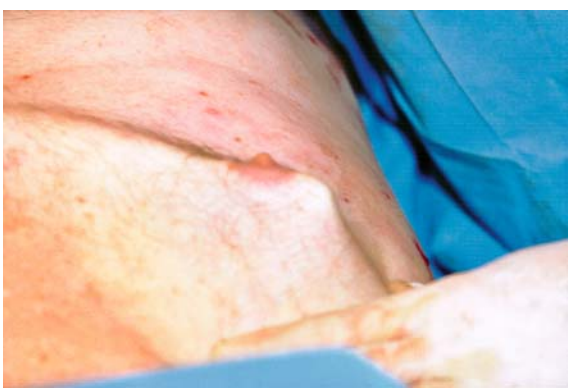

Fig. 28.8. Superficial liposuction of the male breast

28.10 Ultrasound-Assisted Liposculpturing

This modality will be addressed briefly as it relates to superficial liposculpturing. Since 1996 I have used ultrasonic liposculpturing in certain areas. With mechanically assisted liposuction and some of the other newer techniques, I find that I am using ultrasonic techniques to a lesser degree. The hallmark of ultrasonic liposuction is a liquid environment and constant motion.

I feel superficial liposuction should be done first while one is sure there is adequate tumescent fluid in the superficial planes. There must be no "end hits" and the cannula must absolutely be kept parallel and not perpendicular to the skin. There is a slightly longer learning curve for ultrasonic liposculpturing. I, therefore, do not recommend its use for beginner liposuction surgeons.

With experience the results of ultrasonic liposculpturing can be excellent. Personally, I have had no complications with this technique. The areas in which I feel it may have some very significant advantages are the male breast, the epigastric area, the back, and in my hands, the inner thigh. In patients who have had previous liposuction, ultrasonic liposculpturing makes the procedure easier. In cases where there is a need for skin contracture many surgeons feel ultrasonic liposculpturing may have an advantage.

Superficial liposculpturing is used in sculpturing and molding for skin contracture and support. The goal of ultrasound-assisted liposculpturing is to debulk and smoothly sculpture the body with good skin contracture. In the hands of skillful surgeons either technique can give excellent results.

28.11 Laser-Assisted Liposculpturing

This modality is mentioned only because it is on the horizon as a technique that may have great potential benefits. Laser-assisted liposculpturing is at the present time undergoing investigation. This technique was first developed by Neira [14] and utilizes a low-level diode laser that delivers a wavelength of approximately 632 nm. Following infiltration with tumescent fluid the low-level laser is used prior to liposuction. There seems to be a liquefaction of fat, which results in smoother extraction, less postoperative pain and less fatigue for the surgeon. Controlled investigation is presently going on and will need to be evaluated. This may allow easier extraction in the superficial plane as further studies are completed.

28.12 Conclusions

Superficial liposuction combined with liposuction in the deep or traditional planes is necessary if one is to create a sculpture rather than just remove fat. Not every area or every patient will require superficial liposuction. The surgeon needs to know the anatomy and the limitations of his or her procedures. One must know the correct superficial plane. To obtain excellent contouring and avoid irregularity requires some very basic liposuction caveats. Tumescent infiltration is the gold standard of liposuction today. The dermis must not be damaged. Crisscrossing and tunneling in the proper directions is necessary if one is to achieve a smooth result. Avoid horizontal tunnels on the extremities. Use small atraumatic cannulas and evenly and gradually reduce the unattractive localized areas of fat. Be willing to use lipoaugmentation and liposhifting to correct defects.

Use your tactile as well as your visual senses and constantly check your work. Be conservative and err on the side of leaving too much rather than taking too much. Careful markings preoperatively are extremely important.

Use postoperative garments, or taping if you prefer, to hold your results until natural support, contracture and molding have occurred. Know your limitations and do not place the patient at risk. Patient safety has to remain the most important facet in the surgeon's treatment of his or her patient.

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29 Three-Dimensional Superficial Liposculpture for Aged and Relaxed Skin

Marco Gasparotti

29.1 Introduction

Webster's dictionary defines sculpture as "the art of creating forms in three dimensions." Superficial liposculpture [1–13] has evolved from a philosophy of sculpting. The concept of liposculpture differs from traditional liposuction, which focused only on removing localized adiposities.

Three-dimensional liposculpture involves total body reshaping with the creation of a harmonious, optimized body shape. Conventional liposuction teachings emphasized three points:

1. The use of concentric circles in marking the areas to be treated.
2. A focus on the volume of fat removed.
3. The aspiration of fat in the deep plane only

Three-dimensional superficial liposculpture departs from conventional teaching in the following ways:

1. The surgical design involves a geometrical, artistic analysis and marking of the body segments to be modified.
2. A de-emphasis on volume assessment as a determinant for the end point of surgery, emphasizing the importance of profiles. During rhinoplasty, a favorable nasal profile is not determined by how much cartilage and bone by weight or volume is removed, but by appearance only.
3. Fat should be removed in all layers as necessary, not just in the deep plane alone. Deep fat removal allows volume reduction but imposes limits on contouring. Superficial fat removal allows a very fine body contouring and induces improved skin contraction, which enhances the ultimate result.

29.2 Surgical Concepts

Conventional liposuction is based on deep removal of localized fat pads. In 1981 the author modified this technique by shifting the level of aspiration to the superficial areolar layer of fat, to better reshape a body profile, allowing this method to be used also in older patients with very relaxed skin .The technique was an obvious and logical solution to the limitation presented with traditional liposuction (deep fat removal).

The simple deep removal of fat gives us only a reduction of the volume of an anatomical section but not its reshaping, which should be performed taking particular care of the superficial layer of fat. In addition, we can "fix in place" our job with the aid of the skin, that once made lighter, can shrink on new surfaces we have carved. Therefore, the skin becomes the surgeon's best friend and not a liposculptor's enemy, as in a conventional liposuction, where, emptying in depth, we used to leave a thick and heavy adipose cutaneous flap sagging because of gravity and postoperative edema.

The thinner the skin, the more it draws back. The more flaccid the skin, the more it must be thinned to stimulate the skin retraction properties to the maximum, and profit from its ability to readapt, driven by proper elastic compressive bandages and garments. The thin adipose skin flap will therefore act as a support and dynamic container for the properly molded content (the fat). For the first time in liposuction, the skin is an active structural and dynamic element, and not only a passive element of the operation. Through contraction, the skin becomes firmer, the orange skin appearance ("cellulite") is improved, and the skin become smoother because, working in the superficial compartment of fat, most of the fibrous attachments can be released from the subcutaneous fat to the dermis. This also allows the skin to move freely and relocate.

The subdermal fat is reached only if there is a need to maximally tighten the cutaneous adipose flap in very flaccid skin patients. Superficial liposculpture must always respect the subdermal vascular plexus, and leave 3–4 mm of subdermal fat intact to avoid irregularities

29.3 Technique

From January 1981 to May 2003 liposuction was performed by the author on 5,103 patients between 16 and 74 years of age. Most of the adipose tissue was located in the outer thighs and hips (87%), and most of the patients had liposuction in multiple areas, including the inner thighs (41%), abdomen (18%), knees (74%), calves (9%), ankles (36%), and arms (1%). The age of the patients was between 16 and 74, and the maximum volume of pure fat removed was 5 l without any blood transfusion. Patients from which more than 3 l of fat was aspirated spent 12 h in the clinic.

29.3.1 Patient Evaluation

One hour before surgery, a series of photographs are taken in the office documenting the deformities to be corrected. Polaroid pictures are taken of the patient with markings of the operative sites for reference in the operating room. These pictures are very important, especially in patients with very flaccid skin, because the deformity almost disappears when they are placed in position on the operating table.

Patients are prepared for surgery with coagulating therapy consisting of tranexamic acid, vitamin K, and ceftriaxone for 5 days preoperatively. An antibiotic is given intravenously 2 hours before surgery, and is continued orally for 72 h.

29.3.2 Anesthesia

General anesthesia is used in 63% of the cases, especially in older patients, secondary cases with a lot of scar tissue, and in patients where multiple areas have to be treated.

29.3.3 Surgical Markings

The drawing must be very accurate and done in sequence from the right thigh, right hip, left thigh, left hip, gluteus, torso, inner thigh, abdomen, knees, calves and, finally, the ankles and arms. Keep the patient standing, in front of a large mirror:

1. Draw the whole area to be treated with a continuous line up to the furthest point in which the deformity meets the neighboring region, and mark the point of maximum projection of the deformity (Fig. 29.1).
2. Mark with a plus or a minus the points where more or less fat should be removed to obtain ideal curves. The surgery must rigidly follow this drawing, attempting always to follow the outline to the maximum. The areas to be treated will more often than not be different in the two sides; therefore, the drawings will rarely be the same.
3. Mark the areas that will need to be filled (lipofilling) to create the optimal curve.
4. Evaluate, by pinching the adiposities to be removed, the approximate quantity of fat to be removed, and write this amount down adjacent to the site.
5. Mark the eventual depressions or actual dermal irregularities so that we can recognize them during the surgery and not attribute them to technical mistakes (make the patient well aware of these deformities before surgery).
6. Evaluate how much to remove and when to stop aspirating by performing a simple maneuver that consists of pushing the lateral femoral deformity inward to evaluate visually the new shape desired and then marking a line exactly below our hand in this new position. This plane will be the new level we want to take the lateral femoral profile. During the operation aspiration is stopped when this plane is reached (Fig. 29.2). Each type of deformity must be treated according to precise artistic concepts, always trying to include the whole defects within the treatment, to achieve a complete three-dimensional harmony (Fig. 29.3).

Fig. 29.1. Carefully including the whole deformity in the drawings, and marking the highest point of the deformity

29.3.4 Surgical Technique

The patient lies supine only for treatment of the abdomen, while the frog position is preferred for inner thighs and knees, and a supine or lateral position for calves and ankles.

When we operate on hips and the lateral femoral region the patient lies laterally, perfectly in line, with a cushion placed between the thighs so that the protruding area to be removed is emphasized to the maximum.

The supine and prone positions may prevent us achieving correct liposculpture of hips and outer thighs. In the lateral position, in fact, the defect to be corrected is not changed by the underlying pressure of the lateral muscles of the thigh, flattened as they are by the weight of the patient in the supine or the prone position. The lateral position also allows for a better view of the surgical area and less bleeding through alternative compressive hemostasis by change of position.

Two longitudinal incisions of 3 mm are made with a no. 11 scalpel blade. The first is on the upper part of drawing, the second on the bottom, where the fat pad starts decreasing. The region is infiltrated with a solution of 500 ml of saline plus 1 ml of epinephrine by means of a multihole needle, until the contour of the region to be treated is clearly shown. For local anesthesia in minor deformities, 25 ml of 1% Xylocaine and 7 ml of sodium bicarbonate are added to the solution. Ice is then placed on the areas to be treated for better vasoconstriction.

After 10–15 min, the time necessary to obtain an effective ischemia of the region, the operation is begun. Tumescent infiltration with Klein solution is used only for removal of more than 4 l of pure fat. Fifty-milliliter syringes are used or a suction pump with 2–4-mm bent Mercedes-type or one-hole cannulas, and 5 ml syringes with 2-mm cutting-edge cannulas for refinements in the case of hard fat. Bent cannulas help us to work more easily parallel to the skin. After undermining intermediate and superficially in the area to be treated with a free cannula, we defat through tunnels in the intermediate plane first, using a 4-mm cannula until a substantial reduction of the deformity is obtained .

At this point, where traditional liposuction ends, the superficial liposculpturing begins. After intermediate (in the middle of the fat pad thickness) fat removal the area is improved; however, with a few

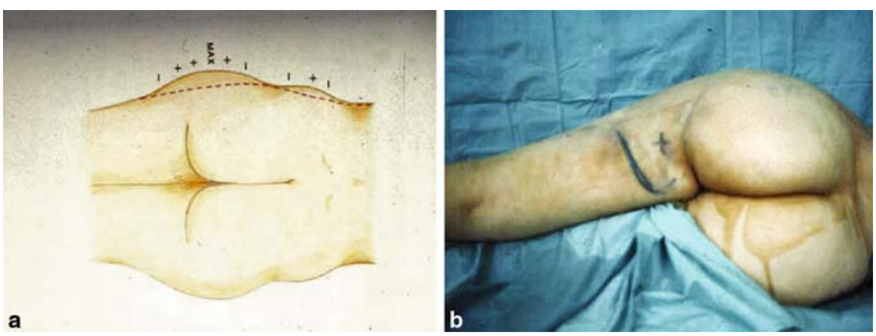

Fig. 29.2. **a** If we stop aspirating when we reach the line (*dotted*) we marked before the operation, **b** we obtain a perfect profile

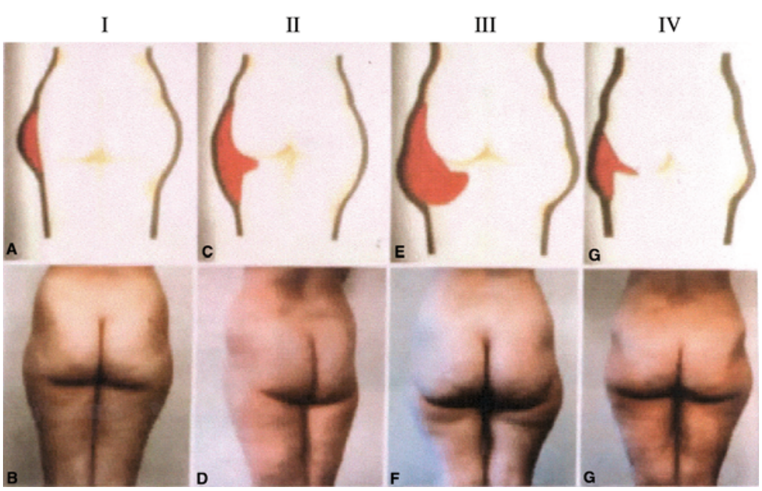

Fig. 29.3. Gasparotti's four types of saddlebag deformities: type I, mainly trochanteric; type II, with poor definition; type III, postero-inferior; type IV, with heavy gluteal fall

maneuvers, some untreated residual fat can be seen to remain and will be visible only when the patient is in the orthostatic position. By pushing the gluteus downward to simulate the effect of gravity, subdermal superficial fat is seen along the whole area of the treated region. Using a 3-mm cannula, a number of crisscrossing tunnels are made to remove this residual fat, by aspirating very superficially. The treated area and the surrounding zones are then refined by superficial aspiration with a 2.5-mm cannula. The skin of the treated region, and the areas close to it for approximately 10-cm around, must be widely undermined to allow a perfect redistribution of the skin flap, evoking a more harmonious retraction of the thin flap, especially in very flaccid skin patients and in secondary lipoplasty. In case any minor irregularities still remain, it is preferable not to persist with cannulas but to digitally mold the fat.

The flap thickness has to differ slightly from the various points of the treated areas, to achieve a harmonious three-dimensional design of curves and volumes. The superficial adipose layer remaining after the suction is extremely thin, and lies on the intermediate fat previously treated.

So-called banana folds can be corrected by superficial liposculpturing. Aspirating superficially good skin retraction can be obtained without removing the deep fat supporting the gluteus weight, avoiding gluteal fall.

Another good evaluation of the profile is done "eyeballing" the patient at thigh level. This method allows adjustment for any asymmetry. Each side must look the same, although different quantities of fat will be removed (Fig. 29.4). A final pinch test helps to determine if there is symmetry of both sides.

Afterwards, a vacuum drain is inserted through a cannula driven through the lower incision, to avoid excessive bruising and possible permanent hyperpigmentation. The subcutaneous area is irrigated with 160 mg of gentamycin diluted in 50 ml of saline. While bandaging the area with Tensoplast, the skin is lifted upward according to Langer's skin tension lines to ensure a perfect readaptation of the flap. The bandages are reinforced with tape (Fig. 29.5). Bandages are only used for the lateral femoral region. Reston foam is used for dressing other areas and then the patient wears a compressive garment at the end of the operation.

The patient who undergoes general anesthesia is hospitalised for 12 h, during which time the vacuum drains are kept in place. Tensoplast and Reston foam stay for 4 days. When they are removed, the patient wears a more compressive elastic garment for 30 days during the daytime only. The garment we designed (Lipopanty or Liposhape, Medestea Internazionale, Italy) has elastic reinforcements specifically conceived to support, not only to compress, the most critical areas (Fig. 29.6). The contraction of the skin flaps of the treated areas lifted upward by tape first and then by the garment will determine a slight elevation and rotation of the gluteus upward. Patients wear compressive stockings for 30 days during the daytime when liposuction of the knees, calf, and ankles is performed. The author used to stay a little bit deeper when treating the abdomen because irregularities of the skin occur more easily. If large retraction of skin

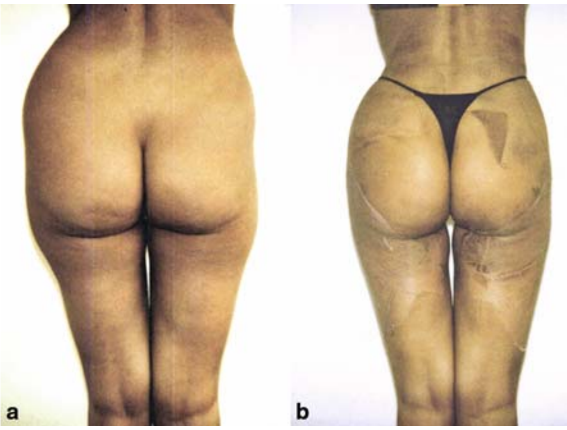

Fig. 29.4. **a** Preoperative patient with marked asymmetry between the two sides due partly to scoliosis. **b** Following the geometrical principles of drawing, good symmetry is also achieved if different volumes of fat are removed from each side

Fig. 29.5. Taping the treated areas to drive the retraction of the skin upward according to Langer skin tension lines

is needed in flaccid skin abdomens, skin is widely undermined as far as the flanks and the suprapubic and inguinal regions. Slight liposuction of the groin and suprapubic area produces a rejuvenating effect on women over 40 years of age.

29.4 Results and Complications

In 5,103 cases of superficial liposculpture, 98% of the author's patients were very satisfied, and the long-term results in terms of body reshaping and skin tone were maintained, even in patients who became pregnant (5%) or either lost or gained weight (37%). In the remaining 2% of patients, the following complications occurred:

- One major mycobacterium infection caused most likely by a contaminated lipofilling that resolved after antibiotic therapy.
- Twenty minor asymmetries that were corrected 6 months later under local anesthesia.
- Eighteen minor skin irregularities in the earliest cases improved later with lipofilling.
- One case of phlebitis in a 70-year-old patient.
- Six cases of transitory (6–12 months) hyperpigmentation of the skin, before routine use of vacuum drains in large fat removal in pale-skin patients.
- Two cases of transitory (8 and 10 months) paresthesia.

Fig. 29.6. Liposhape elastic reinforcement to support and massage the most critical points

There were no cases of skin necrosis, skin damage, or seromas.

29.5 Discussion

Nothing wrong occurs if you stay in the correct plane below the subdermal vascular plexus, respecting 3–4 mm of subdermal fat. In the superficial fat there exists a virtual plane (approximately 0.5–1 cm under the skin) where cannulas glide through as easy as butter. This is the plane of superficial liposculpting. If you are too close to the dermis, your cannula will not glide easily. It is like undermining a face-lift. There is a virtual plane where your scissors glide easily, and you can feel if you are too superficial because your instrument does not go forward. So the trick is to perform thousands of very close tunnels in the superficial areolar layer of the fat, close to the dermis but not against the dermis, to leave a harmoniously defatted flap. Never create a cavity, always aspirate by means of tunnels.

The incision points that we use and the vertical aspiration vectors allow, through the lightening of the buttock, upward retraction of the cutaneous flap of the gluteus and the elevation of its lateral posterior area, tightening the skin.

Three-dimensional superficial liposculpture is not for beginners and has a long learning curve, because it is a more refined and complicated technique than the conventional one.

Further aspiration (10–20 ml) of the inner thigh immediately lateral to the labia majora creates the "light triangle," that gives lightness and harmony to the shape of the gluteus [11].

Removal of fat from the gluteus through vertical tunnels is also mandatory in order to avoid the fall of heavy buttocks on the posterior part of the thigh, and recurrence of the saddlebag and of the so-called banana deformity (Fig. 29.7). Moreover, the release of the connective ligaments, located between the lateral portion of the gluteus and the upper part of the lateral portion of the thigh, further allows the vertical retraction of the skin in this difficult area. In very relaxed patients, the skin of the treated areas, thinned at the maximum to allow a good retraction of the cutaneo-adipose flap, will appear slightly shrunk in the first days postoperatively. It will recuperate totally as soon as the patient starts moving properly.

The three-dimensional superficial technique allowed the author to reduce the numbers of abdominoplasty and thigh-lifting procedures during the past 15 years, limiting the length of scars to the minimum, trusting in the great retraction of the skin that we can obtain by combining a very aggressive superficial defatting of the flap.

29.6 Lipoplasty Without Liposuction

In the author's experience in liposculpture we have constantly obtained a significant reduction of the circumference of hips, abdomen, buttocks, and thighs by having the patient wear a special postoperative garment properly designed for this purpose [4, 5, 9]. These results are due to the lymphatic and venous micromassage produced by the two layers of the garment during the first month postoperatively. Interstitial fluid drainage is stimulated by a harmonious compression and subdermal capillary microcirculation is increased, also improving the aspect of the so-called cellulite (Figs. 28.7, 28.8).

Moreover, the same circumferential reduction on buttocks and thighs has been enhanced lately by giving to the patient two tablets daily of dietary phytotherapeutic preparation (Cellulase Gold, Medestea Internazionale, Italy) for a period of 30 days before surgery and 60 days after superficial liposculpture (Fig. 29.9). This phytotherapeuticic preparation is based on *Centella asiatica* [14], *Melilotus officinalis* [15], *Ginko biloba* [16], bioflavonoids [17], RecaptaCell, bladderwrack, and *Ruscus aculeatus*. The strong antioxidant effect of this formulation increases the cell membrane fluidity [18] for better intra–extra cellular exchange, stimulates microcirculation, activates free radical defenses, contracts blood vessels permeability, enhances drainage of the excess of fluids in

Fig. 29.7. Lengthening the gluteus through vertical tunnels and releasing the connective ligaments in the transition area between the lateral portion of the thigh and the gluteus

Fig. 29.8. a A 65-year-old patient who had a previous liposuction before in another office. **b** After circumferential liposculpture with a minimal inner thigh lifting. See the short scar in the groin area only, and the great skin retraction obtained in the inner thighs

the tissues, and has a lipolytic effect [19, 20], reducing the peroxidation of the lipid membrane of adipocytes, increasing the lipolytic hormones (adrenalin, thyroid, etc.) inside the cells, therefore taking their metabolism to a new normal level. As a result, the use of the phytotherapeutic formulation helps to prevent the fibrous and sclerotic conditions of the connective tissue reducing the "orange skin" appearance of the skin, and helps reduce volumes and circumferences (Fig. 29.10).

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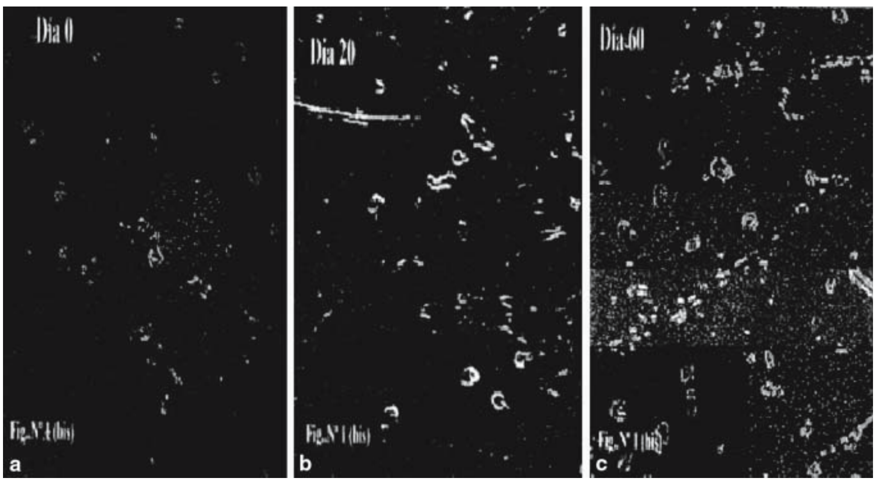

Fig. 29.9. Microcapillaroscopy of subcutaneous tissue affected by "cellulite." **a** Very few blood vessels before the use of Cellasene. **b** At 30 days. **c** Sixty days after having taken two Cellasene tablets a day. Notice the increase of the number of blood vessels in the tissue. (Reproduced with permission of Gustavo Leibaschoff)

Fig. 29.10. **a** Pretreatment of a 39-year-old female patient. **b** Ninety days following wearing of the garment and having taken two Cellasene tablets a day. No surgery was performed on her, and she was not submitted to any diet. Note the circumferential reduction of the body and the great improvement of "cellulite"

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30 Reduction Syringe Liposculpturing

Pierre F. Fournier

30.1 History of Syringe Liposculpturing

It was in September 1985, 7 years after Giorgio Fischer's first demonstration of machine liposuction in Paris, that the author discovered by accident that adipose tissue could be extracted using a syringe. One of my patients wanted to have liposculpturing of the knees, but she was frightened (for unknown reasons) about the use of anesthesia, either local or general, as well as about drugs for premedication or sedation. As she was highly motivated, I performed the operation with the only anesthetic possibility left: cryoanesthesia.

She was admitted to the clinic as an outpatient. In the operating room, ice packs were applied to the knees for 20 min; normal saline with epinephrine (1 mg/l) chilled at 2°C was injected subcutaneously (roughly 200 ml in each knee), and external cryoanesthesia was carried out again for another 30 min. The operation was then performed with absolutely no pain, according to the patient, and with the use of the suction machine, I removed, without difficulty, 100 ml of fat on one side and 120 ml on the other.

As I was a bit doubtful about the absence of pain experienced by the patient (maybe she was a masochist), I wanted to determine, on myself, if such anesthesia was really so effective. That evening, at home, I injected subcutaneously 40 ml of chilled (at 2°C) normal saline (without epinephrine) into my left iliac fossa. After 5 min I took a 5-ml syringe on which was mounted a 19-gauge needle and gave multiple strokes into the fatty layer, in a fan-shaped area, after I had punctured the skin.

My left hand stabilized the skin and my right hand held the syringe during the few minutes needed for the procedure. I felt no pain whatsoever, except when inadvertently I reached the inner aspect of the skin. However, I suffered no pain while the needle was moved to and fro in the adipose tissue.

After I was convinced of the anesthetic power of the chilled, normal saline, I removed the needle and, to my great surprise, saw that the syringe was half-filled with adipose tissue. In order to have a firmer grip on the syringe, as it was a small one (5 ml), I was simultaneously holding the barrel and the fully extended plunger, which I had unintentionally pulled to the end. This simply demonstrated that by giving strokes, fat slivers are mechanically placed in the needle and that the negative pressure created in the syringe by the pull of the plunger transports the fat slivers into the barrel of the syringe. This specimen of extracted fat was later given to my pathologist, who reported the fatty tissue to be undamaged.

The ease of this extraction, done under anaerobic conditions and respecting the integrity and the sterility of the adipose tissue, immediately suggested that I could reinject this extracted fat into other places of the body where needed. Obviously, this procedure would require larger needles and cannulas mounted on larger syringes if I wished to extract larger amounts of fat and to sculpt the body.

The day after my "discovery" two patients were scheduled to have their nasolabial folds decreased, which I usually performed with small cannulas and the suction machine. I used, as the day before, a 5-ml syringe and a 19-gauge needle. The procedure went as smoothly as the day before. I removed 2 ml of fat from each side and at the moment realized that one of the advantages of syringe liposculpturing was the ability to measure exactly the amount of fat extracted from each area.

I began to use larger (14-gauge) needles and manufactured small cannulas (14 gauge) with one, two, or three openings that I mounted on 10-ml syringes for working on double chins and other small areas. The bleeding was lighter than when using needles, and for a while I worked on small adiposities with such equipment. One day, as large cannulas were not available for mounting on 60-ml syringes, I cut the handle of a common Karman abortion cannula, used for liposculpturing, and passed it through the dilated hub of the syringe. To avoid the dead space that exists in such equipment, I primed the syringe with normal saline before I started. After this maneuver, it was easier to pull the plunger (the lock was not yet created), and I was surprised to see that the extracted fat contained less blood than with the machine.

After 2 years of working with such equipment (60 ml syringes and Karman abortion cannulas with cut handles), the manufacturers came to understand the advantages of these instruments and they then perfected cannulas either passed through the hub (French model) or mounted externally on the syringe (Tulip model).

Little by little the advantages of the syringe over the machine became obvious, and I thus elaborated the theory of the "buffering phenomenon." Grazer [1] explained that whereas air can be compressed as many times as desired, a vacuum (or the absence of air) can be obtained only once. Thus, syringe liposculpturing is as powerful as machine liposculpturing but with the advantage that there is a buffering system with the syringe method; this system cannot exist when the suction machine is used.

With the syringe the operation is performed in a fluid medium, whereas with the machine it is performed in a vacuum. The advantages of syringe liposculpturing can be explained by the fact that this buffering system (or shock-absorbing system, the syringe being primed with normal saline before liposculpturing) is placed between the adipose tissue and the negative pressure created by the syringe. The advantages derived from such a system are also valid for pure lipoextraction as well as when the adipose tissue is to be recycled. The advantages of syringe liposculpturing are outlined in Table 30.1.

Once I started using the syringe in 1985, I never went back to using the suction machine. It is obvious that the syringe is a self-contained unit that is far superior to the machine. Use of the syringe gave a new lift to the old procedure of fat grafting, making it safer and simpler and allowing the surgeon to obtain long-lasting results with repeated injections. Each injection adds to the partial improvement obtained with the previous one. The well-established concept of overcorrection when fat grafting is not accomplished in one stage in volume anymore, nor is it done using an open and unreliable technique. Rather, the procedure is done in stages over period of time, using a simple, easy procedure with repeated injections, a method that is readily accepted by the patient and the surgeon.

For the past 17 years, this author has used only plastic syringes on which common cannulas are mounted in all cases of reduction liposculpturing. Cannulas and syringes are selected according to the volume of the adiposity.

30.2 Reduction Syringe Liposculpturing

30.2.1 Equipment

30.2.1.1 Cannulas

Cannulas are classified according to their outside diameter. They are made of metal. Those of very small external diameter (microcannulas) measure 2 or 2.5 mm. Their useful length is 7 or 12 or 24 cm. They have a blunt opening and a blunt tip, which is round or bullet-shaped. Those of average external diameter (minicannulas) measure 3, 3.5, or 4 mm. Their useful length is 14–24 cm, and they also have a round or bullet-shaped tip and one blunt opening. Others have a diameter equal to 5 mm (macrocannulas). They have a useful length of 15–24 cm. The cannulas are mounted on the syringe either externally (Tulip) or passing through the syringe (French model). Special cannulas can be easily mounted on 50- or 60-ml syringes with a long hub, as used by urologists. Two to four small holes may be added on the tip of some annuals (accelerators) and the speed and ease of extraction is increased.

When cannulas are reused, metal cleaners should be used before sterilization. Future cannulas will be made of hard plastic. They will be sterile, disposable, of all lengths, and of all diameters. It would be ideal to have a sterile, disposable cannula and syringe made in one piece: such a model is under study.

30.2.1.2 Syringes

Syringes of average size (10 or 20 ml) are made of plastic and are sterile and disposable. They are used with microcannulas or minicannulas. Small syringes do not need a lock. The plunger is locked with a plastic needle cap.

Large-volume syringes are used with macrocannulas (50 and 60 ml). These syringes are plastic, sterile, and disposable. They should have a large opening of 5 mm or more of outside diameter. The implantation of a cone on the syringe has an 8–10-mm external diameter (Toomey tip). A lock (snapper) is necessary to immobilize the plunger (Fig. 30.1).

It is best to fill the syringe with a few milliliters of normal saline before the extraction to avoid any dead space.

Table 30.1. Advantages of the syringe technique

	Machine	Syringe
Cost of material	High	Not high
Disposable	No	Yes. Future technique: syringes and cannulas in one piece, sterile, and disposable
Transport	Constraints	No constraints
Encumbering/maintenance	High	Not a factor
Machine breakdown	Always possible	No effect on the technique
Ease of use	Heavy equipment, more difficult to use	Light equipment, easy to use
Surgical control	More difficult	Easy owing to lightness of equipment
Surgical precision	Less precision: no exact measure resected quantities	Very precise since there is a measuring of unit of resected volumes (the syringe)
Lipoextraction power	1 atm	1 atm—a vacuum can only be obtained once
Lipoextraction speed	Same as syringe	Same as machine
Buffering effect	No. Impossible	Yes. Thanks to saline solution drawn into syringe before adipose tissue is added
Surgeon's fatigue	More tiring than syringe	Less tiring than machine. Both require the same back-and-forth movements but the syringe is much lighter to work with
Quality of results	Good but uncertain. Possible mistakes	Excellent. Technique more reliable. Few errors possible
Symmetry of results in large surgery	Approximate. More difficult to estimate in large containers	Very precise. Syringe is a measuring unit estimate in large containers
Symmetry of results in small surgery	Very approximate estimate	Extreme precision verified in syringe's graduated scale
Noise during operation	More or less strong depending on the machine. Problem for patients under local or twilight anesthesia	Total silence
Liposanguinous aerosols	Yes. If the filter is inappropriate (AIDS, herpes, hepatitis)	No risks
Adipose tissue and nerve Trauma	Some. Negative pressure transmitted to inside of dissected areas. Operation takes place in a vacuum	Very little. Buffer liquid between negative pressure and dissected areas. Operation takes place in a liquid environment
Shock possibility	Higher because of adipose tissue nerve trauma	A lot less because of buffering effect of the syringe
Perioperative bleeding	Higher because of direct negative pressure on capillaries	A lot less because of buffering effect of syringe
Transfusion possibility	Always possible	Less probable
Amount of adipose tissue resected in same area	Less. Limited by precocious bleeding	More. Bleeding occurs much later
Amount of adipose tissue resected without risking shock, large hemorrhage or transfusion	About 2 l	4 l or more
Work for two trained operators	Risky owing to possible asymmetry of results. Equipment problems	No problem since precise estimate of resected volume by each operator on paired adiposities. Desirable to treat large, medium, Multiple, or paired adiposities
Advantages of operation done by two trained operators		Operative and anesthesia time decreased. Hospitalization and convalescence time shorter. Less fatigue for operators
In case of reutilization of resected adipose tissue	Vaporization and trauma of tissues. Transport in a vacuum with brutal impact	No tissue vaporization. Transport in liquid environment. Buffering if impact. Syringe allows reuse of fat
Why there are not more practitioners using the syringe	Machine seems to give more importance. Patients think the machine does the operation	Using an old instrument like a syringe simplifies the operation too much

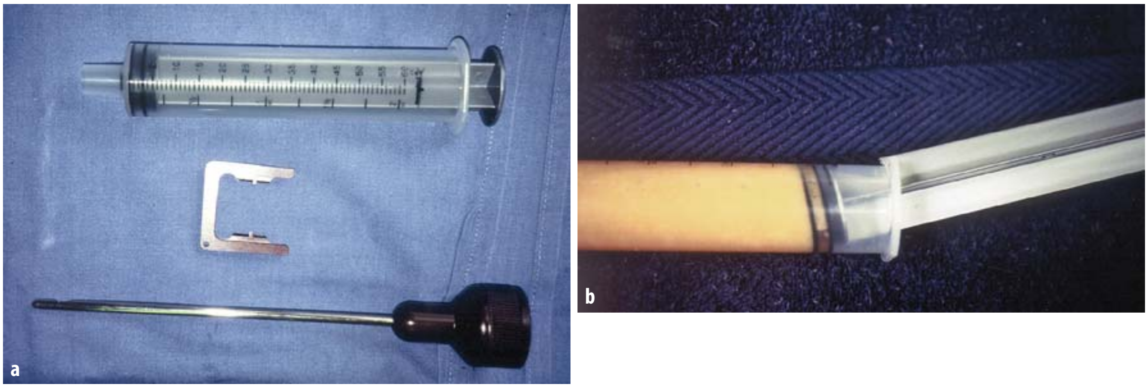

Fig. 30.1. **a** All the equipment needed: a Toomey syringe, a Tulip cannula, a lock. It takes 12 s to fill a 60-ml syringe after infiltration. **b** The makeshift lock

30.2.1.3
The Lock

A lock is necessary when using 60-ml syringes. Different models exist. We recommend the “Johny lock” (Johnson). We use only the makeshift one, which is excellent. The lightness of our equipment decreases possible bleeding.

30.2.1.4
The Awl or Ice Pick

To avoid incision scars, punctures are made through the skin with an awl. This opening can be dilated with a hemostat to allow entry of the cannula. The puncture of the skin made by the awl heals better than an incision with a scalpel and is almost invisible. This puncture needs to be dilated with an artery forceps to avoid friction with the skin, which may give a pigmented spot at the place of the puncture.

30.2.2
Cautions

The larger the diameter and capacity of a syringe, the less its suitability for transportation of the fat. This is why it is much better to use a syringe adapted to the volume of the adiposity and to the volume of fat to be extracted. The outside diameter of the syringe should be as small as possible. This is why a 2-ml syringe for insulin injections is superior to the standard 2-ml syringe, which is much shorter.

The cannulas should also be chosen according to the volume of the adiposity. If specially made cannulas are not available for mounting on plastic syringes, it is a simple task to use the standard machine Karman cannulas. The machine mounting is first sawed off, then the cannula is passed through the barrel of the plastic syringe and pushed with long scissors in a screw-type motion through the plastic cone after the opening has been appropriately cut. It may be necessary to use an ice pick or hemostat to dilate the plastic cone still further. The cannulas have to be adapted perfectly to the cone and syringe.

This equipment is as useful as any specially manufactured cannula for syringe-assisted liposculpturing. The equipment is tight, waterproof, and airproof. Surgeons who choose to make their own equipment can obtain the syringes in medical, dental, or veterinary supply stores. Cannulas of 2, 2.5, and 3 mm can be mounted externally, as their inside diameter corresponds to the inside diameter of the small syringes (Luer lock).

In all systems described, suction is as fast as with the machine, is less shocking, provokes less bleeding, and is less tiring.

30.3
Reduction Syringe Liposculpturing Technique

The goal of the procedure is to perform a partial lipectomy in the localized adiposity. Four steps are required:

1. Removal of the excess adipose tissue in a crisscross dissection/extraction (lesional lipectomy or mesh lipoextraction).
2. Remodeling of the remaining crisscrossed adipose tissue.
3. Redistribution of the skin after a wide peripheral mesh undermining of the neighboring normal adipose tissue has been done with a cannula (perilesional mesh lipoplasty). No removal of adipose tissue during the peripheral undermining has to be done.
4. Adequate immobilization of the treated area until shrinkage and healing proceed satisfactorily.

In some cases, after performing reduction liposculpturing on one or several adipose regions, it is worth using part of the harvested fat (60 ml usually) to fill in the neighboring depressions. The final result will be improved.

The surgeon must keep in mind that closed liposculpturing is an artistic, three-dimensional, architectural technique of body contouring. It is essentially a tactile operation with the surgeon working almost blindly. We are dealing with a volume of space-covering tissue, the skin. Fat is highly vascularized; consequently, a lipectomy has to be performed using a blunt cannula to create crisscrossed dissection/extraction channels. It is imperative to avoid excessive bleeding through the use of vasoconstrictors. It is also crucial to reposition the skin and underlying fat using the shrinking properties of the skin and the technique of peripheral mesh undermining. Finally, adequate immobilization is vital to liposculpturing.

30.3.1 Basic Principles

The following are some of the basic principles in reduction syringe liposculpturing:

1. A crisscrossed lipectomy (tunnels, columns of fat, lattice, and mesh lipectomy) has to be performed. Several approaches have to be made. No more than three strokes in the same direction (Fischer) [2].
2. A peripheral mesh undermining technique is usually part of the operation (without fat extraction). This is mostly important when the skin is of average quality with mature patients.
3. Dissecting hydrotomy with vasoconstrictors (chilled normal saline at 2°C and 1 ml/1 adrenalin) is necessary.
4. The required instruments include a small blunt-tip cannula with one blunt opening, an ice pick, and syringes.
5. The shrinking properties of the skin should be utilized after repositioning and immobilizing the tissues.

30.3.2 Pre-Estimation of the Quantity to Be Resected

The amount of adipose tissue to be resected during liposculpturing must be calculated during the patient's various preoperative examinations. This is a matter of experience and judgment and can be acquired only with time after assisting the operations performed by other surgeons. Only then can an accurate estimate be made.

During the operation, this estimate can be more or less modified, but overall the surgeon has a relatively good idea of the amount of tissue to be resected. It is not a "suck as you go procedure."

Pre-estimation requires the same kind of judgment that is necessary for other aesthetic operations. The eye will examine the state of the skin (thick, with or without stretch marks); the fingers will test the tonicity of the areas to be treated by using the pinch test with the patient in a standing position, lying down, while the underlying muscles are contracted, and while walking.

The pre-estimation of a region such as the saddlebag area can be done only after a careful study of the neighboring adipose areas that can play a role in the origin of the saddlebags: hips, buttocks, and the lower buttocks fold. One must therefore differentiate between true saddlebags, false saddlebags, and mixed cases. Squeezing of the buttocks is requested to differentiate false saddlebags from true ones and mixed cases.

Xerographies, echographies, scanner, or other complementary examinations can be useful but are never demanded because the pre-estimation is above all clinical. The pre-estimation is noted on the patient's card, on special diagrams, or on the Polaroid photographs made during the course of the first visit. Computer study may also be used.

30.3.3 Notes

We once more insist that the surgeon needs to know the approximate amount of adipose tissue to be resected before the operation. The following items depend on the quantity to be resected:

1. Whether the operation can be done all at once or over several procedures
2. Whether conventional, tumescent, local, general, or epidural anesthesia is to be utilized (the dose of local anesthesia also needs to be estimated)
3. The amount of fluids and electrolytes needed
4. The length of the hospitalization (whether or not the patient is ambulatory)
5. Whether a blood transfusion needs to be considered even if today this is not frequent
6. The approximate length of the operation and of the convalescence

30.3.4 Marking the Patient

Marking the patient (Fig. 30.2) is done with the patient in the standing position, just before the operation. We use a green Pentel pen; the skin marker must be of good quality to resist the preparations. We mark (1) the adiposity by encircling it (2) 1–1.5 cm around the previous circle (the tip of the cannula will be pushed until the second marking, so there will be no stair-step deformity), and (3) beyond the adiposity between 2 and 8 cm from the second marking. This corresponds to the extent of the peripheral mesh undermining. Finally, the openings (or incisions) should be marked by a circle to avoid any permanent or transient tattooing from the ink of the marking pen. All the adipose regions are marked before the operation, as is the site of the intended incisions or openings. The approximate amount of resection will be marked in the middle of the adiposity.

30.3.5 Anesthesia

Reduction liposculpturing can be done according to the type of anesthesia that the patient desires whether general, twilight, epidural, local, or cryoanesthesia. Local anesthesia is the preferred method. For many years we have used the tumescent technique as Klein [3] described it; chilled saline at 2°C is used instead of saline at room temperature. We consider chilling as very important with tumescent anesthesia. The cold increases the anesthesia, decreases the bleeding and prevents shock. A thorough study of tumescent anesthesia is a must before practicing liposculpturing.

External cryoanesthesia can be used in addition to local anesthesia. Ice packs will improve the anesthesia and decrease the bleeding. If refrigerated bags are used, one should watch the patient carefully because the bags can cause skin burns or pigmentation. This does not occur with ice cubes.

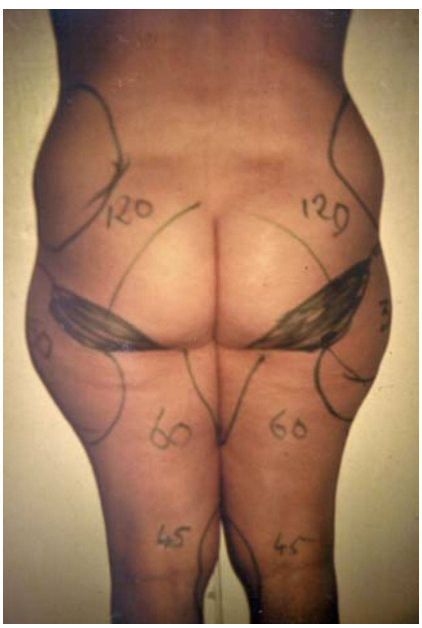

Fig. 30.2. Marking the patient

30.3.6 Preparation of the Area

In all cases of reduction liposculpturing, the area should be injected to decrease bleeding as well as to enhance the procedure. A 60-ml syringe or a pump is used for this preparation. During general or epidural anesthesia, we use the following solution: 1 l of chilled normal saline at 2°C and 1 mg epinephrine. The amount injected is roughly half of the estimated fat to be removed. This solution is injected deep into the fatty layer to obtain a spasm of the vessels at this level. After 5 min, another injection of chilled saline at 2°C, with epinephrine, is administered in the upper layer before starting the procedure. There are no special recommendations as the area is prepared with the local anesthesia when using tumescent anesthesia as described by Klein [3]. The tumescent solution is always chilled at 2°C. Between 1 and 4 l is injected in the average case.

30.3.7 Approaches in Liposculpturing

The planned approach has to allow for easy, efficient work in the adiposity to obtain the best possible result. Approaches used long ago at the beginning of the procedure which are concealed far from the adiposity must be avoided if they interfere with proper working conditions. As many approaches as are necessary will be performed for the crisscross work; there will be a minimum of two. Puncturing the skin in the right tension line is better than incising it. In all of the approaches used for the past few years, we have used an awl or an ice pick to make the opening. Should the awl or ice pick puncture be too small to allow the passage of the cannula, the hole can be dilated by passing first one branch and then the second branch of a hemostat, which are separated very gently. As there is no incision of the skin, the healing of the wound is far superior to a standard incision and is almost invisible. The wound needs to be closed in most of the cases by a fine nylon 5-0 suture or by an inverted stitch of absorbable material.

30.3.8 Positioning the Patient

The position of the patient should, of course, be the most adequate and convenient for the surgeon. Choices include the supine position, the prone position, and the lateral position. With all of these positions, arms or legs to be moved during the operation should be prepared according to the needs of the surgeon. Under local anesthesia, there is no problem, as the patient can move or be moved if necessary. This also holds true if epidural anesthesia is used. However, during general anesthesia, the patient is supine, and it is necessary to elevate a side of the patient to permit the surgeon to work on the waist, the hip, or the lateral chest roll. Other localizations are within easy reach, e.g., thighs, knees, and double chin. It is also possible if the patient is in the supine position to work on the buttock or to create an infragluteal fold, although this is not as easily done as in the prone position. By moving the patient who has been specially prepared, it is possible to work on almost all localized adiposities of the pelvis in the supine position.

When using general anesthesia turning the patient from the prone to the supine position or vice versa during a liposculpturing procedure should be avoided whenever possible. Nevertheless, it is sometimes necessary to do this and special precautions should be observed by the surgeon and anesthesiologist. For safety reasons, it is much better to do the requested procedures in two stages instead of taking risks with the patient when a change of position is needed.

A word of caution: positioning the patient is important, as the surgeon should not be working in unfavorable conditions. The surgeon should always have easy access to the different approaches needed during the procedure in order to do the best work possible. Tumescent anesthesia allows the surgeon to work in the best conditions as the position of the patient is easily modified.

30.3.9 Surgical Technique

In describing surgical technique, the work on a hip with a 3- or 4-mm cannula and a 60-ml syringe will be used as an example. At the previously marked sites, incisions or openings are made (we prefer the puncture) and are dilated with a hemostat. Pretunneling is not absolutely necessary but is recommended if the fat is hard. The cannula is directed in the area before liposculpturing is begun. Before it starts, one should fill the syringe with 5 ml of chilled saline; this will then act as a buffer. The cannula is then passed through the opening while the left hand folds temporarily the skin.

The plunger is withdrawn and kept withdrawn by the surgeon’s right hand. The maneuver is not difficult and can be made easier by the use of a stop. The cannula will be moved in a fan-shaped motion, approximately three times in the same direction (we do not recommend that it stay in the same tunnel). The strength of the surgeon is exerted when pushing the cannula into the adipose tissue, not when pulling it. The opening of the cannula will face down during this maneuver. After 60-ml of fat has been collected in the barrel, the syringe is emptied into a basin on the operating table. The same procedure will follow using another approach and so on to perform even crisscrossed work.

When the adiposity is conical (saddle bags or abdomen) the surgeon has to work in the middle of the adiposity, below the conical portion, giving small strokes to “decapitate” this adiposity, and he or she has to give long strokes to “level” the adiposity, using different approaches to obtain crisscrossed work (Fig. 30.3).

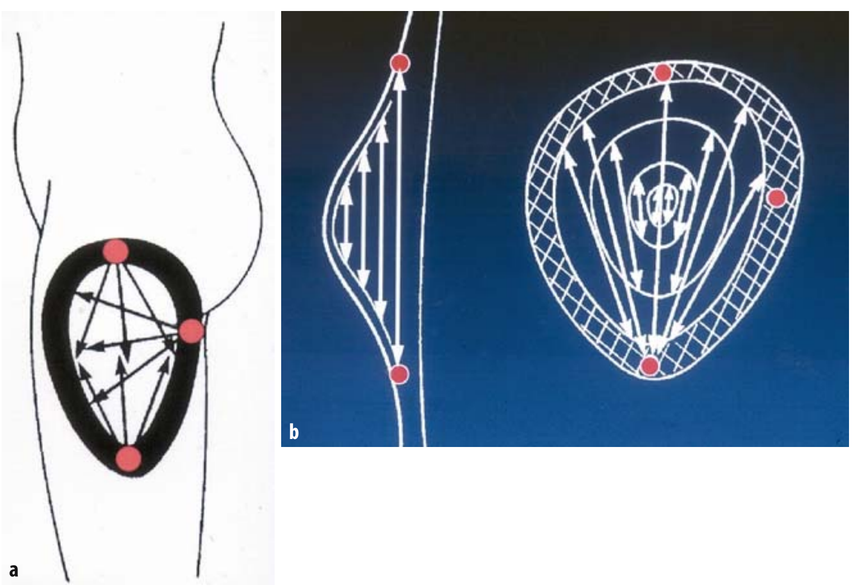

Fig. 30.3. a Approaches in saddlebag liposculpture include a central crisscrossed lipoextraction zone and peripheral mesh undermining. **b** Saddlebag liposculpture. Small strokes are given in the center to “decapitate” the adiposity

Three approaches are used when treating in a clockwise direction and so on saddlebags. Three for an abdomen. Even crisscrossed work is achieved when using a different approach to fill a syringe. The left hand still guides and follows the work of the right hand. Liposculpturing is a tactile operation. The work of the hands is summarized in Table 30.2.

The division of labor between the two hands is opposite to that for standard surgery, in which the right hand is the one that dominates. With liposculpturing the left hand is the “brain hand,” and the right one is a mere piston.

One may in some circumstances use a smaller cannula (no. 2) to do the crisscrossing at a different level. At intervals, the left hand will pinch the skin (pinch test) between the index finger and the thumb to evaluate the thickness of the fold. The surgeon will usually monitor the modification of the contour of the area treated to avoid an overcorrection and will also check the volume of fat removed against the pre-estimate.

A 1-cm uniform thickness of fat covering the area should be left, and this result is checked by a pinch test made with the left hand. Should the fat in the syringe show too much blood, the surgeon must stop suctioning the area and work on another part of the adiposity. Should the patient complain under local anesthesia, the surgeon should inject more of the anesthetic solution.

It should be noted that the skin has to be grasped in order to place the cannula in the right place. The left hand should be flat during the whole operation to stabilize the tissues and should exert some pressure on the tissues.

When the lipectomy has been completed and the expected amount of fat removed, the surgeon will perform a peripheral mesh undermining using the same openings and the same instruments. No suction is done during this procedure. The cannula is pushed in a fan-shaped motion until it reaches the marked line of the mesh undermining. This mesh is also done in a crisscross fashion through the area already lipectomized. The peripheral mesh undermining allows the excess skin that is covering the crisscross lipectomized adiposity to fit better in its new bed; less resistance will be encountered in the neighboring tissues because many retinacula cutis will have been severed. The peripheral mesh undermining must be proportional to the amount of fat removed and also to the quality of the skin. When a small amount of fat is removed in a young patient it is unnecessary.

When one area is completely treated, the surgeon will work on the opposite paired adiposity unless another well-trained lipoplasty surgeon has already done the second side. When a neighboring depressed area has to be grafted, part of the fat that has been harvested will be washed with normal saline and reinjected in a crisscross manner. This area will be remodeled with the surgeon’s left hand and immobilized together with the other treated areas. Remodeling of the adipose area is done with the surgeon’s left hand. We never drain.

When some patients have heavy legs we use Cherif-Zahar’s [4] technique under general anesthesia: a tourniquet is applied on the thigh after emptying the leg of its blood using an elastic bandage (Chap. 21). No infiltration is necessary. There is no bleeding during the operation and the results are excellent.

Table 30.2. Summary of the work of the hands

The left hand	The right hand
Stabilizes	Pushes
Lifts	Pulls
Grasps	Dissects
Hardens	Fills the syringe
Guides	Empties the syringe
Localizes	Pulls on the plunger
Palpates	Measures the amount of fat extracted
Monitors	
Carries out the pinch tests	

30.3.10 Dressing

Unless a special garment is used, the surgeon will do the dressing using Elastoplast. Several layers have to be used because the dressing acts as an external splint.

30.3.11 Fluid and Electrolyte Balance

When using general or epidural anesthesia, the anesthesiologist will take care of the problem of fluid and electrolyte balance. Roughly double the amount of fat removed has to be given to the patient in fluids. When using tumescent anesthesia no fluid should be given intravenously as recommended by Klein [5].

30.3.12 Technical Considerations

The quantity of fat to be removed is the visible resection. One has to think that during the procedure the to-and-fro movements of the cannula devitalize a certain amount of adipose tissue, which later will be resorbed by the body. This is the invisible or biologic resection. During the procedure, there is adipose tissue destruction. The volume of fat reduction is obtained in two different ways: mechanical disruption and suction friction scraping.

The visible resection is the one obtained by the scraping motion of the cannula, which also removes a part of the fat that has been mechanically disrupted. The invisible resection is made up of most of the devitalized fat obtained by the friction of the cannula and of some of the mechanically disrupted fat. After a certain period of time, the procedure will create scar tissue, which will be followed by contractions, as is true for any operation on or below the skin. This consideration enhances the prognosis for a thorough and even lipectomy. The peripheral mesh undermining in the whole area treated is to obtain a homogeneous contraction of the scar tissue.

The skin will be affected by the primary contraction of the muscular fibers (immediate, active process). The adipose tissue will be modified by the contraction of the fibrous tissue (passive contraction, delayed). After a liposculpturing procedure, there is an immediate improvement in contour owing to the biologic resection. The skin will also be modified immediately by the primary contraction of elastic fibers, and later by the contraction of the underlying fibrous scar tissue.

Surgeons performing liposculpturing should remember that the most important consideration is "not what is removed, but what is left and how it is left" (as in a rhinoplasty). If too much blood is in the aspirate, one should stop working in the area and work on another part of the adiposity or on another adiposity. Under no circumstance should windshield-wiper movements be made, as they will cut the adipose columns that harbor vessels, nerves, and lymph vessels. When lumps are felt under the skin, one should work on them with a smaller cannula (decreasing work).

The following points are to be remembered:

1. Small cannulas with one opening should be used. Cannulas with accelerator are also widely used.
2. Blunt tip and blunt openings should face downward (opposite to the scale on the syringe).
3. The syringe should be used for extraction and hydro-cryodissection.
4. An atraumatic technique with no windshield-wiper movements should always be used.
5. Tunnels should be fan-shaped, starting from the puncture wound.
6. Dissection should be blunt and deep, using the direct approach and puncturing with an ice pick. Superficial liposculpturing with thin cannulas may be used in selected cases.
7. Crisscrossing (tunnels and fat columns, lattice work) should be done. Two or more approaches can be used.
8. The left hand should direct the operation.
9. Peripheral mesh undermining should be performed when necessary.
10. Remodeling and immobilizing should be done.
11. Grafting the neighboring depressed areas has to be considered sometimes.

30.4 Cautions in Liposculpturing

The following cautions should be kept in mind: (1) never use sharp cannulas; (2) the opening should always look down opposite to the scale of the syringe; (3) never make windshield-wiper movements; and (4) decreasing work may be useful in certain circumstances; i.e., the use of a smaller cannula after a larger one has been used. Asepsis is very important: the incision is minor but the wound is major.

Pushing the cannula below the skin and waiting, without moving it, does not remove fat; when using a suction machine or a syringe: it is necessary to move the syringe in the fat to see the fat flow in the syringe or in the tube. This is why liposuction is not a good term for the procedure. Lipoextraction is a more accurate word. Lipoextraction carried out artistically is liposculpturing. Liposuction makes one think of a passive act without possible complications, whereas liposculpturing makes one think of an active act with possible complications.

Larger-diameter cannulas produce more damage to the fat. A large contour defect can be created very rapidly and is difficult to treat. Smaller cannulas (3- or 4-mm external diameter) are advised. Because 1 cm of fat has to be left below the skin, all contour defects, such as cottage cheese deformity, can be treated later in a separate procedure (e.g., cutting the subcutaneous connections with a 14-gauge needle and grafting a few milliliters of autologous fat) or superficial liposculpturing. Superficial liposculpturing with a small cannula (2 mm) can be performed during the main procedure, if necessary.

30.5 Complications

It has been said that there are few complications but many errors in liposculpture. When using the syringe cannula technique many complications are complications of "beginners." All "unpleasant events" of anesthesia (general, epidural, or local) can be seen but are rare. It is the same with surgical complications (hemorrhage, infection, etc.) in trained hands. There is less bleeding edema and shock with the syringe during major cases. The complications that we have encountered with the syringe are mostly aesthetic complications (insufficient resection, a resection that is too large or irregular, cutaneous waves due to a bad skin tonicity and postlipoplasty irregularities). A good selection of candidates and a rigorous technique following a lengthy practical and theoretic training will help avoid most complications.

When treating postlipoplasty irregularities the syringe fat grafting or the liposhifting technique as described by Saylan [6] can be used (loosening the fat subcutaneously, shifting the fat externally, and fixation of the fat). As Fischer says "Lipoextraction is easy, liposculpture is difficult."

30.6 Results

As the results obtained with the syringe cannula are as good as those with others instruments (machine, ultrasonic, powered) and the technique is safer and simpler, we recommend the syringe cannula technique (Figs. 30.4–30.6). It should be remembered that what matters is not what is in our hand, but what is in our head. It is not the instrument that is doing the operation, it is the liposuction surgeon. No instrument can replace talent and experience.

Fig. 30.4. Saddlebags in a mature patient: **a** preoperatively; **b** postoperatively

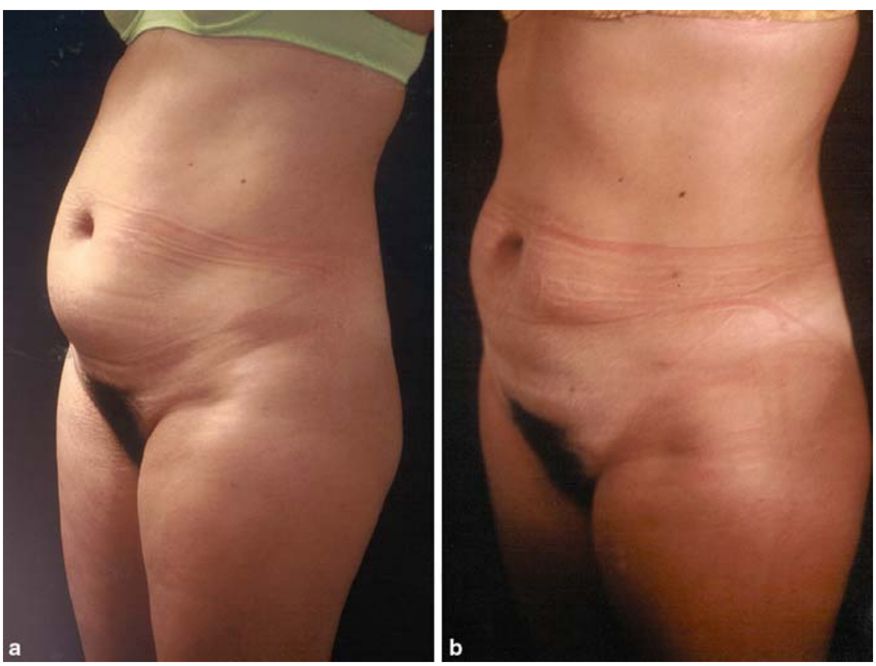

Fig. 30.5. Liposculpture of the abdomen: **a** preoperatively; **b** postoperatively

Fig. 30.6. Neck and face liposculpturing: **a** preoperatively; **b** postoperatively

30.7 Summary

The use of the syringe has been an advance in reduction and incremental liposculpturing. A real democratization in the medico-surgical group has been possible owing to the simplification of the equipment. The shock-absorbing action of the syringe makes the operation safer. Excellent results are obtained because one does perfectly symmetrical work. The syringe is a unit of measurement in this surgery of volume.

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Orthostatic Liposculpture

Giorgio Fischer

31.1 Introduction

Many factors contribute to the success of a good liposculpture: the technique, the correct instrumentation, skin elasticity and muscular tone, the ability of the surgeon, and last, but certainly not least, the force of gravity. The force of gravity has been, even since our invention of liposuction in 1974, our greatest enemy. We have continued to fight against the force of gravity throughout the years.

Orthostatic liposculpture has been the resolution to all of my problems. The orthoststatic bed offers the possibility to operate on the patient in the most natural way. Many times the results we achieved were not the expected ones and this was only because when lying down, adipose and muscular masses are naturally dislocated. Before the invention of the bed, the surgeon had to imagine how these masses would be once the patient was standing up. Today it is possible to observe the entire patient in an everyday position. It is only now that we are able to really sculpt the body of a patient.

Many changes have occurred in liposculpture since I first reported my work in 1975 [1] and published my work in 1976 and 1977 in the *Bulletin of the International Academy of Cosmetic Surgery* [2, 3]. These changes include instrumentation, infiltration, and the surgical technique.

31.2 Instruments

The first cannulas were very different from the ones we use today. The first cannula was blunt and open on one side. The cannula was motor-driven. Inside the blunt cannula was a rotating cylinder, which went back and forth in order to facilitate the rasping in certain places. This rotating and cutting cylinder could be disconnected by simply pressing on the cannula's hand piece and in this way the cannula could be used as the simple cannula we use today. The blade inside the cannula was further eliminated and a straight cannula was used. The diameter of the cannulas used in the years has decreased in caliber from 5 or 6 mm used in the past to 2 or 3 mm.

I observed that if the amount of fat taken in each tunnel was reduced and instead more tunnels were made, the final result was better. To prevent wavelike results I invented other types (two) of cannulas, which are still in use today. The first one is a swan-neck cannula that completely replaced the straight cannulas I was using. This cannula is easier to use since it stays parallel to the skin and is not influenced by the way the surgeon handles it. The straight cannula always tends to make oblique tunnels from up to down, while what we really want are straight tunnels.

The other cannula I invented was the guided cannula. This cannula enables the surgeon to leave an equal amount of subcutaneous tissue under the skin that can vary according to the surgeon from 4 mm to 1 cm. The variation of the thickness can be obtained by simply turning the cannula rightwards or leftwards. The way to use this cannula is to press the guide cannula downwards against the skin and in this way the twin cannula in the subcutaneous tissue is only the mechanical part of what can be seen outside.

The instrumentation was very much ameliorated by Fournier [4–6] when he introduced a new and easier way to carry out liposculpture through the syringe-assisted technique. This technique does not necessitate the use of a motor-driven cannula. The cannula is easy to control and bleeding is much less compared with that for the traditional technique.

31.3 Tumescent Liposuction

Klein [7], in 1987, offered a revolutionary idea with Klein's infiltration, or what is called the wet or tumescent technique. The tumescent technique gave us the possibility of removing larger amounts of fat because of the drastic reduction in blood loss. Also, the analgesic effects remain for more than 18 h. Orthostatic liposculpture could have never been invented without this solution. Previously general anesthesia was used for all liposculpture procedures, while with tumescent infiltration intravenous sedation is sufficient. Today the patient can be conscious and collaborate in the various stages of the operation where the evaluation of the muscular tone is of the utmost importance.

31.4 Tumescent Liposuction

Klein's solution consists of lidocaine, epinephrine, and sodium bicarbonate in saline solution. I do not use real Klein's solution since the infiltration of large quantities of liquids dislocates the masses too much. I attempt to estimate the amount of fat to be taken away and try to infiltrate exactly the same amount.

The last great invention in liposculpture I believe is orthostatic liposculpture. The possibilities given to the surgeon to operate on the patient with the orthostatic method are very important. In this way you really have the sensation you are sculpting somebody's body. Force of gravity is not an enemy anymore.

31.5 Procedure

The patients are always marked standing up and photographs are taken. In this way all adipose masses are dislocated downwards and we can work on reality instead of having to imagine everything.

The realization of the bed came into my mind when one day I was taking pictures of a patient behind Fischer's harp (Fig. 31.1). This has vertical lines and is placed in front of the patient for preoperative and postoperative photographs. It helps to see the patient asymmetries. This allows better evaluation of the areas to be treated. I had invented the harp many years ago but only in the early 1990s did I realize that I wanted to operate on my patients in that same way.

Pictures and drawings are a very important step in the procedure. Making the patient contract the buttocks, for example, may help you distinguish false from true fat deposits. This can also be done in the operating theatre when the patient is standing on the rotating orthostatic table. It is not necessary to operate for the whole time with the patient in the orthostatic position. The major debulking is done in a slight Trendelenburg position and never completely supine. Many surgeons operate upon their patients with the patients in a lying-down position and make their patients stand up for the last checks. Of course they can do this if they are using local anesthesia. I believe this is very dangerous. The patient has the risk of a hypotensive crisis and there are difficulties with keeping the surgical field sterile. We have the means to overcome this problem and are no longer justified if we make mistakes that could have been avoided. Instrumentation is available and has to be used.

Moreover, we have to keep in mind that this is one of those factors that contribute to a good result. Today we have the possibility to operate with this method and it is absurd even to think of operating in a hori-

Fig. 31.1. **a** Fischer's harp. **b** Asymmetries can be seen using the harp

zontal position. Many "risk" factors in fact cannot be eliminated and I refer to those individual characteristics that belong to each patient such as muscular tone or skin elasticity. Poor skin elasticity in fact will probably result in poor skin retraction in certain parts of the body even if the procedure is carried out in the best of ways. In the last few years I have realized that there is another individual characteristic which no one has ever taken into consideration, and that is vascularization of the leg. This vascularization is a random one and this means that some parts are more vascularized than others. As seen in the anatomical pictures some very large areas are left without much vascularization. Also if thermography of the leg is used, different areas of the thigh can be seen to have random blood supply. All of this brings us to the conclusion that even if the same amount of fat is taken away from an area, there can always be irregularities. This is because fat lives differently according to the different blood supply. This brings us to the conclusion that we must try to eliminate all of those factors that can be eliminated, such as using the proper technique and proper instruments, since many factors are individual ones that cannot be changed.

In 1992, I created the first prototype of the bed. This made it possible to bring the patient from a horizontal position to an orthostatic one. The bed was manual and it had two fixed arm holders and was a bit uncomfortable both for the patient and for me. The calves of the patient were also fixed.

The second orthostatic bed was produced in the same year and was still manual, but it had a rotating platform on which the patient could turn around. In 1993 I improved the bed and this model is still in use today (Fig. 31.2). This table is motorized and has many possible positions between the orthostatic and the supine positions. The shoulders of the patient are held by a sling, which is soft, comfortable, and very resistant. This leaves a good view of the thorax for the anesthetist. The table also has an intravenous holder attached to it, which rotates together with the bed. The rotating plate is secured to the base of the operating table. The extreme ease and rapidity of the table's movements is able to prevent loss of conscience because of orthostatic hypotension.

After preoperative marking (Fig. 31.3), the patient is taken into the operating room, skin sterilization is performed, and the patient is positioned on the bed. The patient is then shown what will happen during the operation. Infiltration starts under intravenous sedation. When infiltration has ended, the various areas are massaged firmly in order for the solution to spread equally (Fig. 31.4). I then start tunneling with the harpstring technique. I called the technique this since the tunnels are made in a vertical direction. Today I use 2–3-mm cannulas. Not more than two or three passes are made in the same tunnel, otherwise they become too large. Tunnels must be made in a vertical direction (Fig. 31.5). No horizontal tunnels should be made.

It is my habit to do first one leg or one part of the body and then do the other one. In this way we will have an example to follow. Following completion of liposuction, the areas are massaged with a steel tube (Fig. 31.6).

Usually I do not combine deep liposculpture with the superficial one. When doing deep liposculpture swan-neck cannulas are used, while a guided cannula is used when doing superficial liposculpture.

It is very important to keep in mind that while operating the skin should always be kept wet. Only in this way can the gloved hand of the surgeon really appreciate what is being operated on. The left hand should be kept flat on the skin. The more you press, the more fat is rasped away. At the end of the operation I pass over the operated areas with an iron–steel tube, which is rolled energetically. One of the tubes is smooth and the other one is undulated. This helps us to even out the work.

31.6 Postoperative Care

I use 3M Reston foam and then apply elastic tights, which will be two sizes larger than the patient's size

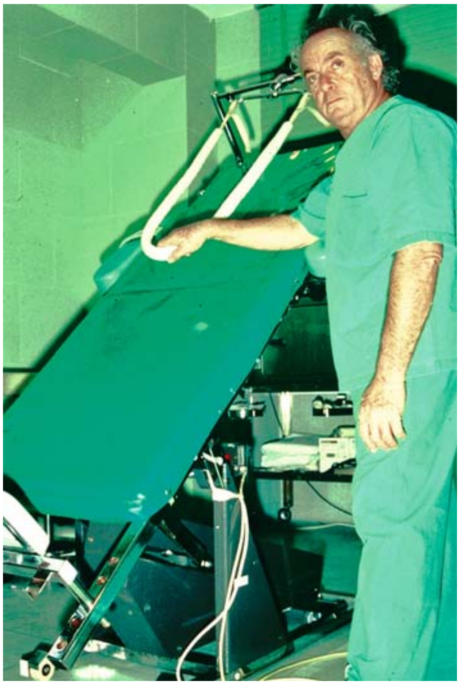

Fig. 31.2. Latest model of the orthostatic bed

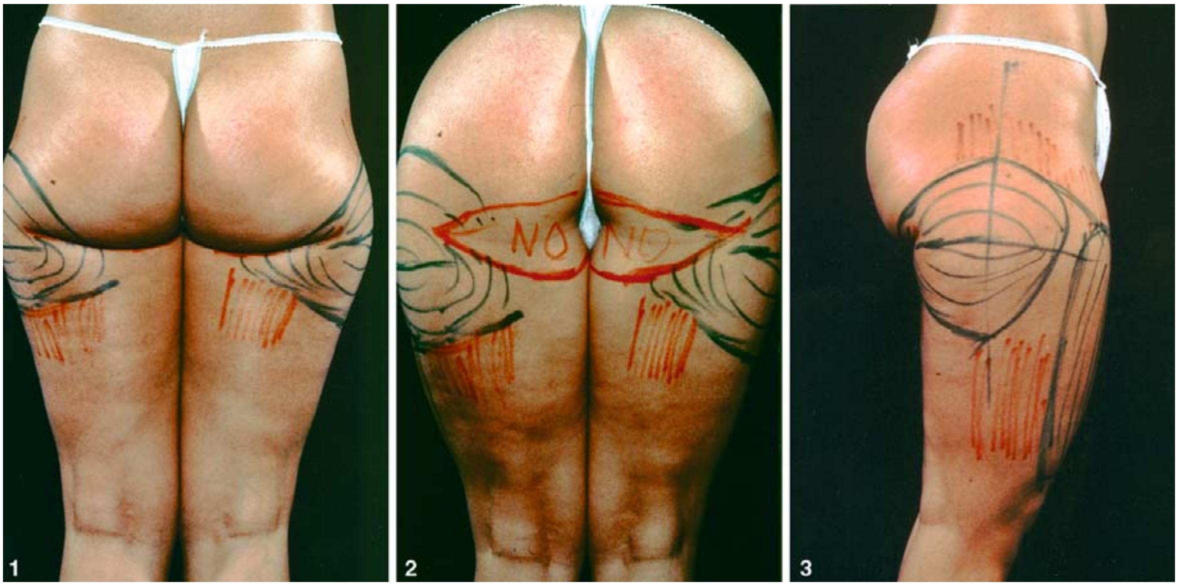

Fig. 31.3. Marking the patient

Fig. 31.4. Massage of the area following tumescent infiltration to distribute the fluid evenly

in order to fit them well over the foam. The patients will continue wearing the tights for 1 month after the operation. Bandages are not used because if the operation is carried out properly, there is no need to use them. They are also very uncomfortable for the patients.

Postoperative massages are of the utmost importance. Four days postoperatively the patient starts massage sessions with three sessions per week in the first month and two in the second and third months. The massage consists in lymphodrainage massage for the first 20 min and a deep strong connective tissue massage for the next 40 min.

Fig. 31.5. Liposuction tunnels are made vertically rather than horizontally

31.7 Conclusions

After many years of experience I have realized that before what seemed to be excellent results in the horizontal position were only good results in the orthostatic position. Today I am able to see in the operating room what the final result will look like (Fig. 30.7).

Fig. 31.6. Massage with a steel tube after completion of liposuction

Fig. 31.7. a Preoperative patient with lipodystrophy of the trochanteric areas. **b** Postoperatively following orthostatic liposuction of the trochanteric area

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Part VI
Ultrasound

Ultrasound-Assisted Liposuction: Past, Present, and Future

32

William W. Cimino

32.1 Introduction

The use of high-frequency vibrations in surgical instruments, commonly referred to as ultrasonic surgical instrumentation, typically involves a frequency of vibration in the range from 20 to 60 kHz. The metal probe or tip of the surgical instrument moves forward and backward at the aforementioned frequencies to create a desired surgical effect. The choice of frequency and the design of the tip of the metal probe determine the application of the instrument and how the device interacts with the targeted tissue.

32.2 History

Ultrasonic instrumentation for surgical application was first introduced for the dental descaling of plaque in the late 1950s and early 1960s by Balamuth [1]. This technique and technology for dental scaling are still widely used today.

In 1969 Kelman [2, 3] adapted the vibrating metal probe to the phacoemulsifcation procedure. Aspiration and irrigation capability were added to the basic vibrating device to facilitate the safe and effective removal of the cataract. Today, over two million cataracts each year are removed in the USA using this technology and associated techniques [4]. The clinical effect of the phacoemulsification device on the cataract has been attributed to a microchopping effect [5]. Safe and effective techniques and technology for this ultrasonic instrumentation have evolved to the degree that the cataract removal portion of the phacoemulsification procedure is often finished in less than 5 min per eye and over 98% of all cataract removals in the USA are now done using the phacoemulsification technique.

In 1974 the phacoemulsification device was further modified and applied to neurosurgery for tumor removal. The objective of the device was to selectively remove pathologic brain and spine tissues with minimal residual trauma to remaining tissues. The Cavitron ultrasonic surgical aspirator (CUSA) device, the first such instrument, is still in wide use today. Several companies produce ultrasonic aspirators for neurosurgery and these account for approximately 200,000 procedures per year worldwide. The tissue selective nature of the devices, i.e., the ability to spare nerves and vessels, has been attributed to the device's ability to differentiate between tissues with different water contents and to a process called cavitation. The cavitation theory has never been proven and alternative theories have been presented that base the selective tissue effect more on mechanical actions [6–8] and view the cavitation process as an unavoidable consequence, but not the primary mechanism of tissue interaction.

In the late 1980s and early 1990s the concept of an ultrasonic instrument was adapted to a cutting and coagulating device with application to laparoscopic surgery in the abdomen. Techniques and technology were developed and are used today for laparoscopic cholesystectomies, laparoscopic appendectomies, laparoscopic Nissen fundoplications, and other laparoscopic procedures. It is estimated that between 400,000 and 600,000 procedures per year are done using this technology (worldwide).

The application of ultrasonic instrumentation to body contouring surgery began in the late 1980s and early 1990s. Scuderi [9] and Zocchi [10–14] pioneered the application of ultrasonic vibration to fat emulsification and removal. The hope and objective of this effort was to create both technology and associated techniques that consistently produced a safer and more effective means of aesthetic body contouring when compared with known methods of the time, namely, suction-assisted lipoplasty (SAL). The benefits of tissue selectivity demonstrated and utilized in the previously mentioned surgical applications were expected to produce a method of lipoplasty that was more "fat-specific" than the existing and well-known suction cannula. This technology and technique were named UAL for ultrasound-assisted lipoplasty.

The first-generation UAL device was produced by the SMEI Company of Italy and utilized smooth, solid probes at a frequency of 20 kHz. The solid probes had a stepped design with diameters at the tip as small as 3.0 mm (small probe) and diameters at the base as large as 6.0 mm (large probe). The basic technique involved good surgical practice and two fundamental rules: (1) the essential use of a wet environment produced by infiltration of sufficient wetting solution and (2) constantly moving the probe to prevent thermal injury [13]. Initial surgical times were in the range from 10 to 12 min for a 250–300-ml removal or approximately 4 min of ultrasound time per 100 ml of aspirate [13].

Around 1995 growing interest in UAL in the USA prompted the plastic surgery community leadership to create a UAL Task Force that included representation from the American Society for Aesthetic Plastic Surgery, Aesthetic Society Education Research Foundation (ASERF), American Society of Plastic Surgery, Lipoplasty Society of North America, and Plastic Surgery Education Foundation. The mission of the Task Force was to evaluate the new ultrasonic instrumentation for lipoplasty and to assist in its teaching and introduction in the USA. Teaching courses were offered under the oversight of the Task Force with didactic and hands-on training. Subsequent to his Task Force efforts, Fodor [15] published his experience on 100 patients using a contra-lateral study model. His conclusions comparing SAL with UAL found no significant differences between SAL and UAL and failed to prove the claimed benefits attributed to UAL.

During the UAL Task Force period second-generation UAL devices became available. These devices included the Lysonix 2000 (Lysonix, Carpinteria, CA, USA) and the Mentor Contour Genesis (Mentor Corporation, Santa Barbara, CA, USA). The Lysonix system operated at a frequency of 22.5 kHz and utilized hollow ultrasonic cannulae that aspirated emulsified fat simultaneously with the emulsion process. Cannula offerings were "golf-tee" and "bullet" designs with diameters of 4.0 and 5.1 mm. The golf-tee-tip design with a 5.1-mm diameter was the most commonly used design, in theory because of its "higher" efficiency. The Mentor Contour Genesis was an integrated system with suction, infusion, and an ultrasonic generator all packaged in one moveable system. The ultrasonic frequency was 27.0 kHz and also utilized hollow ultrasonic cannulae similar to the Lysonix, with diameters offered from 3.0 to 5.1 mm. The shape of the tip of the Mentor cannulae was flat with side ports for aspiration for all tip diameters.

The UAL technique continued to evolve with both the Lysonix and Mentor devices. Originally, application times were long and significant complications were reported and safety was questioned [16–21]. As application times were reduced the complication rate declined. Application times were reduced to 1 min of ultrasound per 100 ml of aspirate [22, 23]. The concept of "loss of resistance" became widely known as a realistic surgical endpoint. Rapid probe movement [23] was introduced as another means to safely control the energy presented by the second-generation machines. Overall, results ranged from safe and effective use of UAL to high complication rates and questionable safety.

In July 1998 Topaz [24] published an article concerned with the long-term impact of UAL owing to hypothesized sonoluminescence, sonochemistry, and free-radical generation. To study the safety issues raised by this publication, ASERF organized a Safety Panel Meeting, held in St. Louis in November 1998, that included experts in biochemistry, ultrasonic surgery, and cavitation physics, and experienced UAL users. A number of research efforts and studies were launched and completed to address issues identified at the meeting and a summary report was produced by the Safety Panel coordinator [25]. Conclusions reached by the panel of experts record that (1) more needs to be known about the tissue interaction process, (2) hydrogen peroxide is the only reactive oxygen species potentially produced by UAL that is capable of inducing DNA damage, (3) hydrogen peroxide was not detectable following direct sonication of wetting solution with a UAL machine (100-nmol resolution), and (4) the authors must conclude that there is no significant risk of malignant transformation from H_2O_2 (or any other reactive oxygen species) produced during UAL [25].

In the late 1990s the Lysonix Company and the Mentor Corporation, the second-generation device manufacturers and distributors, became involved in litigation concerning patent infringement. The lawsuit lasted until late 2001, at which time the Mentor Corporation prevailed and received a judgment against Lysonix. As a direct consequence, the Lysonix Company was subsequently absorbed by the Mentor Corporation. During this litigation period, technologic advancement and continued development of the equipment and accessories was literally frozen, resulting in a complete lack of response to clinical and market needs.

As a consequence of the Topaz article, the Lysonix/Mentor litigation, the generally less-than-successful clinical success, and clearly visible feuding between the European progenitors of the UAL technique and the plastic surgery leadership in the USA, use of ultrasonic instrumentation for body contouring surgery began to fall into disfavor as a technique of choice for body contouring surgery. Analysis of this process showed that cost of the equipment, a long learning curve, manufacturer marketing without sufficient clinical and fundamental science, improper application techniques, larger incisions, longer surgical times, and conflicting results presented at major plastic surgery meetings resulted in confusion and disappointment in the surgical community worldwide.

A number of surgeons continued to use the ultrasonic instrumentation safely and effectively [26–29]. Their evolving technique allowed them to get effective results without the complications noted at the introduction of the technology. Further, use of the ultrasonic devices was safely expanded to the face and breast [30, 31].

In early 2001 a third generation of ultrasonic instrumentation for body contouring surgery became available. This technology was named VASER, for vibration amplification of sound energy at resonance. The VASER technology and associated technique (Sound Surgical Technologies, Lafayette, CO, USA), called VAL for VASER-assisted lipoplasty, was designed to minimize or eliminate known complications from earlier generations of UAL technology and to simultaneously realize the benefits of ultrasonic instrumentation as established in other surgical arenas. The guiding concept was to develop instrumentation that would emulsify fatty tissue quickly and safely with the absolute minimum amount of energy, thereby achieving the desired result with little or no residual trauma to the remaining tissues. VASER instrumentation introduced the concepts of pulsed delivery of ultrasonic energy, small-diameter solid probes (2.2–3.7 mm), and grooved probe designs to increase efficiency. Gentle emulsion cannulae for the aspiration phase were introduced to preserve the delicate structure of the tissue matrix after the emulsion process was completed.

In 1999 and 2001 Cimino [8, 32] published the first scientific studies that defined the amount of power delivered to the tissues by various ultrasonic surgical devices and clearly defined the variables under the control of the surgeon that determine safety and outcomes. This basic scientific information led to clearly understood relationships between "causes" and "effects" when using ultrasonic surgical instrumentation for body sculpting surgery. As a direct consequence, the suction aspect of ultrasonic instrumentation was eliminated (hollow ultrasonic cannulae) and replaced by solid probe designs, probe diameters were significantly reduced, efficiency was improved, and pulsed energy delivery was introduced, all of which significantly reduced the energy delivered to the patient. A pilot clinical study [33] on 77 patients using the VASER and the VAL technique (multicenter) showed zero complications and effective results.

32.3 Present and Future

At the time of this writing (early 2003) the use of ultrasonic energy for body sculpting surgery is in a transitional phase. Earlier first- and second-generation technologies are exiting the marketplace and newer third-generation technology/techniques is/are being investigated and slowly introduced to the surgical community. Further research and clinical investigation will determine whether or not continued advancements will result in technology and techniques that will present the patient and the surgeon with a more "fat-specific" method for lipoplasty that, in the end, produces safer and more desirable aesthetic outcomes.

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Ultrasound-Assisted Liposuction: Physical and Technical Principles

Alberto Di Giuseppe

33.1 Introduction

Ultrasound-assisted liposculpture has developed as a modification of liposuction for body contouring and fat reduction. The effect of sound waves in the subcutaneous tissues is to emulsify the adiposities and, at the same time, preserve the vessels and nerves.

The technique relies on the surgical use of ultrasonic energy, which allows the selective destruction or emulsification of adipose tissue producing a "cream" which is then aspirated. The procedure produces less edema and bruising than traditional liposuction and allows a great degree of skin retraction owing to "stimulation" of the dermis of the treated areas.

Clinical application of ultrasound-assisted liposculpturing is for lipodystrophy, secondary cases, difficult areas such as inner thigh, circumferential thigh, calf, and abdomen. There is little blood loss and a greater volume of fat tissue can be removed in one session. Ultrasound-assisted liposuction (UAL) can be used to treat obesity.

This method has been applied to surgery of the breast for volume reduction of the adipose components in the fatty breast (mostly in juvenile breast) and skin retraction after dermis stimulation for correction of minor degree ptosis. The main concept of this technique relies on the selective destruction of mainly the fluid fraction of the adipose tissue, which represents nearly 90% of all the adipose tissue's volume.

In contrast to traditional liposuction, which attacks and destroys mechanically all the structures of the dermis which may have undesired side effects, UAL selectively destroys only the target adiposities and spares the supporting structures of the skin and dermis, such as vessels, nerves, collagenic matrix, and elastic fibers, thus conserving the elasticity of the treated areas [1].

33.2 Physical principles

The standard acoustic spectrum comprises of a wide range, going from 1 Hz (infrasound), to 100 Hz (audible-sound), to 10–100 mHz (ultrasound), which is too high to be perceived by the human ear. This frequency spectrum has been utilized in industrial application and medical application. The audible sound range varies from 100 to 10,000 Hz and the medical application range varies from 105 to 107 Hz.

Ultrasound waves are the result of the transformation of normal electric energy into high-frequency energy (over 16 kHz). These waves are produced by high-power ultrasonic generators, which produce and transform the electric energy into ultrasonic energy. The energy from the generator is transmitted to a piezoelectric quartz crystal or ceramic transducer and then transformed into mechanical vibrations that are amplified and transmitted. Other medical applications of ultrasound are dental cleaning, phacoemulsification for cataract surgery, diagnostic imaging, kidney calculi fragmentation, and in neurosurgery.

33.3 Cavitation (Bubble Mechanism)

Cavitation can be defined as a peculiar activity induced by the application of ultrasound waves in a liquid or liquidlike material that contains bubbles or pockets of gas or vapor. The consequences could be the production of (1) stable or (2) transient cavitation. In order to allow the cavitation to occur, the following conditions must be met:

1. Must have dissolved fat in the tissue
2. Must have nucleation site at which microbubbles form
3. Density/viscosity of the medium must not be very high

Fatty tissues cavitate more easily than compact tissue and tumescent infiltration makes cavitation easier. There is an increase in the fragility of the target cell (adiposity) and the acoustic intensity must exceed a threshold to cause the bubbles to grow. As a consequence of the cavitation phenomenon, implosion of bubbles results in cell disruption and fat emulsification.

The formula to determine the cavitation number (*N*) is [2]:

$$N = \frac{PA + PH + PV}{(D/2) - V^2},$$

where PA is atmospheric pressure, PH is hydrostatic pressure, PV is vapor pressure, *D* is density, and *V* is volume.

The cavitation number expresses the cavitation mechanism. Cavitation is the consequence of an alternation of the peak compressional pressure and the peak rarefactional pressure, which alternate as a function of time (Fig. 33.1).

In order to produce this mechanism, a special titanium probe attached to the piezoelectric transducer is able to convert the ultrasonic energy into the tip of the probe with 100% of the energy translated into ultrasonic energy at the tip of the probe. The cycle of ultrasound waves is passed through the titanium probe and causes an alternation of circular waves with nodal points of energy concentrated along the probe and into its tip. All of the energy will be concentrated in a perfectly functioning and efficient system.

The amount of cavitation is not just a theoretical mathematical expression, but expresses clearly the efficiency of the system. The higher the number, the higher is the specificity of the system and the higher is the chance to target fat cells as sole recipients of the ultrasonic action

33.4 Instrumentation of UAL

The instrumentation of UAL is as follows:

1. Power console
2. Piezoelectric transducer
3. Titanium probes
4. Cannulas: 2–4 mm in diameter
5. Skin protector
6. Manual remodeling instrument

The piezoelectric transducer has two frequencies, serial and parallel, which are resonant and antiresonant frequencies. The equipment can be designed using either resonant or antiresonant frequency to deliver exactly the same output parameters without interfering with the equipment safety or efficiency.

The bubble mechanism (cavitation) causes the formation of bubbles of progressively increasing size in the fatty compartment. The alternation of positive and negative pressures, with an expansion and contraction at a frequency corresponding to the ultrasonic wave, leads to the progressive instability of the bubbles and microcavities already formed until their final explosion (Fig. 33.1). Expansion and compression, implosion and explosion, related to alternate cycles, are the phenomena causing cavitation which leads to the final destruction of the target cells, the adiposity.

The quick compression of gas inside a microcavity generates heat that causes an increase in temperature and creates a local "warn point." Even if the temperature can reach very high values, the cellular volume

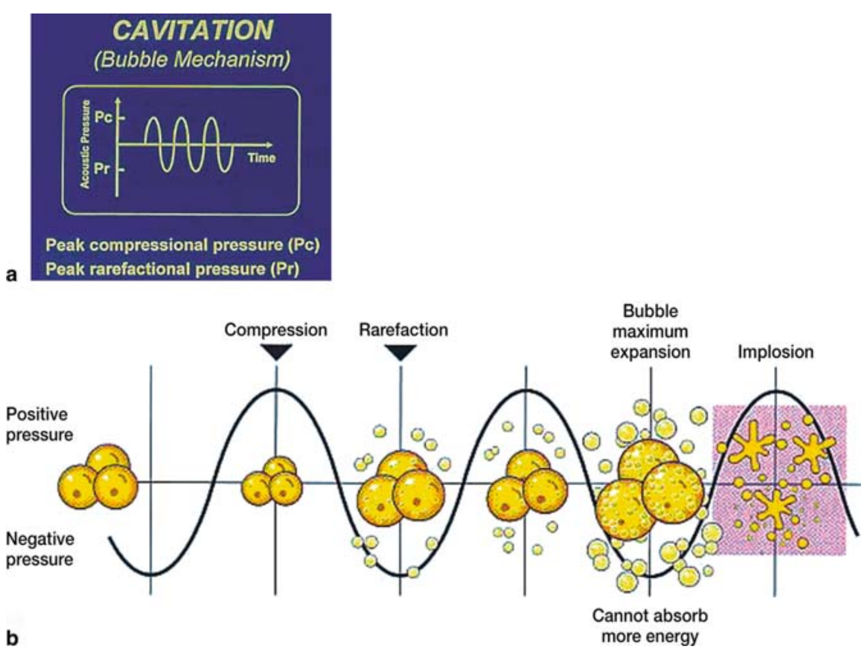

Fig. 33.1. Cavitation is the result of compression and rarefaction pressure

involved in this thermal phenomenon is so small that the heat generated is immediately dispersed toward surrounding structures where the temperature does not vary.

33.5 Effects of UAL

The effects of UAL on adipose tissue are:

1. Micromechanical effect: The consequence of damage produced by direct action of the ultrasonic waves and the organic intracellular molecules which are violently moved and displaced in the extracellular space with subsequent breaking up of macromolecules.
2. Cavitation effect: The cellular fragmentation from cavitation determines the diffusion of the lipid matrix (fatty acids) of the adiposity into the intercellular space where a stable emulsion with interstitial fluid and infiltration solution occurs. The formation of free radicals and the denaturization of the lipoproteinic components of the cellular membranes may lead to a progressive lipolytic action, which will partially continue even after the ultrasonic treatment has ended.
3. Thermal effect: A hyperemic secondary mild effect is associated with the friction action of the titanium probe moving through the tissues. These effects are restrained and negligible if the technique is properly applied. Thermal effects do not cause any damage to cells, structures, or fluids involved and do not cause any undesired biological reaction, especially at the protein chain level.

The use of ultrasonic energy is a wet and dynamic technique and should not be applied to dry tissue and if these two basic rules are followed, thermal injuries should not occur. If injury does happen it is related to improper utilization of the method. There should be adequate infiltration of the tissues before applying ultrasonic energy and the hand piece and probe must be moved constantly along the planned tunnels into the fatty compartment.

Mistakes due to lack of experience and proper training are:

1. Lack of uniform infiltration in the area to be treated
2. Poor infiltration (lack of tumescence)
3. Loss of tumescence over time during surgery
4. Energy applied without moving the probe

The author has verified experimentally that a burn occurs when there is continuous application of ultrasonic energy at a single point of the skin for more than 1 min. Superficial burns are probably due to lack of proper tumescence in the treated area.

33.6 Technique

UAL requires a longer period of learning compared with standard liposuction. The steps of the technique are:

1. Preoperative planning
2. Patient setup
3. Tumescent infiltration
4. Ultrasonic treatment
5. Emulsion suction
6. Manual remodeling
7. Postoperative care

33.7 Preoperative Evaluation and Planning

The clinical difference from traditional liposuction is that the fat is not removed immediately and continuously as the procedure proceeds and, therefore, does not have the visual view of the result as the surgery proceeds. It is important to preoperatively mark the areas to be treated, placing markings at the outer limits of the areas, and then topographic markings to indicate progressively thicker areas of fat to be liquefied and removed. These topographic markings demarcate areas that need greater or lesser amounts of ultrasonic energy applied. The usual preoperative evaluation of subcutaneous tissue thickness with the pinch test and the rolling test is helpful in determining where to place these markings.

Crisscross tunnels are also marked since these indicate the lines of ultrasonic energy application, which must be taken into account. In order to liquefy fat, the passage in a single tunnel is repeated at least seven to eight times with a gentle, slow motion.

When operating upon the trochanteric area, the Gasparotti point (G point) is marked in the natural infragluteal fold (Fig. 33.2). Areas where skin retraction is essential are marked so that a thickness of 5–10 mm will be obtained.

Plasma triglyceride levels should be monitored. Zocchi [3] reported a significant drop of triglycerides from 84.3 mg/ml preoperatively to 75.1 mg/ml postoperatively. These parameters were followed at 24 h, 1 week, and 1 month after surgery. Free fatty acids are eliminated progressively and this reduction continues for weeks after surgery.

33.8 Patient Setup

UAL is a longer procedure than liposuction. In order to decrease the surgeon's discomfort the author developed a new way of positioning the patient on the operating table. When treating the gluteal, trochanteric, circumferential thigh, knee, and calf, the patient is positioned face-down with a rolling plastic bar to support the abdominal area. The rolling bar is larger than the operating table and the table is positioned higher than the surgeon, who sits beside the table. The complete leg is sterilized and wrapped in order to accomplish movement during surgery. The leg can be lifted, moved forward and backward, moved laterally, or off the operating table, recreating the natural gravitational position as when standing. This helps evaluate body mass behavior before and after surgery in order to judge how the body fat distribution is changed by the procedure.

When the leg is dropped the surgeon evaluates the effect of gravity without the muscle tone activity. Under local anesthesia with full patient cooperation, this gravitational effect is immediate.

Catheterization is mandatory in the majority of the patients, where a large quantity of tumescent infiltration is utilized.

Fig. 33.2. Marking the infragluteal fold areas of fat thinning and areas of skin undermining and stimulation. Note, in dark blue sites of skin incisions

33.9 Tumescent Infiltration

Zocchi [3] modified Klein's formulation for standard liposuction. He realized a hypotonic solution would reduce the density of subcutaneous tissue and facilitate cavitation of the subcutaneous fat. The hypo-osmolarity of the solution weakens the lipocyte membrane, swells the cells, and aids the liquefaction process produced by the ultrasonic energy. The standard physiologic solution is diluted 50% with distilled water to obtain the hypotonic solution, which is injected with the Klein infiltration pump. The author prefers a pump manufactured by SMEI that has the advantage of recording the total amount of fluid effectively infiltrated, has a control of the speed of the infiltration (which is recorded on the monitor), and can be utilized as a peristaltic aspirating system for cleaning (Fig. 33.3).

The tumescent infiltration solution for ultrasonic liposculpturing was:

- Lidocaine: 500 mg (50 ml of 1% lidocaine solution)
- Epinephrine: 1 mg (1 ml of a 1:1,000 solution of epinephrine)
- Sodium bicarbonate: 12.5 mEq (12.5 ml of an 8.4% $NaHCO_3$ solution)
- Normal saline: 500 ml of a 0.9% NaCl solution
- Distilled water: 500 ml
- Chondroitin sulfatase: 1,000 turbidity reducing unit in 20 ml

This solution was utilized when performing UAL under local anesthesia and/or with intravenous sedation. When performed under general anesthesia, the quantity of lidocaine is reduced to 200 mg per liter of solution, which is enough to ensure postoperative analgesia. There are reports that advise that chondroitin sulfatase could increase the absorption of lidocaine, which would decrease the usual total dose of lidocaine utilized with the tumescent technique. Klein suggests that dexamethasone can be substituted for chondroitin sulfatase, which would reduce postoperative edema, help working in fibrotic areas, and

Fig. 33.3. Infiltration pump for the tumescent technique (from SMEI, Italy)

not affect the lidocaine absorption rate (J:A. Klein, personal communication, 1995. The author found no significant difference in utilizing distilled water instead of normal saline. The author utilizes the original Klein solution since there does not appear to be any significant difference in adding distilled water or chondroitin sulfatase.

The infiltration solution for local anesthesia is:

- Lidocaine: 500–1,000 mg. The concentration depends on fibrosis of the target areas.
- Epinephrine: 1 mg.
- Sodium bicarbonate: 12.5 mEq.
- Normal saline: 1,000 ml.

The infiltration solution for general anesthesia is:

- Lidocaine: 200 mg
- Epinephrine: 1 mg
- Normal saline: 1,000 ml

When performing procedures where more than 2,500–3,000 ml of infiltration may be used the patient should be catheterized at the time of surgery. Normally the tumescent solution will compensate for the loss of fluids with the UAL method; however, an intravenous line should be inserted. No more than 500–1,000 ml intravenous fluids is given for moderate fat removal (less than 5,000 ml). Intravenous sedation is sometimes administrated with Propofol (Diprivan), the dose depending on the patient's weight and the operation time. In major cases, when more than 5,000 ml of infiltration is performed, diuretics are routinely administered intravenously to avoid overloading the cardiac and renal systems. Continuous monitoring of the patient is accomplished during surgery.

O_2 saturation by a peripheral fingertip pulse oximeter, blood pressure, pulse, and breath frequency are monitored as well as urine output. Diuretics can improve the urine output during surgery depending upon the circumstances. The author prefers that the anesthesiologist handle fluid balance, monitoring, and analgesia.

33.10 Anesthetic Solution Used with the Tumescent Technique

Knize and Pepper [4] stated that tumescence is realized when a ratio of 1:1–1:1.5 is followed between the proposed total aspiration and the volume infiltrated. There is no need to infiltrate with anesthetic solution 2–3 times the amount of aspiration planned. The

Area	Volume range (ml)
Abdomen, upper and lower	800–2,000
Hip (flank or love handle), each side	200–800
Lateral thigh, each side	500–1,000
Anterior thigh, each side	500–1,000
Proximal medial thigh, each side	250–600
Knee, each side	200–500
Male breast, each side	400–800
Female breast, each side	500–800
Submental (chin)	100–200

epinephrine vasoconstrictive affect is not changed by infiltration of the tissue with excess solution. There is no further diminution in bleeding when an excessively large amount of tumescent solution is infiltrated.

33.11 Ultrasonic Treatment

After the tissues are infiltrated solid titanium probes are connected to the ultrasonic generator via a handle that contains the ceramic piezoelectric transducer and are introduced into the subcutaneous tissue through small incisions. The probe is moved through the tissues with a slow, regular manner in a crisscrossing pattern. In this way, the high-frequency vibrations are directly conveyed through the titanium probe to the tissue being treated.

In order to avoid friction injuries or burns to the site of entrance of the titanium probe, a plastic skin protector is utilized at all times. Solid titanium probes are preferable to stainless steel probes because the titanium conducts a significantly greater amount of energy and consequently results in better cavitation. Steel can create too much heat and can easily break.

The type of probe used depends on the body area being treated. For volume reduction and skin stimulation, a 35-cm probe with a diameter that ranges from 5.5 mm in the proximal portion to 4 mm in the distal portion is used. For treatment of the face and neck, a 21-cm long probe (3–4.4 mm in diameter) is utilized. A shorter 12-cm long probe (2.5–4 mm in diameter) is used for the breast and for surgical undermining. A solid probe has been found more efficacious than a hollow probe (Fig. 33.4). A hollow probe is not as strong and could break in the tissue as the result of the vibrations produced when the ultrasonic energy is applied (Sculpture, by SMEI, Italy).

Some ultrasonic devices are being sold that are hollow probes with holes on the side of the tip so that fat emulsion can be aspirated at the same time as the fat destruction. A double-circuit system allows the application of ultrasonic energy and immediate aspiration of the fat emulsion. This reduces the duration

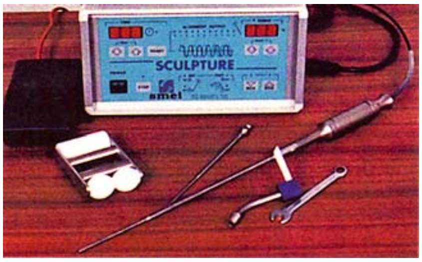

Fig. 33.4. Ultrasound generator with a piezoelectric transducer and solid titanium probes (Sculpture by SMEI, Italy)

of surgery. Standard UAL consists of fat destruction with ultrasonics and then aspiration with a low-power aspiration system (cleaning or aspiration phase of the technique). Placing holes on the side of the tip of the hollow titanium probe reduces the specificity and efficiency of the system.

The technique is less specific for fat destruction and for subcutaneous skin "stimulation" in order to allow skin retraction. The hollow cannula could be utilized in the deeper planes in order to speed up surgery, but there is risk when it is utilized in the superficial fat layer when skin retraction is required. Being less specific for fat tissue, the instrument can cause burns more easily. When atmospheric pressure is decreased during aspiration, cavitation is diminished, and thus the specificity and efficiency of the system purely for fat is decreased.

Scheflan and Tazi [5] tested several prototypes of ultrasonic machines, assessed them clinically, and observed endoscopically their effects in real time. Some of the machines were wholly ineffective, while others seemed promising but functioned inconsistently. They concluded that the ideal machine should have a 2–4-mm hollow cannula that emits effective, consistent, and controllable ultrasonic energy at the tip, does not heat up, and simultaneously aspirates. The rod should be Teflon-coated to reduce friction and should be malleable to improve "reach." The cannula ports should be small, well-rounded, and atraumatic and the pump should be designed to aspirate with low negative atmospheric pressure. Such a machine is technologically possible and will reduce the surgeon's fatigue, will save time in surgery, and will be more effective by increasing the volume that may be aspirated in one session and tightening the skin envelope.

33.12 Skin Retraction

The application of the ultrasonic probe must be in the subdermal area in order to induce postoperative skin retraction. The duration of the procedure and the amount of energy required to liquefy the excess fat vary with the character of the tissue, the volume of the planned reduction, and type of lipodystrophy. Hypertrophic lipodystrophy is easier to treat than mixed lipodystrophy or hyperplastic lipodystrophy. Less energy is required when the adiposity contains large volumes of fluid compared with tissues that are firm and the fat content and the ratio of tissue to fat are less. For instance, in the treatment of inner thighs, application of ultrasonic energy set at 65% power for 10–12 min is required to obtain a volumetric reduction of 250 ml and to give good skin "stimulation."

Clinical experience is helpful in establishing the time of application of the ultrasonic energy. The author applies up to 1 h of ultrasonic energy to defat the abdomen. The number and the location of access incisions also vary according to the treatment site. For the abdomen, usually, only a 2-cm suprapubic incision is required for good radial energy application. The addition of two 3-mm incisions in the upper lateral sides of the abdomen allows the removal of only the emulsion with a traditional small Teflon-covered cannula connected to a low-pressure (0.3 atm) vacuum. For the buttocks and lateral and posterior sides of the thighs, two 2-cm incisions located in the middle portion of the infragluteal fold on each side are utilized.

33.13 Aspiration-Cleaning

Removal of the fat emulsion with a low level of suction (not more than 0.2–0.3 bar) is performed with clear tubing in order to monitor the aspirate. When whole adiposity is observed in the aspirate, suctioning is immediately ceased. A 2- or 3-mm Teflon-coated cannula manipulated with very slow back-and-forth movements is utilized. Aspiration should not be performed concurrently with ultrasonic energy application. Suctioning reduces the volume of fluid that was added to enhance the cavitational effect and this would reduce the degree of cavitation and increase the amount of heat generated, producing significant side effects.

33.14 Manual Remodeling

After the liquefied subcutaneous fat is removed with suction, the residues of the lipocytes and the connective tissue containing autologous collagen remain in place. The area is manually remodeled utilizing a device (roller) developed for this purpose. This maneuver removes the residual fluid, modifies the shape of the tissues remaining at the treated site, and creates a regular, homogenous skin surface.

The total surgical time of a typical case of lipodystrophy in which trochanteric areas, inner thigh, and knees are treated varies from 2 to 2.5 h. A major case of total body remodeling, with major volume reduction (7,000 ml), can easily require 5–6 h of surgery. Despite the increased length of surgical time (40% more), ultrasonic liposculpturing broadens the indications for traditional liposuction.

33.15 Hematocrit

The final result of the application of ultrasound energy to the fat tissue compartment is the destruction of the adiposity and the creation of a fat emulsion represented by the liquid part of the fat fragmentation (as a result of the adiposity implosion) plus the fluid of the tumescent infiltration utilized preoperatively. This creamy emulsion is what characterizes the ultrasound technique in comparison with standard liposuction. The former is a gentle fragmentation of the adiposity with creation of a fatty emulsion that is then aspirated and the latter is a mechanical destruction of the fatty compartment with aspiration of the destroyed elements. The former is a selective destruction of the fatty cell, since UAL is able to target only tissue with low density and low molecular cohesion, as fat tissue. Vessels, nerves, elastic fibers, and connective tissue fibers of the subcutaneous structures are preserved. The latter is an unselective methodology, and is unable to target only the adiposity, while all the anatomical components are attacked and destroyed, such as vessels and elastic fibers. This explains why UAL is accomplished with low blood loss, and the hematocrit drop after surgery is considerably reduced. This is clearly shown in clinical experience.

Traditional suction-assisted lipectomy (SAL) removal of 150 ml of aspirate results in a 1% decrease in hematocrit. Lewis [6] using the syringe SAL, showed that a 1% hematocrit drop resulted from 300 ml of fat aspiration. With the introduction of Klein's tumescent technique [7], SAL in combination with tumescent infiltration leads to a 1% decrease in hematocrit with 450 ml of fat removal. Zocchi [8] reported high-volume fat removal with UAL combined with the tumescent technique resulted in a 1% drop in hematocrit and was related to 1,050 ml of aspiration. This is the reason why more fat can be removed without great blood loss using UAL.

In the author's experience, 6,000–8,000 ml of aspirate could be removed after at least the same amount of Klein modified solution infiltration without transfusion. Scheflan and Tazi [5] reported aspiration up to 20 l of emulsion using SAL using only one or two units of blood (autotransfusion).

33.16 Endoscopic Evaluation

Tazi and Scheflan [9] introduced endoscopic evaluation of ultrasound-assisted liposculpture. The author began using this method with a Stortz endoscopic system and camera. The tumescent technique was used in the inner thigh area and the abdomen. The instrument was placed in the superficial layer of the subcutaneous fat verified by needle depth. UAL was performed with crisscross tunnels, recording the technique by video.

An adjacent area was treated with standard liposuction. The results were:

1. Standard liposuction appears to be a more aggressive technique, with mechanical destruction of the subcutaneous tissue including vessels, nerves, and supporting structures.
2. Ultrasonic liposculpting is a gentler, selective method, which is aggressive only in the fatty compartment of the body, sparing vessels, nerves, and elastic supporting fibers. Alterations in the tissue resulting from the use of SAL are a thickened dermal undersurface, markedly thickened vertical collagenous fibers, intact lymphatic vessels, and intact blood vessels.

Scheflan and Tazi [5] hypothesized that it is this horizontal and vertical thickening and shortening of the collagen in the dermis and ligamentous fibers that is responsible for the remarkable skin tightening. The closer to the skin and the more complete the removal of fat from the immediate subdermal space, the greater the skin-tightening effect. Although infrequent, significant complications such as thermal burns and skin necrosis are possible.

33.17 Postoperative Care

Elastic compression of the treated areas is necessary for 4–8 weeks postoperatively in order to achieve a satisfactory long-term result. The author utilizes two pairs of high-compression pantyhoses worn over one another following the application of a soft elastic-compressive dressing (EPIFOAM by Biodermis, Las Vegas NV, USA) The compressive dressing is removed after 1 week.

Broad-spectrum antibiotics are administered routinely in the first 48 h postoperatively. In treating the abdomen or breast, suction drainage is utilized for 1–2 days. After a period of 1 week of relative rest, the patient is encouraged to increase activity. A period of lymphatic drainage with minimal compression twice a week for 4–8 weeks will help to decrease postoperative edema when the legs are treated. No massage is necessary since the area treated has minimal swelling and is soft. For local ecchymosis, Heparin cream can be used for 1 week.

Skin incisions utilized for UAL are large (2 cm at least) and sutures are removed in 7 days. More incisions are used during surgery in order to allow clearing of the treated areas. These incisions allow drainage of the infiltrated solution, which normally continues for the first 12–18 h postoperatively. The healing time following ultrasonic liposculpturing is longer than after traditional liposuction.

33.18 Clinical Experience

In the male patients, the areas treated were chin and neck, breast for gynecomastia, abdominal area, and hips. Some of the cases were combined with other surgical procedures.

In the female patients, knees, calves, and ankles could be treated together with breasts, abdomen, trochanteric areas, gluteal areas, thighs, flanks, arms, chin, neck, and dorsum. Many patients had combined surgery (with mammoplasty, rhytidectomy, and abdominoplasty.

Zocchi [10, 11] has used this technique to treat axillary hyperadenosis and hyperhidrosis, as well as for periosteal fat pads. It has also been used to remove large lipomas and cellulite. Scheflan and Tazi [5] have used the procedure for partial omentum ablation [12].

Illouz [13] and Pittman [14] have suggested utilization of liposuction in the breast to improve body contouring and to reduce volume. Lejour [15] presented a review of the principles and clinical application of standard liposuction to breast tissue. Initially, Lejour tried to suction the juvenile fatty breast as a temporizing measure until breast growth was complete and a more definitive operative procedure could be performed. Sometimes suction was combined with traditional open surgery, in order to better define the contour of the upper outer quadrant fat redundancies, or to defat the mammary lateral or medial triangles.

Large amounts of fat are found in patients with breast hypertrophy, even thin adolescents. Although the amount of fat in the breast increases with age, especially after menopause, fat in varying proportions can also be found in the breast of young patients. The amount of fat in the breast is variable as is its distribution. For this reason, not all women with large breasts are candidates for liposuction or UAL.

If fat is mixed with glandular tissue, it may be impossible to penetrate it with a blunt cannula and liposuction is not feasible. Preoperative mammography is necessary before considering the utilization of liposuction or UAL in the breast. Approximately 60–70% of patients with large breasts are candidates for liposuction or UAL alone or combined with open surgery. Fat can be suctioned or destroyed selectively with UAL from all parts of the breast with the exception of the retroareolar region, which is mostly glandular. Subcutaneous aspiration must be extensive in order to obtain the necessary skin retraction and the risk of localized skin necrosis may be increased. Subcutaneous skin stimulation with UAL is an effective measure to obtain skin retraction and for correction of mild ptosis.

Postoperative risk of fat necrosis or calcification is the reason why some surgeons avoid the use of suction lipectomy in the breast. Some calcification may develop in the breast after any mammoplasty procedure. The calcifications that occur after mammoplasty are rounder, more regular, and less numerous and should not be confused with those associated with cancer.

In the young fatty breast, the volume can be reduced and ptosis corrected. Aspiration of 600–800 ml of emulsion (after infiltration with the tumescent technique of the same amount of fluid) can result in a nice improvement of the breast contour and shape, together with elevation of 3–4 cm of the nipple, which is visible on the first postoperative day. The breasts are soft and natural. It could be used as a temporizing procedure to reduce breast volume and is completed in a second stage, with a periareolar breast mastopexy, avoiding the longer scar (vertical type or L-type) of a standard mammoplasty. Further clinical experience is necessary with this technique.

33.19 Complications

33.19.1 Skin Necrosis

Skin necrosis may result from thermal and/or vascular compromise (Fig. 33.5). The closer the surgeon works to the skin, the greater the risk of skin damage. With very loose skin, where skin retraction is required, the more “stimulation” applied, the better the tightening effect. After UAL treatment of the target area, the skin envelope must be free enough so that it can be plicated with the pinch test. The skin acts as a sort of “skin graft.”

The solid rod emitting ultrasonic energy liquefies wet fat but heats dry, dense tissues. For this reason, extreme caution must be exercised when working directly under the skin. Excessive friction or an overheated titanium rod may cause burns at the entry site

Fig. 33.5. Skin necrosis of the breast from thermal injury

or on the skin surface. A rigid skin protector at the incision site will prevent burns at the entry site.

33.19.2 Fat Fibrosis and Fat Necrosis

Fat fibrosis and necrosis are manifested as a sensitive induration in the subcutaneous tissues. The areas of fat fibrosis persist for a long period of time unless treated with pressure or intralesional steroids. These areas may cause skin hypersensitivity, pain, and discomfort.

33.19.3 Skin Pigmentation

Brown pigmentation of the skin is due to hemosiderin deposits or postinflammatory hyperpigmentation. Hyperpigmentation is long lasting and resistant to treatment, but will eventually fade. This is more frequent in fair, thin-skinned individuals, and is commonest on the upper inner thigh.

33.19.4 Sensory Alternations

Paresthesia and dysesthesia may be present after UAL. This could be due to the ultrasonic energy stripping the sensory nerves of their phospholipid envelope. This demyelinization may result in depolarization of fine cutaneous sensory nerves [5]. Hyperesthesia and dysesthesia have occasionally been reported after conventional liposuction, especially superficial liposuction, so it is possible that mechanical factors are also involved.

Manual lymphatic drainage massage or pressure garments are indicated when large areas of "pins and needles" are reported. Temporary neuropraxia of a branch of the mandibular branch of the facial nerve has been reported in a case of neck defatting and aggressive UAL skin stimulation for a neck lift [16, 17]. The neuropraxia resolved spontaneously in 3 weeks. Similar problems have been reported with standard liposuction of the neck and face.

33.20 UAL And Obesity

With the tumescent technique and UAL, the total amount of fat that can be aspirated in a single stage is increased (up to 21 l) [10]. The author limits the total amount of aspirate in a single stage to 10 l in order to avoid possible complications. The treatment of obese patients with UAL is combined with diet (Simmons gonadotropin diet). This regimen includes 40 days of treatment with low-dose human chorionic gonadotropin (125 units intramuscularly daily) and 500-cal daily diet [18]. The low amount of calories given is well tolerated because of induced depressive action of the appetite centers and fat mobilization from fatty deposits by gonadotropin. This double action leads to dramatic weight loss with little discomfort to the patient despite the low-calorie diet for a short period of time. Weight loss of 15–18 kg can be achieved without loss of strength or diminution in brain capability [19].

33.21 Conclusions

Ultrasound-assisted liposculpturing is a standardized method that has been utilized in Europe and South America for at least the past 5 years. In the author's clinical experience excellent results are achieved in cases of fat excess and base skin. UAL has a training curve, best gained by direct instruction from a surgeon fully versed in the procedure. The equipment is expensive and the technology is improving. The technique is a valuable adjunct to body-contouring surgery.

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VASER-Assisted Lipoplasty: Technology and Technique

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Disclosure

William W. Cimino is the Founder, Chairman, and Chief Scientist of Sound Surgical Technologies LLC. He has a financial interest in Sound Surgical Technologies LLC.

34.1 Introduction

Suction-assisted lipoplasty (SAL) is generally regarded as safe and effective with well-known and well-documented clinical results and potential complications. For this method of lipoplasty the fundamental mechanism of tissue removal is avulsion, i.e., the fatty tissue is pulled into a hollow suction cannula by vacuum and then avulsed or torn by the movement of the cannula. Results and potential complications are a direct function of the avulsive/cutting process.

VASER-assisted lipoplasty (VAL) presents a fundamental change in the treatment and subsequent removal of targeted fatty tissues. The fatty tissue is first selectively emulsified using ultrasonic frequency vibrations delivered on a metal probe and then the emulsified tissues are removed using a gentle, minimally avulsive aspiration process. The VASER system's high selectivity for fatty tissue results in decreased overall damage to the tissue matrix comprising fat cells, vessels, nerves, structural tissues, and lymphatic tissue. VAL uses ultrasonic frequency vibrations to emulsify the fatty component of the tissue matrix but in a fundamentally different manner than earlier versions of ultrasonic instrumentation for lipoplasty, namely, ultrasound-assisted lipoplasty (UAL). The primary differences are that the VASER system delivers significantly less power to the tissues while simultaneously increasing fragmentation/emulsion efficiency compared with UAL devices and eliminates the simultaneous aspiration feature of UAL devices [1, 2].

Ultrasonic energy was introduced to the plastic surgery community in the form of UAL in the late 1980s and early 1990s [3–8]. UAL technology was characterized by large-diameter (5-mm) ultrasonic cannulae, simultaneous aspiration and emulsion, continuous energy delivery, and sharp-edged elements at the cannulae ends, usually associated with the suction port holes. The UAL technique was characterized by generally longer application times than those of SAL owing to low-efficiency ultrasonic cannulae designs to create the emulsion and low-efficiency aspiration owing to the small (2-mm) suction lumens in the ultrasonic cannulae. While both excellent results [9–14] and complications [15–20] were reported, there was no clear understanding of the causes for the excellent results or the complications other than the unfortunate general assignment to "ultrasonic energy."

VASER technology uses ultrasonic frequency vibrations but delivers the energy to the tissues in a substantially different manner than UAL. In brief, VAL technology is characterized by small-diameter probes (2.2–3.7-mm diameter), *pulsed* delivery of the ultrasonic energy, and grooved probe designs that provide energy dissipation along the sides of the probes in addition to the front face of the probes. The VAL technique is characterized by procedure times similar to or shorter than typical SAL procedure times and incision sizes comparable to those of SAL. The amount of power delivered to the tissues and a method of measuring the efficiency of each probe design (including other ultrasonic devices) are summarized in the research published by Cimino [1].

34.2 VASER Technology

The technological advancements incorporated in VASER technology are designed to deliver the absolute minimum amount of vibratory energy to the tissues and still achieve the desired emulsification/fragmentation of the fatty component of the tissue matrix. These advancements include the use of small-diameter solid probes in the range 2.2–3.7 mm, grooved probe designs to increase efficiency, pulsed delivery of the vibratory energy to reduce the average energy delivered, gentle aspiration cannulae designs to reduce tissue avulsion while maintaining aspiration performance, and refined instrumentation design with regard to size and weight to provide more artistic use and movement.

The amount of energy delivered to the tissues by an ultrasonically vibrating probe is roughly proportional to the square of the diameter of the ultrasonic probe or cannulae, meaning that small reductions in diameter result in significant reductions in delivered energy. Therefore, the design objective is to utilize the smallest possible diameter probe that accomplishes the desired emulsification in reasonable time. Generally speaking, probes smaller than about 2 mm in diameter are too flexible to control (unless they are very short) and probes larger than about 4 mm in diameter present excessive amounts of energy to the tissues. The performance tradeoff is that these smaller-diameter probes have reduced contact area with the tissue and will therefore take longer to achieve the desired emulsification. To increase the efficiency of the emulsification process and to decrease the operative time, grooves have been added to the tips of the probes to provide additional emulsification zones as shown in Fig. 34.1. With this grooved design, tissue that contacts the sides of the probes will be emulsified in addition to the emulsification that occurs on the front surface of the probe, significantly increasing the emulsification efficiency and decreasing operative time.

Because the vibratory energy is dissipated from the sides of the probe as well as the front surface of the probe, the energy is less concentrated and results in a softer and more effective emulsion of the fatty tissue. The number of grooves determines the relative partitioning of the vibratory energy. Four identical 3.7-mm probes were evaluated having zero, one, two, and three grooves, as shown in Fig. 34.2.

For the 3.7-mm probes shown in Fig. 34.2 the partitioning, the power for an 80% setting, and efficiency (80%) characterizations are in Table 34.1.

The results show that increasing the number of grooves moves more energy to the sides of the probe. Note also that the overall power and efficiency also rise, meaning that the probes with more grooves are not only more efficient but are also able to contact more tissue. The applicability of the different probe designs to different types of tissue (soft to fibrous) is discussed in detail in the next section on the VAL technique. The reader is referred to Ref. [1] for a more detailed discussion of methods and meanings related to the power and efficiency calculations.

The VASER system can deliver the vibratory energy to the tissues in two different forms. The first is called continuous wave, a form where the vibration is "on" continuously at constant amplitude, commonly

Fig. 34.1. 3.7-, 2.9-, and 2.2-mm grooved VASER probes

Fig. 34.2. 3.7-mm VASER probes with zero, one, two, and three grooves

Table 34.1. Partitioning, H_2O power, and efficiency for four VASER probes

Probe	Percentage front	Percentage side	80% power (W)	Efficiency (μJ/mm^3)	applicable Tissue type
3.7-0	100	0	5.1	80	None
3.7-1	65	35	7.9	125	Fibrous
3.7-2	55	45	9.3	150	Moderate
3.7-3	42	58	12.1	195	Soft

used in previous-generation UAL devices. The second form is pulsed mode, a form where the vibratory energy is delivered in short-duration bursts, referred to as VASER mode. The advantage of VASER mode is that the peak energy is delivered in a short burst (the on condition) and is strong enough to emulsify fatty tissue while the average energy delivered over time is reduced compared with that for the continuous mode. VASER mode delivers around ten bursts per second to the tissues, fast enough so that VASER mode is generally imperceptible to the surgeon and fast enough so that the resultant on/off effect is uniform, smooth, and repeatable with regard to emulsification of the tissue. If the burst rate is less than about ten times per second then the on/off effect of the device begins to present a timing issue to the surgeon with regard to the forward and backward strokes of the device and also tends to produce less consistent results because of the physical spacing of the on periods in the tissue.

Emulsified fatty tissue is more easily removed with aspiration cannulae than non-emulsified fatty tissue; therefore, only gentle aspiration is required. A series of emulsion cannulae, called The VentX cannulae, were designed for efficient emulsion removal and minimal trauma to the tissue matrix. The cannulae design features are discussed in detail in the next section.

34.3 VAL Technique

The following guidelines cover safe and effective use and application of the VASER system for VAL including the infusion, emulsification, and aspiration phases. Probe selection for the various types of tissues (guideline 4) is discussed in detail following the 11 guidelines for infusion and emulsion. Aspiration is discussed after the section onprobe selection.

34.3.1 Infusion and Emulsification

1. Infusion. Use sufficient and appropriate amounts of wetting solution. Make sure that the wetting solution is uniformly and evenly distributed in the intended fragmentation volume. A gentle firmness and fullness in the targeted area is desirable. Allow sufficient time for vasoconstrictive requirements (usually at least 10 min minimum for 1:1,000,000 concentrations). Apply wetting solution slightly beyond the marked boundaries and in all potential port locations. If you cannot achieve a sufficient distribution of fluid then do not use the VASER system in that location. The targeted ratio of wetting solution in to total aspirate out is approximately 1.5:1. If more than a 2:1 ratio is used the VASER system begins to lose efficiency owing to the presence of excessive fluid. If less than a 1:1 ratio is used then there will not be enough fluid to easily form an emulsion.
2. Incision protection. Skin ports are designed to protect the incision edges during the fragmentation phase with minimal incision size (approximately 4-mm incision) and also protect the incision edges during the suction phase. The skin ports should go in easily, otherwise the incision is too small or the port is hooked on the underside of the dermis.
3. Skin protection. Use a towel (wet or dry) to cover the skin near the skin port. This protects the skin in the accidental situation where the probe is levered into any exposed skin near the skin port. This is especially important across the lower abdomen when working in the upper abdomen and near creases (buttocks). Note: A single towel layer will not protect the skin from prolonged contact with the vibrating probe or if the probe is levered strongly into the skin through the towel. If prolonged contact or strong levering is unavoidable, use a triple-folded towel to ensure skin protection.
4. Probe selection. Use the correct probe (see chart). Use initial settings as suggested in the chart. Adjust the setting so that the probe moves smoothly through the tissue. If the probe is dragging or struggling then all of the energy will be used to penetrate the tissue and very little emulsion will occur. In this case move the amplitude up a notch or two. If this does not solve the problem then switch to a probe designed for more fibrous tissues (see the chart).
5. Probe movement. Keep the probe moving at all times. Move it smoothly at a speed that the tissue and amplitude setting will allow without excessive pushing. Do not let the probe sit (vibrate) in one location. A speed just slightly slower than standard suction cannula movement is appropriate.
6. Torquing. Do not torque the probe! Move the probe in and out like spokes of a wheel, do not lever (torque) the probe sideways or up and down. The skin protector should not be used as a fulcrum! Torquing will lever the probe into the skin protector so that frictional rubbing can cause heat build-up in the skin protector.
7. Application time and surgical end points. Look for a “loss of resistance” to probe movement in all areas of the intended fragmentation volume as the primary indicator of the surgical end point. Initial application times can be based on 1 min of ultrasonic application (continuous or VASER mode) for every 200 ml of wetting solution infused at a site. This guideline usually results in only partial

emulsification of the target volume. With experience application times can rise to 1 min for every 100 ml of wetting solution. This guideline results in a more complete emulsification of the target volume. (These times are *only* suggestions; your requirements will be dictated by many factors that cannot be covered in this short space.) Special note: For the upper abdomen use 1 min of ultrasonic application for every 200 ml of wetting solution infused until experience allows otherwise.
8. End-hits. Prevent end-hits or punching into the dermis from below. Place incisions so that probe movement is generally parallel to the skin. Do not try to go around tight corners—this may result in potential an end-hit or torquing of the probe.
9. Cross-tunneling. Cross-tunneling is highly desirable for more uniform fragmentation and to improve the subsequent aspiration performance.
10. Free air vibration. Keep the tip of the probe inside the patient at all times. Do not vibrate the probes in free air or they may be subject to cracking.
11. Dry application. Do not reapply the VASER probe after a site has been aspirated (the site is dry).

34.3.2 Probe Selection

One of the most critical understandings necessary for successful VAL is the proper choice of the probe for the tissue type, tissue volume, and anatomical location. The key elements are (1) the diameter of the probe and (2) the number of grooves located at the tip of the probe. The smaller-diameter 2.9-mm probes all have three grooves for maximum efficiency and can be used on tissue from soft to fibrous because of their small diameter. The 3.7-mm probes may have one groove, two grooves, or three grooves and should be selected on the basis of the tissue type and intended application. Tissue type ranges from very soft to very fibrous in five grades as shown in Table 34.2. The probe design and appropriate amplitude settings for each tissue type are shown. Table 34.2 shows additional guidelines for the selection and use of the various probes.

1. Do not vibrate the probes in free air. Always keep the tip of the probe, at least the distal 1–2 cm, in contact with tissue or fluids and inside the patient and skin port, before initiating vibration. Vibrating the probes in free air can lead to cracking of the probe owing to unintended transverse vibrations.
2. The 3.7-mm probes are intended for rapid debulking and contouring of medium to large volumes of soft to fibrous tissue.
3. The 2.9-mm probes are intended for debulking and fine contouring of smaller volumes of soft to extremely fibrous tissue, for sensitive areas, and for more superficial work.
4. General volume considerations. If a single anatomical site is expected to yield less than about 500 ml then consider using the 2.9-mm probes. If the expected volume (single anatomical site) is estimated to be between 500 and 1,000 ml then consider using either the 2.9-mm probes or the 3.7-mm probes, depending on how fibrous the tissue is and the nature of the anatomical site. If the expected volume is over 1,000 ml (single anatomical site) then consider using the 3.7-mm probes.

For a given diameter, probes with more grooves (rings) fragment tissue more efficiently, but do not penetrate fibrous tissues as easily because a significant amount of the vibratory energy is coupled from the sides of the probe as opposed to the front surface. Therefore, for a given diameter, probes with fewer grooves (rings) are more appropriate for fibrous tissues. If the tissue is too fibrous for a selected 3.7-mm probe design, select a probe with fewer rings. For comparison purposes a three-ring 3.7-mm probe distributes approximately 58% of its energy from the sides and 42% from the front surface. A two-ring 3.7-mm probe distributes approximately 45% of its energy from the sides and 55% from the front surface. A one-ring 3.7-mm probe distributes approximately 35% of its energy from the sides and 65% from the front surface.

Table 34.2. Tissue type, VASER probe selection, mode, and amplitude setting

Tissue type	Continuous mode?	VASER mode?	2.9 mm, 3-groove (any length)	3.7 mm, 3-groove (any length)	3.7 mm, 2-groove (any length)	3.7 mm, 1-groove (any length)
Very soft	Yes	Yes	60–80	70–80	70–80	–
Soft	Yes	Yes	60–80	70–90	70–90	70–80
Medium	Yes	Yes	70–90	80–90	80–90	70–90
Fibrous	Yes	2.9 mm only	80–90	–	80–90	80–90
Very fibrous	Yes	No	80–90	–	–	80–90

Smaller-diameter probes will penetrate fibrous tissues more easily than larger diameter probes, irrespective of the number if rings. The 2.9-mm diameter probes all have three rings because their smaller diameter allows penetration of even the most fibrous tissues with three rings.

General recommendations: Use the 3.7-mm two-groove probes for most applications, 70–90% amplitude. Use the 3.7-mm three-groove probes for larger volumes of very soft tissue (70–90% amplitude) or the 3.7-mm one-groove probes for more fibrous tissues (70–90% amplitude). Use the 2.9-mm three-groove probes for smaller volumes, sensitive areas, fine contouring, or very fibrous tissues (60–80% amplitude). Ninety percent amplitude may be used with any 2.9 or 3.7-mm probe, but consider selecting a probe more appropriate for the "fibrousness" of the tissue if 90% amplitude is required for smooth, gliding motion. Use continuous mode for general use, if tissues are quite fibrous, or for higher-speed fragmentation. Use VASER mode for more delicate work, softer tissues, or for finer sculpting. VASER mode may be used for general use when probe selection is appropriate.

34.3.3 Aspiration

Once a fatty area has been emulsified the next step is to remove the emulsified tissues and fluids using aspiration. In theory and in practice almost any type of aspiration cannula will suffice. However, aggressive suction of an area treated with the VASER system is generally not required and will result in excessive trauma to the tissue matrix. Once appropriately treated with the VASER system the fatty tissue is largely in fluid form and does not require high-vacuum aggressive avulsion for removal. A gentle aspiration is sufficient and expedient and will result in decreased trauma to the tissue matrix. For this purpose gentle aspiration cannulae, called Vent cannulae, were developed to complement the emulsification of the VASER system. VentX cannulae employ smaller port sizes for a selected cannula diameter than more traditional cannula and are less traumatic than traditional cannulae. The largely fluid emulsified tissues are removed, while the tissue matrix is maintained.

The port size (slot width and length) and the cannula diameter determine the application of the cannula, the speed of the cannula, and the aggressiveness of the cannula. The VentX cannulae use port sizes that maximize tissue and fluid removal speed while reducing suction trauma by balancing the total area of the ports with the cross-sectional area of the cannula. Port sizes with areas larger than the cross-sectional area of the cannula lumen, as in most traditional cannula designs, are unnecessarily traumatic.

The recommended approach to the selection of a VentX cannula is to use a diameter one size larger than you would normally use because the port sizes on the VentX cannulae are smaller than those found on traditional suction cannulae. The cannulae descriptions that follow should help with cannula selection.

The 4.6-mm SST-6 pattern is designed for rapid emulsion removal and debulking with small ports for reduced suction trauma. The port size on this cannula is slightly smaller than the port size on a traditional 3.7-mm Mercedes cannula.

The 3.7-mm SST-6 pattern is designed for general debulking and shaping with less suction trauma than a standard 3.7-mm Mercedes cannula. The port size on this cannula is slightly smaller than the port size on a traditional 3.0-mm Mercedes cannula.

The 3.0-mm SST-6 pattern is designed for finishing and feathering, or slightly slower but less-traumatic debulking. The port size on this cannula is slightly smaller than the port size on a traditional 2.4-mm Mercedes cannula.

In addition to smaller port sizes, these cannulae also include a precision continuously vented handle that creates a means by which the suction tube is continuously cleared during the aspiration process. This continuous venting has been named the VentX effect and decreases the available vacuum at the cannula by approximately 0.25–0.50 in. Hg. The VentX effect significantly increases the efficiency of aspiration when large amounts of fluid/tissue are in the suction tube. The suction tube will always appear to be empty because the VentX effect continually and rapidly empties the suction tube even when the cannula remains inserted in the patient. The VentX effect does not have a strong impact on suction performance during the final feathering and finishing steps because very little tissue/fluid is in the suction tube.

34.4 Summary

VASER technology is the third generation of ultrasonic instrumentation for lipoplasty. The VAL technique combines the VASER technological refinements in energy delivery and instrumentation with improved clinical techniques to produce a fundamentally different method of fatty tissue manipulation. The objective of this effort has always been to minimize tissue matrix trauma while obtaining the desired clinical outcome with maximum safety and effectiveness. Future works include the application of the VASER system and associated techniques to the face and neck and other areas.

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Ultrasound-Assisted Lipoplasty for Face Contouring with VASER

Alberto Di Giuseppe

35.1 Introduction

In the last 11 years (1992–2003) the author has been deeply involved with ultrasound-assisted lipoplasty, initially utilizing the Smei solid-probe device for the emulsification in body contouring. From 1995 to 2003 the same tool was applied in breast reduction and mastopexy, by emulsifying the fatty component of the female breast, similarly to what is done in male gynecomastia, where even the glandular component can be progressively destroyed [1, 2].

A greater amount of skin retraction was achieved with ultrasound-assisted liposuction (UAL) with a solid probe, especially in difficult patients (loose skin, abdominal flaccidity), than with suction-assisted liposuction (SAL) as indicated by Scheflan [3].

There is substantial literature analyzing the phenomenon of skin retraction, which always follows superficial liposculpture, even by standard small cannulas [4, 5] or by ultrasonic energy delivered by a solid titanium probe.

35.2 Old and New Technology

Most of the authors [6, 7, 8] agreed on the evidence of more substantial skin retraction (following fat aspiration or emulsification) when accomplished by a superficial undermining of the skin (as with blunt small cannulas or with a small solid titanium probe), but many warned against the potential complications of the technique (skin irregularities, dumping, holes, skin necrosis, skin burn) [9, 10]. The main concerns were due to three factors:

1. The more superficial the technique becomes, the more important the skill capabilities of the surgeons, their sense of artistry, and their attitude to a three-dimensional view of the body are. So personal experience and skillfulness is a priority.
2. The instrumentation for performing the technique well is really important. For superficial liposculpturing [11] small-diameter blunt cannulas (1.8–2.7 mm) are expressly utilized, with low-powered or even no suction at the same time. More than a superficial aspiration, it is a wide undermining of the loose skin that is realized, with several passages with the small blunt cannulas in a widespread direction.
3. The instrumentations for ultrasound-assisted lipoplasty were even a major problem in the past. All the major manufacturers (Mentor HS, with Contour Genesis/McGhan-Inamed with Lysonics 2000) developed power tools as well, with low efficiency.

Cimino [12] analyzed all the UAL tools on the US market, including Smei (Italy), evaluating the power, the setting, the energy, and the efficiency in terms of fat emulsification capability for each single probe (solid or hallow cannula) and arrived at the conclusion that all of them were delivering too much energy for the target they were pursuing (fat emulsification). All the energy that was not necessary for emulsification turned out to be thermal energy, potentially dangerous and the cause of sequelae and complications (seroma, burns, skin necrosis). The design of the probes and cannulas was another great matter of concern.

The probes were too large (the Lysonics hollow probe was 5.1 mm, the Contour Genesis probe was 5.1 mm, and the Smei Sculpture probe was 4.7 mm) and were only available in a straight fashion (no curved solid probe were even thought to be achievable), with poor efficiency by delivering energy only on the tip of the probe surface. With those poor instruments, it was really difficult to perform a superficial undermining of the loose skin, similar to what is done with superficial liposculpture utilizing really small diameter cannulas.

The lack of good technology available on the market, despite very high prices, the poor research by the main manufacturers in new, more efficient instrumentations, determined a progressive reluctance by many surgeons to even consider UAL for body contouring and especially superficial liposculpturing.

In January 2002 the author started utilizing (the first device in Europe) the new VASER UAL tool by Sound Surgical (Denver, CO, USA). The new tool was immediately shown to have great technological advantages in comparison with previous devices:

- Less energy delivered
- High efficiency
- New shape, design, and fashion of the solid titanium probe (even a curved probe)
- New size and diameter of the probes (2.2–3.7 mm)
- Continuous and even pulsed rate of administration of ultrasound energy
- Built-in aspirating system with high efficiency
- Built-in infiltrating system

The high efficiency of the new device, the new small size probe, and the possibility of delivering energy even at a pulsed rate (thus decreasing by 50% the total energy administered locally) allow the device to work efficaciously and safely in a subdermal plane, thus allowing undermining of the superficial skin envelope for higher skin retraction (similar to what is done with superficial liposculpturing with blunt small cannulas).

This new technology has been successfully applied all over the body in the last 2 years, in more than 250 clinical cases of contouring with no complications. Similar results have been reported by Jewell and Souza Pinto [11].

Seroma, burns, and skin necrosis are no longer a worry with the last technological upgraded VASER for UAL body contouring.

35.3 Skin Retraction: the Theory and Basic Science

For better understanding the phenomenon of skin retraction, it is necessary to review the physical properties of skin [13]. The physical properties of skin include:

- Viscoelastic properties of skin
- Skin tension properties
- Skin extensibility
- Directional variations in skin properties

35.3.1 Viscoelastic Properties

Creep and stress relaxation are basically the two viscoelastic properties. Creep occurs when a piece of skin is stretched and the stretching force is kept constant and the skin continues to extend, depending of course on the force involved.

Stress relaxation occurs when a piece of skin is stretched for a given distance and that distance is held constant: the force required to keep it stretched gradually decreases (Fig. 35.1).

35.3.2 Skin Tension Properties

The naturally occurring extensibility and tension in skin are often confused and referred to inaccurately as “elasticity.” Skin tension is of particular importance in wound healing. The tension naturally present in skin is presumably a function of the elastic fiber network existing in a state of tension: collagen fibers have no power of retraction.

35.3.3 Skin Extensibility

Skin extensibility is greatest in infancy. As skin is repeatedly stretched and relaxed throughout life, the ability of the elastic matrix to return skin from its extended state to its fully relaxed state is gradually lost, and skin extensibility is replaced by skin laxity.

35.3.4 Direction Variations in Skin Properties

Skin tension lines were studied by Langer, an anatomist in Vienna, who lived from 1819 to 1884. With his studies on fresh cadavers, he described the so-called Langer’s lines, which are (1) cleavage lines, (2) tension lines, (3) retraction lines, and (4) minimal extendibility lines.

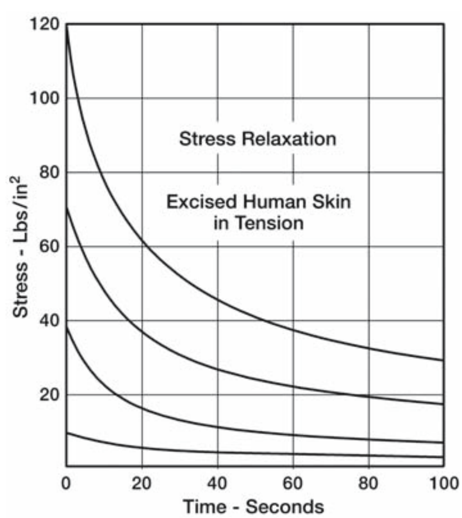

Fig. 35.1. Stress relaxation. (From Gibson and Kenedi [14])

35.3.5 Skin Anatomy

The dermis consists of two layers: a superficial or papillary layer and a deep or reticular layer. The reticular layer is formed by dense coarser collagenous fibers arranged in layers mostly parallel to the surface of facial skin. Elastic tissue is distributed throughout the dermis. Connective tissue cells are sparsely distributed among the fibers. Fibroblasts are often associated with most cells.

35.3.6 Skin Thickness

Skin varies widely in thickness from region to region, and with age [15]. The dermis thickens gradually until the fourth or fifth decade, and after this the skin thins again.

35.3.7 Contraction

Contractible fibroblasts, called myofibroblasts, contract open wounds. Skin grafting can affect this process, depending on the type of graft. Surgeons often speak of skin-graft contraction, but in fact what is seen is a combination of graft and wound contraction. In a similar wound, full-thickness grafts contract minimally, while split-thickness grafts contract significantly.

Exceptionally, in thin split-thickness grafts, the dermal component of grafted skin appears to exert the main influence on wound (secondary) contraction [16]. The main factor is how much of the deep dermis is present.

Clinical prevention of graft contraction therefore means using full-thickness grafts whenever possible, as the inhibitory effect of the full-thickness skin graft upon a contracting wound seems to be due to the inclusion of the full thickness of the deep dermis and appears to work via suppression of the myofibroblast population. Transferring a vascularized flap prevents retraction and secondary contraction of the skin.

35.3.8 Loose Skin

Particularly in loose, relaxed skin (the phenomenon is extensible all over the body), the thinner a flap, the higher the retraction achievable.

In theory and in clinical experience with lipoplasty, if we succeed in thinning the superficial layer of subcutaneous fat as much as possible, we would achieve a greater degree of wound contraction, and thus retraction of the overlying tissue. This is the fundamental for utilizing VASER UAL in soft-tissue recontouring, particularly in the face.

The highest skin retraction is achieved without an open surgical approach with skin removal and fewer scars are produced to obtain a stretched skin effect. In clinical practice, in the last 2 years, 68 patients have been treated with VASER UAL for facial contouring. There were substantially two clinical indications:

1. Heavy face or neck
2. Loose facial skin

In both cases, the aim was to establish a technique which could optimize skin retraction by action of internal VASER ultrasound energy applied with a small-caliber (2.2-mm) solid titanium probe, thus eliminating the need for extended visible incisions and thus scars.

In the heavy face, the level of action of ultrasound energy is applied to the real consistency of the excess subcutaneous tissue. The setting of the UAL device is at 30% of the total power. The mode of action for administrating ultrasound energy is the classic multidirectional fashion. The technique is not a substitute for a facelift or other aesthetic surgery procedures, which implies an open approach and does not pretend to achieve the same kind of result. There is no effect on muscle relaxation and the tightening effect relies only on skin retraction and redraping. But the technique can easily be combined with other procedures (such as blepharoplasty, temporal lift, skin resurfacing, and endoscopic brow lift). It is an office procedure which requires, if not combined with other techniques, no more than 60 min, producing (but with no external visible scars) results which are similar to a subcutaneous facelift).

35.4 Technique

Surgical steps include:

1. Preoperative plan and markings
2. Anesthesia: Klein's modified formula, intravenous sedation
3. Site of incisions
4. Ultrasound energy delivery
5. Aspiration (if required)
6. Dressing
7. Postoperative care

35.4.1 Preoperative Plan and Markings

There are substantially two clinical indications:

1. Heavy face or neck
2. Loose relaxed facial skin

In the heavy face and neck, the area of fat redundancy and the site of skin incisions are marked (Fig. 35.2).

In loose facial skin, the lines of retraction and tension lines (Langer) are marked.

When combined with other surgeries planned at the same time, further specific drawings are added depending on the surgery planned.

35.4.2 Analgesia–Anesthesia

Analgesia is provided by Klein's [17] modified formula, expressly designed for face and neck. This contains a higher percentage of lidocaine and adrenaline, owing to the higher sensibility and innervation of face territory in comparison with fat tissue. The modified Klein formula is:

- Ringer's lactate: 1,000 ml
- Lidocaine: 1–1.5 g
- Adrenaline: 1–15 mg

Normally, between 350 and 500 ml of solution is necessary to fully anesthetize the entire face and neck, bilaterally, including the forehead.

Infiltration in undertaken with the Klein blunt needle in a subcutaneous pattern and a crisscross fashion. In face and neck, tumescent status is easily reached, thanks to the high distension and adhesion of tissues, with less than 100 ml for the midface. The author's anesthesiologist combines the pure local analgesia with a light intravenous sedation (300 mg Diprivan in a bolus when starting infiltration). Alternatively, the anesthesiologist can consider preoperative sedation.

Postoperative long-term analgesia is secured by Klein's very diluted solution. For infiltration the same incisions are used that will be required for the access to probes for VASER ultrasound delivery.

Retro-tragal, temporal, subdermal, latero-cervical, vertex, or mid forehead incisions are the alternative sites for access of blunt infiltration needed.

Infiltration should be done slowly, as typical of the Klein solution, superficially, to avoid major important structures of the face and neck. No more than 10 min is needed before starting the procedure and waiting for full effect of lidocaine and adrenaline in the face, which is much more vascularized than fat located elsewhere in the body. It is wise to infiltrate only one side and wait until the analgesia is completed, then start working at that site. In fact, tumescence of the face is a very temporary status and it is impossible to infiltrate the entire face at the beginning, as the tumescence will be lost where reaching the contralateral side, having treated the initial site. A precision fluid management system can make infiltration accurate to ±1 ml for any volume, eliminating fluid tracking errors.

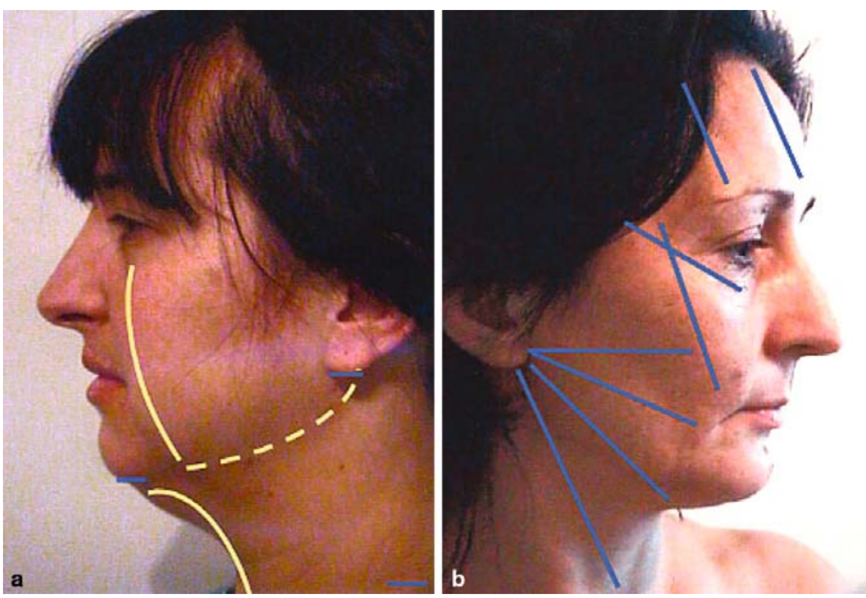

Fig 35.2. a Heavy face. *Markings* lines of heaviness. **b** *Markings* lines of subcutaneous underlining

35.4.3 Site of Incisions

For infiltration, the author likes to use the same incisions that are required for the access of the probes for delivering the VASER ultrasound energy (Fig. 35.3). Retro-tragal, temporal, submental, latero-cervical, vertex, and mid forehead incisions are chosen, depending on the areas requiring ultrasound energy. The incision sites do not need to be protected by a skin port (skin protector) as used in other body areas. The ultrasound energy setting is lowered to 30% of the total power of the device, by using the 2.2-mm probes. Reducing the caliber of the probe reduces the ultrasound energy delivered, and reducing the power even further decreases the total amount of energy.

35.4.4 Ultrasound Energy

When the area is fully anesthetized, and tumescence achieved, the incisions at the retro-tragal site or the submental site are started first. The skin incision is carefully widened with the puncture instrument, which allows the tip of the probe to enter the subcutaneous tissue. Then, with the power set at 30%, the fine 2.2-mm probe (long and short with one or two grooves) is gently passed into the subcutaneous tissue of the face and neck in the attempt to gently "undermine" all the area, working in the traditional crisscross fashion. The skin close to the incision is protected from friction injuries with a wet gauze. The titanium probe is slowly advanced to free completely the adhesions of the underlying subcutaneous tissue from the skin-dermal layers. For wider and faster emulsification or undermining, the 2.9-mm probe is often utilized (one or two grooves).

When the target is just to free and stimulate the retraction of the skin, as in loose facial skin, the operation ends when the undermining is completed. When the target is to decrease the bulk of certain areas (such as cheeks, or submental, or lateral mandibular areas), the probe should be addressed in the target areas and planes, and left in place for a longer period, just to allow emulsification of the fat tissue present.

The VASER probes are very efficient in shape and design, as they present one or two grooves laterally to the tip, which increases the surface of emulsification, once only restricted to the tip.

The number of the grooves is inversely proportional to the type of tissue present. A one-groove probe is preferred for more fibrotic fat, whereas a three-groove probe is preferred for loose fat (Fig. 35.4).

The technique is fast with the probe easily advancing while undermining the subcutaneous tissue of the target areas. In a full-face contouring, the author normally starts with the forehead, which is addressed with two incisions, one at the vertex (median forehead) and the other at the temple after good tumescence. This is achieved with 80–100 ml of solution. The undermining is obtained in a subcutaneous plane, respecting frontal and superficial temporal fascia. The probe gently undermines tissue to the glabella and the radix of the nose. The infraorbital and supraorbital nerves are localized in a deeper plane and are not encountered by the probe during the undermining phase. In the temporal region, care must be taken to avoid the frontal branch of the facial nerve. This is the main issue in all facelifts with the superficial musculoaponeurotic system (SMAS) technique.

However, if the the action of ultrasound energy into the subcutaneous tissue is limited with a small amount of energy delivered together with a probe with a very efficient cavitation, the secondary potential side effects to the underlining myelin sheet of the facial nerve branches are not present.

The extension of undermining is limited to the nasolabial fold and to the periorbital inferior orbital rim. Laterally, the author never passes through the lateral margin of the orbit. The full extension of the

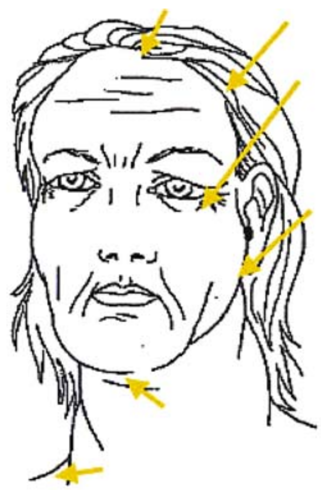

Fig. 35.3. Sites of incisions

Fig 35.4. One-, two-, and three-groove probes

mandible and submental and neck regions can be approached (through an incision placed behind the ear and under the chin).

Ultrasound energy delivery ceases when the undermining is completed. Normally, 2-3 min is necessary to undermine the entire forehead, 4–5 min for cheek and temporal areas, and 3–4 min for neck submental areas. The total time (bilateral approach) is no more than 20 min in a full-face treatment.

No suction is required at the end of treatment. The remaining infiltrated solution is partially absorbed by the subcutaneous deeper tissue. Part will flow out from the access incisions and from two stab incisions that are always placed at the end of surgery in the most declivitous area treated (usually, at the lateral sides of the neck). The incision lines can be left open or just approximated with 6/0 nylon.

35.4.5 Dressing

An elastic garment support (Fig. 35.5) is always used and is left in place for a minimum of 3–5 days and for 2–3 weeks overnight. Head elevation and ice pads are often indicated to minimize bruising, ecchymoses, and edema.

Heparin cream or homeopathic Arnica cream is advised twice a day until facial bruising passes over. In the case of prolonged postoperative fibrosis, a silicon foam adhering sheet is applied mostly to the chin area (overnight) in order to soften tissues. Another option is to start with early Endermologie massage (10 days after surgery) in order to decrease edema and long-lasting tissue hardness.

Fig 35.5. Face-supporting garment

35.5 Results

The differences between the two devices used are related to the software of the ultrasound device, the shape, design, and caliber of the probes (both solid), which makes VASER more efficient, very safe, and reliable.

The technique was applied to

1. Heavy face
2. Loose facial skin as a sole procedure, or combined with other facial techniques such as blepharoplasty, malar lift, temporal lift, endoscopic brow lift, chin prosthesis placement, and autologous fat graft (Coleman technique). The technique is very versatile, minimally traumatizing, results in little bruising and little postoperative edema, has easy recovery, and is (mostly) very safe.

UAL VASER was utilized subcutaneously to undermine facial skin and enhance retraction for contouring for loose facial skin. In heavy faces (fat neck and chin, mandible, and cheek areas), the technique was utilized to debulk excess tissue, recontouring the face (Fig. 35.6). VASER was combined with other techniques such as blepharoplasty, temporal lift, endoscopic brow lift, malar lift, and chin implant (Fig. 35.7). Once the UAL probe has stimulated the retraction of soft tissue of the face, a fat graft can be positioned to enhance results in cases of facial atrophy or lack of volume. Facial skin resurfacing (with an erbium laser) can be combined in a gentle way to smooth the skin surface.

VASER was shown to be a more versatile, gentle, smooth technique, owing to the new probes, particularly efficient, and the software of the ultrasound device, which delivers half the energy of the older machines on the market (Contour and Lysonics).

35.6 Complications

Type	Number
Seroma	0
Skin necrosis	0
Burn	0
Facial nerve palsy	0
Alopecia of the temporal line	1
Redo cases with open surgery	5
Contour irregularities	3

The complication rate was very low:

- Five cases of redo (patients unhappy about the results of the UAL face contouring, who required a more extensive open surgery approach)
- No case of facial nerve paralysis, even temporary was noted
- Skin necrosis and burns were absent
- No hematoma was noticed
- Contour irregularities (three) were treated with another UAL superficial VASER

35.7 Conclusions

The application of a superficial ultrasonic solid probe to the face is a safe and reliable technique in selected cases. The new technology (VASER) was highly efficient and very precise, with small solid probes, which allows a fine contouring of bulky areas, and helps redraping loose facial skin to the underlying structures. The results are similar to those obtained with a traditional open subcutaneous lift, but with virtually

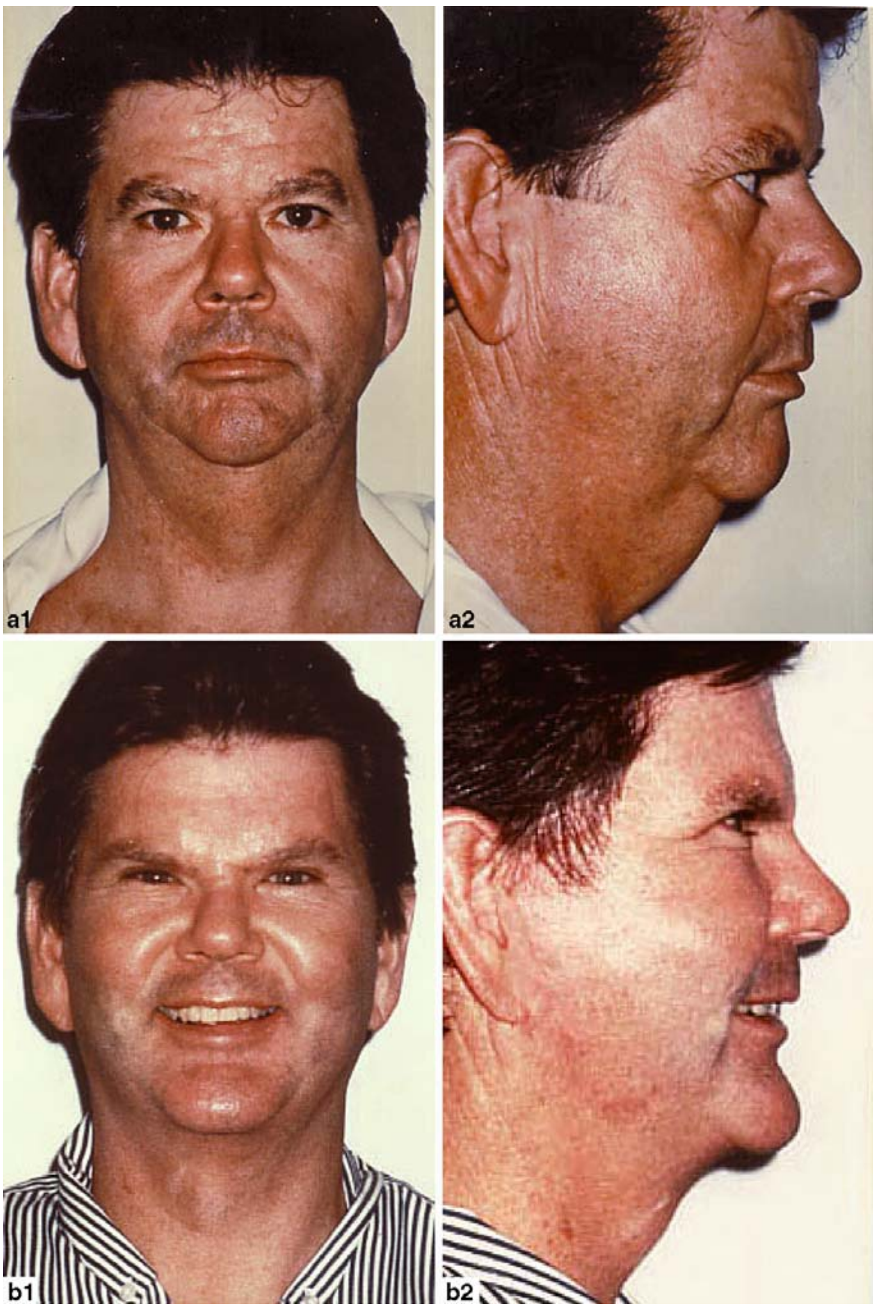

Fig 35.6. **a** A53-year-old patient with heavy face and neck. **b** Two years postoperatively following VASER to debulk cheeks, mandible area, and neck

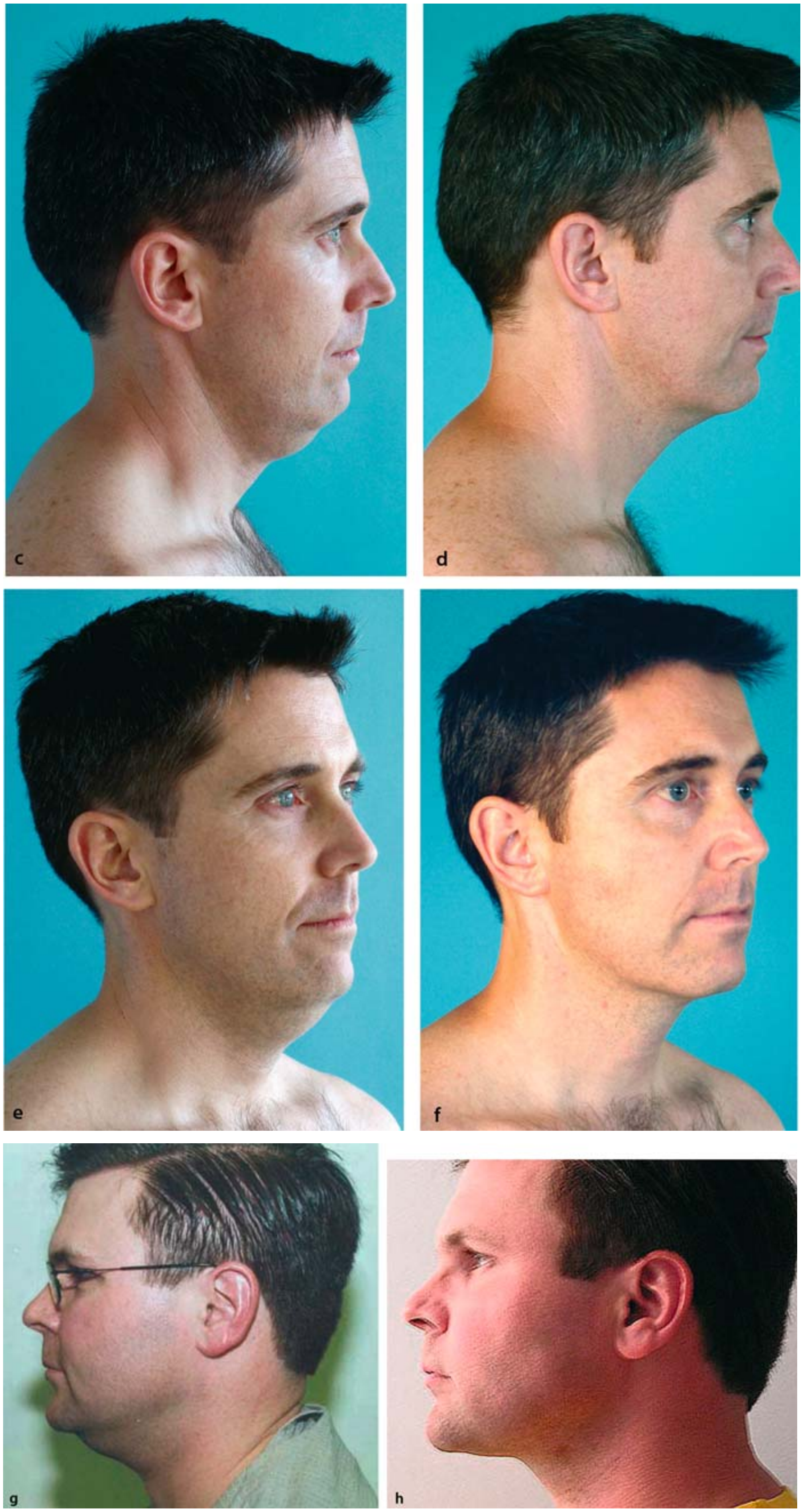

Fig 35.6. c,e Preoperative. **d, f** Postoperative after Vaser Ultrasound 2,2 ml remodelling of the lower third of the face and neck. **g** Preoperative. **h** Postoperative after Vaser Ultrasound 2,2 ml remodelling of the lower third of the face and neck.

Fig. 35.7. VASER plus chin implant. **a** A 25-year-old patient with heavy cheek, face, and chin hypoplasia. **b** Postoperatively after VASER to the cheek and orbital region for debulking. Cheek implant through a vestibular approach

no scars, minimal surgical trauma, and quick recovery.

Selection of patients is the key for success. Expectations of patients for results should be carefully explored with limits of the technique being explained and fully understood to avoid misunderstanding. Under those circumstances, patients are happy with this minimally traumatizing technique, which fits the actual expectations of cosmetic surgery marketing: natural results with a minimally invasive method.

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36 Mastopexy (Breast Lift) with Ultrasound-Assisted Liposuction

Alberto Di Giuseppe

36.1 Introduction

The possibility of lifting the breast mould to an upper position relies on two factors in breast ultrasound-assisted liposuction (UAL) surgery:

1. The upward rotation of the breast, when the lower quadrants of the mammary cones are thinned and diminished in volume by fatty emulsification
2. The subdermal skin stimulation of the entire breast (during the initial phase of breast undermining), which contributes to enhance the tissue retraction, to accommodate the new "brassiere" of the elevated breast

36.2 Upward Rotation of the Breast

By decreasing the weight of the breast and by gently elevating the gland, the nipple-areola complex (NAC) rises (Fig. 36.1) This concept is applied in breast UAL surgery in cases where the weight of the breast increases the gravitational forces which project the mammary tissues downward. The degree of breast ptosis varies and the kind of breast ptosis can change. From pure glandular ptosis (due to a real descent of the gland) to skin ptosis due to lack of skin tone with skin laxity, there are a series of intermediate conditions, which vary from patient to patient (Fig. 36.2).

When utilizing UAL for breast reduction or mastopexy the surgeon must choose the ideal candidate, who has a mild to hypertrophic female breast with a large amount of fat tissue. Lax skinny breasts and pure skin ptosis are clear contraindications for this technique. The amount of breast lift which is obtainable with UAL is variable, but up to 5 cm of NAC elevation can be obtained simply by decreasing the weight of the breast. The tissue elevation clearly follows the antigravity laws: a lighter breast rises up naturally by simply decreasing the weight of the mammary cone.

36.3 Subdermal Skin Stimulation

UAL, when performed with a solid titanium probe, can be safely utilized close to the subdermal skin plexus, by a surgeon with great experience using UAL. The conditions concerning safety include a UAL device which utilizes exclusively solid titanium probes (hollow probes are contraindicated and potentially really dangerous since there is lower cavitation as higher amounts of thermic energy are delivered, with a much higher risk of complications). The author has used two devices (Smei Sculpture and Sound Surgical VASER) which clearly fulfill this criterion. The VASER is a particularly safe device, as it delivers half of the ultrasound energy of the previous devices, emulsifying at the same time the target fat cells.

The new design of the titanium probes, with one, two or three grooves, and the size of the probes (2.2,

Fig. 36.1. Lifting by decreasing the weight of the breast

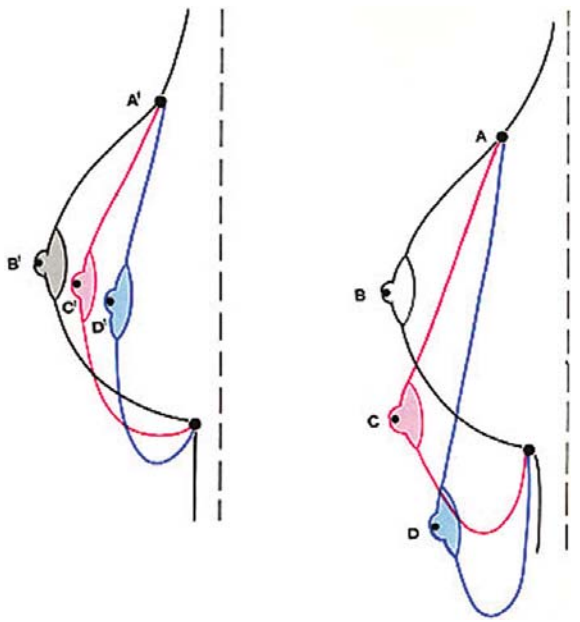

Fig. 36.2. Glandular and cutaneous ptosis

2.7, and 3.9 mm) perfectly adapts to the final scope of emulsifying the fatty component of the breast without interfering with the vascular network of the subdermal plexus. This allows complete undermining of the subdermal skin envelope of the mammary region from the breast tissue itself. While totally undermining the skin envelope allows full, extended mobilization of the breast tissue, the emulsification of fat allows a decrease of the total weight of the breast itself. By combining these two effects, the tissues can redrape nicely at a higher level. When undermining the skin envelope with a solid titanium probe, a superwet tumescent infiltration is imperative since UAL energy is delivered and is more effective through wet tissues, where the cavitation effect is 1,000 times higher than in dry tissues.

The subcutaneous undermining stops when the entire skin envelope is freed from the breast underlying tissues. Care is need to perform a homogeneous plane, after proper infiltration of tumescent solution.

Up to 1,500 ml of fluid can be necessary to obtain a good tumescence on breast tissue, including subdermal tumescence infiltration, for each size.

When the Smei Sculpture is utilized with the standard 5-mm probe, the power of the device is set to 50% of the total. When the Sound Surgical VASER with a 2.7-mm probe is used for subdermal undermining and the 3.9-mm probe is used for fat breast emulsification, the power of the device is set to 70–80% of the total. The total power is related to the amplitude setting of the single device, which is not an absolute value, but an index related to the parameters of the single device.

The efficacy of the subcutaneous undermining is strictly ligated to the biological effect, which it determines. Skin contracture is a typical side effect of a skin graft applied to cover a defect, whatever area of the body. To contrast this effect, a skin flap is often utilized, or a full-thickness graft. As a consequence, the thinner the subcutaneous tissue of a flap (or absent as in a split skin graft), the higher retraction or contracture that is achieved. This could be an excellent point of reference for ultrasound surgery of the breast, as in other areas of the body.

The ultrasound titanium probe is able to defat the subcutaneous layers of the skin close to the subdermal space. The vascularity and innervation of the subcutaneous skin plexus are perfectly conserved, as ultrasound energy targets only the fat cell, sparing all the important vascular network. The elastic fibers and the connective tissue trabeculae, which connect the skin with the subcutaneous layers (in a vertically oriented fashion), are progressively denudated and exposed. When this happens, these elastic fibers are clearly free to contract.

The thinner the flap, the better the skin retraction. The UAL device, which specifically allows the thinning of the flap in a safe manner (thus conserving the vascularization and innervation of our flap), allows a greater (and safer) level or quantity of skin retraction than with other previous techniques. The biological concept of utilizing the thinnest achievable skin flap for better skin retraction is fundamental for breast contouring surgery and breast lift with ultrasound.

Skin retraction is best achieved when UAL is utilized close to the subdermal layer. Normally 0.7–1.0 cm of skin thickness is conserved whatever part of the body is treated. Similarly, in breast lift, when undermining the full breast tissue from the overlying skin envelope, a 1.0-cm layer is left in place to assure viability and good perfusion to the flap, besides improving contour deformities or secondary defects.

In breast lift (or breast reduction with upward breast rotation) it is possible:

1. To reduce breast volume, affecting directly the fatty component of the breast
2. To undermine completely the full extent of the skin, breast envelope, in order to achieve greater skin retraction, and thus breast elevation

36.4 Discussion

The type of technique used varies according to the patient encountered. Mild breast asymmetry with

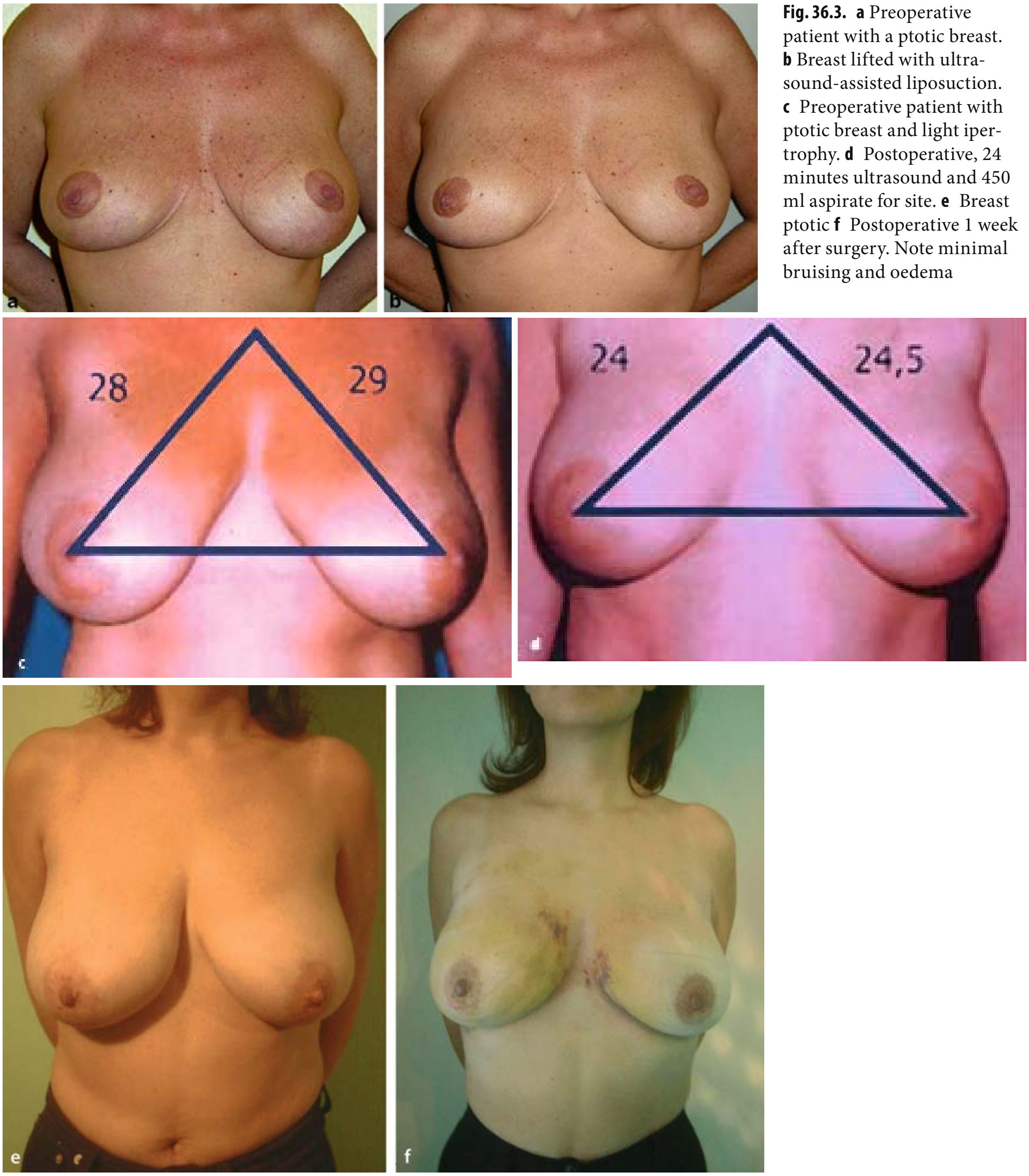

Fig. 36.3. **a** Preoperative patient with a ptotic breast. **b** Breast lifted with ultrasound-assisted liposuction. **c** Preoperative patient with ptotic breast and light ipertrophy. **d** Postoperative, 24 minutes ultrasound and 450 ml aspirate for site. **e** Breast ptotic **f** Postoperative 1 week after surgery. Note minimal bruising and oedema

right breast ptosis can be treated together with upper abdomen body contouring. Bilaterally, UAL is used to undermine the whole skin envelope of the breast to achieve skin retraction and subsequent elevation of the breast and correction of the ptosis.

Typical breast hypertrophy associated with breast ptosis can be treated with fat emulsification of both breasts and aggressive, subcutaneous undermining with skin stimulation, in order to determine retraction and lifting of the entire breast region. The NAC position after surgery can be raised.

Cases of mild hypertrophy associated with severe glandular-skin ptosis can be treated with UAL removing moderate amounts of fat (500 ml of fat can be removed bilaterally). Histological analysis of the aspirated solution shows substantially adipose content with no glandular component. Residual vessels, nerves, or elastic fibers are not found. A large component of connective tissue is found in the supranatant fat. A similar pattern was reported in the work by Chun et al. [1]. Upward rotation of the NAC of the entire gland and elevation from the infraclavicular notch occurs. The distance from the lateral inframammary crease and the NAC can be reduced and this explains the result and the upward rotation of the entire breast cone.

Six months and 1 year postoperatively mammographic studies show progressive fibrosis with the intense tissue reaction that helps retraction of the breast tissue and which maintains the new breast shape (Fig. 36.3). The technique results in no external visible scars. The upward rotation of the breast mould due to the skin retraction, which sustains the newly shaped mammary cone, allows a nice, naturally looking result.

Young women especially wish to have correction of the ptotic position of this breast, determined by timing, pregnancies, and postlactation involution, but they dislike scars. The ideal in aesthetic plastic surgery is obviously a nice result without visible scars. In selected patients, this can be obtained in breast ptosis, even considering the limitation of the correction which is achievable. It is impossible to pretend to achieve the same degree of NAC elevation which occurs after an external approach and open surgery. With an external approach, such as in breast open surgery mastopexy, the gland is extensively mobilized and thus the NAC is free to rise. The price to pay is often a vertical and periareolar scar, or even an L-shaped scar. With the modern techniques, sometimes a periareolar technique permits, in selected cases, nice-looking results to be achieved, if the degree of the ptosis is not particularly pronounced.

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37 Histologic Changes with Breast Ultrasound-Assisted Liposuction

Joseph T. Chun, James W. Taylor, Stuart E. Van Meter

37.1 Introduction

Much has been written on the use of liposuction in breast reduction surgery, mainly describing traditional techniques [1–7]. The excellent contributions of Lejour, Matarasso, Courtiss, and Gray demonstrate the usefulness of traditional liposuction in reduction mammaplasty, either as an adjunctive procedure [7, 8], or as the sole technique [1–6]. The safety and efficacy of traditional suction-assisted liposuction (SAL) of the breast has been documented [2, 3], and some authors believe modeling of the breast is safer and easier after liposuction has been performed [7, 8].

Following Zocchi's popularization of ultrasound-assisted liposuction (UAL) [9], there have been multiple reports of the use of UAL in breast reduction [10–13]. UAL may be advantageous in dense, fibrous breasts [13], and has gained popularity and acceptance in the treatment of gynecomastia [3, 6, 13]. UAL is highly selective with regard to the tissues damaged [14], and fat is the primary target; hence, its usefulness in breast reduction mammaplasty since the major component of the breast in cases of macromastia is fat [15].

The tissue effects of ultrasound energy and UAL have been documented [14, 16]. The author studied the histologic changes caused by the use of UAL in the breast and examined the effects of UAL on breast parenchymal tissue.

37.2 Study Results

The subject population was women who were scheduled to undergo breast reduction mammaplasty by traditional surgical techniques. All patients were healthy and stable for elective surgery, and subjects were excluded for any previous breast pathology or previous breast surgery. IRB approval (UT GSM IRB no. 2059) and informed consent for participation in the study were obtained.

After breast reduction, specimens were resected, the tissue was examined grossly in the operating room by both surgeon and pathologist, and representative portions were selected for study. Portions of the breast were characterized as either parenchymal tissue, or fatty tissue, and 4-cm×4-cm×2-cm sections of each area were selected for the study. Each block of tissue was then divided in half, half being the test side, and the other half serving as the control. Both parenchymal tissue and fatty tissue underwent treatment with a UAL machine (Mentor Contour Genesis G-4000 at 75% for 4 min). No tumescent solution was used, though saline was used to prevent tissue desiccation prior to treatment. Specimens were then fixed in formalin and prepared for permanent section examination. Control specimens were not treated with UAL, but were examined histologically. The remainder of the breast reduction tissue was sent to the pathology department for routine gross and microscopic examination.

Four consecutive breast reduction patients agreed to take part in the study. Breast specimen weight ranged from 430 to 1,530 g, and averaged 988.75 g. No gross pathological changes were noted at the time of surgery, and this lack of significant gross pathology was confirmed by microscopic examination. Microscopic diagnoses included fibrocystic change and stromal fibrosis, but no other evidence of atypia or malignancy.

In all cases, parenchymal and fatty breast tissue control specimens showed no deviation from the diagnoses provided from routine examination of the bulk of the breast tissue. The parenchymal breast tissue treated with UAL was intact, and stromal and epithelial components were generally well preserved. There were; however, histologic changes at tissue edges that resembled and were, in fact, indistinguishable from thermal injury or electrocautery-type artifact (Fig. 37.1). These histologic changes included smudging and streaming of epithelial nuclear chromatin, and hypereosinophilia and homogenization of stromal collagen (Fig. 37.2). These alterations were limited to a narrow 1–2-mm zone at tissue edges. The fatty breast tissue treated with UAL was largely emulsified, and any remaining intact adipose tissue fragments showed no significant histologic changes.

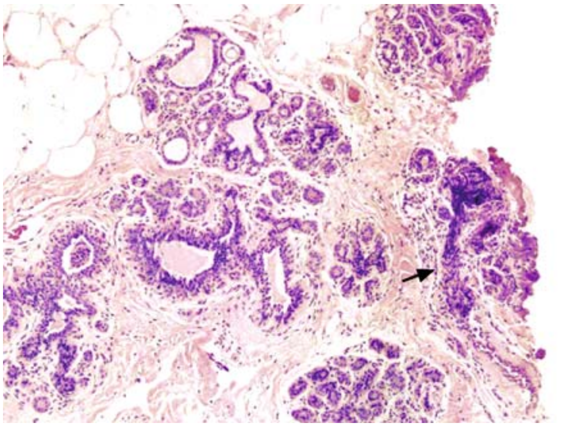

Fig. 37.1. Histologic changes at tissue edges that resembled and were, in fact, indistinguishable from thermal injury or electrocautery-type artifact

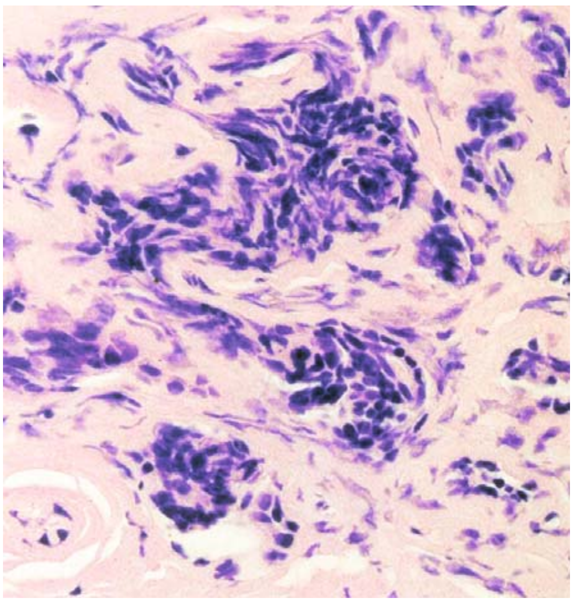

Fig. 37.2. Smudging and streaming of epithelial nuclear chromatin, and hypereosinophilia and homogenization of stromal collagen

These histologic findings were seen consistently in all four cases.

The breast reductions otherwise proceeded uneventfully, and there were no postoperative complications.

37.3 Discussion

Traditional liposuction techniques (SAL) have been applied to the breast to perform reduction mammaplasty and mastopexy [1–7]. Matarasso and Courtiss [1] reported a series of breast reductions using liposuction alone, and each author then subsequently expanded the indications for this technique [2, 3]. With the finding that nipple-areola position improved following liposuction-reduction, ideal nipple-areola position was no longer felt to be a preoperative requirement [2]. Ptosis, pseudoptosis, and enlargement of the nipple-areolar diameter could all be treated successfully with SAL alone [3]. More recently, Gray [4, 5] has essentially abandoned all traditional excision techniques in favor of liposuction-only breast reduction. Over the course of a 3-year experience, Gray reports that liposuction breast reduction has proven to be safe, effective, and a better choice than traditional methods for breast reduction [5]. Despite the satisfaction reported with traditional techniques [17], Gray's contention is that the complication rates associated with these techniques are unacceptably high. With liposuction-only breast reduction, complication rates are less than 1% [5]. In addition, patients were able to return to work in 1 week, and were essentially scarless. Operating room, recovery room, and anesthesia charges were greatly reduced [5].

UAL has been used by plastic surgeons to conduct lipoplasties on various parts of the body, and its use has been shown to be effective and safe [18–20]. In their large series of 250 consecutive UAL patients, Maxwell and Gingrass [18] report excellent results with few complications. Those few complications were felt to be avoidable with proper technique. Zocchi [19, 20] has consistently shown the safe and effective use of UAL, and has been at the forefront of this developing technique.

While the use of SAL in the breast has its champions, the use of UAL in the breast has not been as widespread. For fear of medical legal repercussions in the event of subsequent breast cancer, Gorney [21] issued a warning to all plastic surgeons to avoid the use of UAL in the breast. Despite this plea for restraint and caution, UAL of the breast is gaining popularity, and there are multiple reports of breast reduction using this technique [10–13, 18]. Unlike other fatty areas of the body, the breast is not strictly adipose tissue. Breast tissue is composed of adipose, lymphatic, vascular, ligamentous, and, perhaps most importantly, glandular parts. The sensory nerve components of breast tissue cannot be ignored. Although histologic evaluations and tissue effects of UAL have been studied [14, 16] in human and animal models, those same evaluations on breast tissue have not been extensively reported.

Maxwell and White [13] reported breast reduction using UAL alone in two patients. Besides obtaining excellent clinical results in those two cases, postoperative mammograms showed only increased parenchymal density, and no calcifications. They also report the favorable adjunctive use of UAL in other forms of breast surgery, such as secondary breast reduction and second-stage breast reconstructions. No histologic data were reported in that study. In a larger series of reported UAL cases, Maxwell and Gingrass [18] include four cases of breast reduction with UAL alone. Histologic evaluations in this report demonstrated lipolysis without breast parenchymal injury. These authors urged caution in applying this new modality to a "cancer-prone" organ. Maillard et al. [10] reported one case of UAL-only breast reduction in a case of major breast asymmetry. Again, excellent clinical results and no mammographic abnormalities were reported, but no histologic data were available.

Walgenbach et al. [11] studied ten patients undergoing UAL of the breast prior to traditional breast reduction. The goal of that study was to investigate the effect of UAL on breast tissue using histologic examinations. In each case, UAL was performed on the breast, and these areas were then subsequently excised in the performance of open surgical reduction. Biopsies were then obtained from this pretreated tissue. Findings included destruction of adipocytes' cellular structure, destroyed adipocyte cell membranes, and a very homogenous aspirate. These findings are consistent with the known effects of UAL on adipose tissue, and could have been predicted from previous data. Interestingly, the breast tissue was essentially intact, and there were no signs of ultrasound-induced cellular destruction. The glandular structure was kept intact, and there was no alteration in breast glandular cellular integrity. There was no difference between ultrasonically treated and untreated breast tissue.

Di Giuseppe and Santoli [12] recently reported a large series of 120 patients who underwent breast reduction or mastopexy with the use of UAL alone. Preoperative mammograms were used to exclude any patients with questionable abnormalities, and were also used in patient selection; patients with a dense glandular appearance on the mammogram were not candidates for the procedure. Except for the glandular periareolar tissue, all parts of the breast were treated with UAL. Two or three stab incisions were used for cannula access, and all levels of the breast were treated. Superficial, subcutaneous layers were treated in an effort to stimulate skin retraction and subsequent mastopexy effects. Good clinical results were obtained, no major complications occurred, and no suspicious mammographic changes were noted at the 5-year follow-up. Serial breast biopsies were obtained at 6 months and 1 year. These histologic investigations demonstrated increased fibrotic response to thermal insult, and a prevalence of fatty scar tissue. They concluded that UAL in the breast was safe, effective, and spared the glandular tissue and vascular network. In the subsequent commentary, Grotting [22] raises the question of a possible link between the UAL technique and future breast cancer, though states that there may be indications for its use.

The goal of the present study was to examine the histologic effects of UAL on breast tissue, and specifically to determine if any changes occurred in the breast glandular components. Histologic examinations were carried out in four consecutive breast reduction cases. The tissue was excised first, and then treated with an ultrasound cannula. No tumescent solution was used for two reasons. The breasts could not be infiltrated with wetting solution prior to undergoing traditional reduction mammaplasty, as this would artificially inflate the weights of the resected specimens. These being insurance-approved cases, we wanted to avoid any questions regarding resected specimen weight. Secondly, once the tissue had been resected, true tumescence was not possible, especially in the denser, more glandular portions of the breast. Therefore, this technique was essentially a "dry" UAL, an occurrence that in the in vivo, clinical setting should be avoided [23, 24]. The fact that this was a dry UAL probably accounts for the finding of electrocautery, coagulation-type artifact at the tissue edges. The saline used to prevent desiccation of the tissue may have been beneficial in keeping temperatures at an acceptable level, and the constant movement of the cannula was also partially protective.

Despite these measures, histologic examination of the glandular tissue at the treated edge was consistent with thermal injury, and was indistinguishable from typical electrocautery-type artifact. The histologic picture of breast parenchyma treated with UAL was that of thermal degeneration, with smearing of nuclei and coagulation of cellular structures. The fatty breast tissue treated with UAL reacted as fatty tissue would in any other area of the body: the fat was emulsified. Any fat that remained after the treatment period appeared as normal fat histologically. Friction thermal effects due to mechanical vibrations along the probe surface in contact with the tissues are known to occur [20]. Tissue temperatures may increase up to 5°C during the first 5 min, and after this, 3°C for every additional minute of applied energy [20]. The zone of thermal injury noted in our histologic examinations measured 1–2 mm, and was confined to the tissue edges in contact with the probe. This 1–2-mm zone of injury corresponds to that reported by other authors [18], and is consistent with CUSA zone of injury data [24]. Other studies reporting histologic data show no or little effect of UAL on breast glandular tissue [11, 12, 18] and this is likely due to the use of tumescent techniques, and subsequent protection from direct thermal effects. We have essentially treated breast tissue in an abusive, harmful way with the UAL device, and the maximum sustained injury is a 1–2-mm zone of electrocautery action.

Our histologic findings, like other reported results [11], represent only immediate tissue responses. Follow-up mammographic data in other studies do not demonstrate any suspicious changes in the breast parenchyma after treatment with UAL [12, 13]. The long-term effect, if any, of UAL on the breast tissue is an area for further investigation, and perhaps protocols for examination of aspirated materials are in order as well [25]. Questions have been raised not only regarding the long-term effects of UAL, but also about potential problems with the subsequent development of breast cancer, or spreading an undiagnosed breast cancer [6, 21, 22, 26, 27]. The relevance of the histologic effects of UAL on breast tissue may have a scope spanning both safety and efficacy in plastic surgery, as well as surgical oncology.

37.4 Conclusions

The results of this study indicate that UAL does cause a 1–2-mm zone of minor distortion of breast parenchymal tissue, and that this tissue damage is identical to that caused by electrocautery. We conclude that UAL of the breast should be a safe procedure. Its histologic effects are identical to those caused by electrocautery devices, and electrocautery use and the subsequent tissue damage are both well tolerated and have no long-term risks.

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38 Excessive Free Radicals Are Not Produced During Ultrasound-Assisted Liposuction

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38.1 Introduction

High-intensity ultrasound energy has been used since the 1970s, when phacoemulsification was introduced. This technique was later extended to neurosurgery, with increased energy and dosages. Barnett et al. [1] concluded in 1997 that "there is at present, no indication that medical ultrasound is capable of inducing mutations in mammalian tissue in vivo." Still, high-intensity ultrasound energy carries the risk for oxidative stress, which has been shown to be involved in the pathogenesis of a variety of diseases, such as atherosclerosis and cancer [2–4]. With the application of ultrasound-assisted liposuction (UAL) in breast surgery, surgeons inevitably are approaching a tissue that is very susceptible to DNA damage, particularly because undetected premalignant lesions, such as carcinoma lobular in situ, are found in up to 4% of women. Still, until now, there is no clinical proof of a direct malignant effect of UAL and breast tissue.

Several clinical studies have confirmed that UAL is an effective and safe technique with few or no complications when performed by experienced hands [5, 6].

In 1998 and 1999 Topaz et al. [7, 8] expressed their concern about the complicating negative effects of UAL, especially the formation of large quantities of free radicals in vitro resulting from the cavitation phenomenon. Cavitation phenomena are produced in liquid media subjected to high-intensity ultrasound with the rapid formation and collapse of gas or vapor microbubbles when the pressure during the rarefaction phase of the cycle reduces the total pressure to a specific threshold value [9].

Collapse of these bubbles is the suspected cause for the breakdown of adipocyte membranes and the physical explanation of the effectiveness of UAL [9].

Topaz et al. noticed the formation of free radicals, which are a by-product of the brief high-temperature peaks and are created by the bubble collapse in vitro. They also postulated that the high-energy shock is able to break chemical bonds in a variety of molecules. This effect is called sonochemistry. The reaction of free radicals with RNA and DNA, resulting in mutations, may have long-term-effects.

Herr et al, [10] investigated whether these highly reactive radicals were also formed during in vivo liposuction in the presence of the living defense system. The concern was that large numbers of free radicals generated in the direct neighborhood of unsaturated fatty acids may be expected to overwhelm the natural local antioxidant capacity, inevitably leading to lipid peroxidation. The resulting lipid hydroperoxides are metabolized to toxic secondary products, such as malondialdehyde, 4-hydroxynonenal, and other aldehydes. Measurement of malondialdehyde, for example, in aspirates of patients undergoing UAL, can be considered a measurement of relevant lipid peroxidation.

38.2 Basic Science of Lipid Peroxidation

Because internal UAL is performed in a lipid-rich environment, there is a high probability that lipid peroxidation is initiated if free radicals are produced in this procedure [11]. Most fat is stored in adipocytes in the form of triglycerides, various proportions of which are polyunsaturated fatty acids. Polyunsaturated fatty acids have at least one carbon–carbon double bond and are susceptible to oxidation. In contrast, saturated fatty acids lack carbon–carbon double bonds and are therefore resistant to oxidation.

Polyunsaturated fatty acid oxidation consists of three distinct phases: (1) initiation, (2) propagation, and (3) termination [12]. Peroxidation is initiated when a free radical or reactive oxygen species extracts a hydrogen atom from the carbon–carbon double bond of a polyunsaturated fatty acid and leaves behind a carbon-centered alkyl radical. Alkyl radicals are unstable; they quickly (10^{-6} s) undergo molecular rearrangement to form a peroxyl radical. Peroxyl radicals are stabler, with half lives of approximately 7 s and can participate in a variety of reactions, the most relevant of which is propagating a chain reaction by removing a hydrogen atom from another fatty acid [13]. Such a chain reaction converts hundreds of polyunsaturated fatty acids into lipid hydroperoxides from a single free-radical initiator. Propagation continues until it is terminated by either consumption of available polyunsaturated fatty acids or elimination of free radicals by antioxidants like lipid-soluble antioxidants β-carotene and α-tocopherol that efficiently terminate lipid free-radical chain reactions. This fact was not considered in the work of the Topaz group.

38.3 Materials and Methods of the Study

The detection of free radicals in vivo is difficult, because they are short-lived, having lifetime ranges of nanoseconds to picoseconds [14]. Because free radicals are very reactive, they can leave indirect footprints by oxidizing molecules such as unsaturated fatty acids [15].

In this study lipid peroxidation products in the form of malondialdehyde equivalents were measured by a photometer. For this purpose, the thiobarbituric acid reactive substances (TBARS) assay was chosen. In this test, malondialdehyde, a major product of lipid peroxidation, reacts with thiobarbituric acid to produce a pink adduct that can be measured spectrophotometrically.

A total of 17 patients were enrolled in the study. One woman underwent liposuction twice within 1 year; thus, there were 18 liposuction procedures in total. The indication for UAL was lipodystrophy of the abdomen, hips, upper and lower legs, upper arms, and male breast, as well as the neck in one patient with Launois–Bensaude lipomatosis. Some patients had several regions of lipodystrophic areas; therefore, several specimens were taken, providing a total of 28 samples. All patients had general anesthesia and in addition, tumescent local treatment as a fundamental prerequisite for UAL (Zocchi solution). The samples were put into sterile Eppendorf cups and were immediately deep-frozen in liquid nitrogen and stored below –35°C until analysis.

38.4 Results

The median baseline malondialdehyde concentration in 28 samples obtained before UAL was 3.40 nmol of malondialdehyde per gram of adipose tissue (16th percentile, 1.74; 84th percentile, 13.28). Two minutes after the treatment had started, malondialdehyde equivalents increased to 7.45 nmol malondialdehyde per gram of adipose tissue (16th percentile, 2.57; 84th percentile, 15.49). However, the increase did not reach statistical significance by the *t*-Wilcoxon signed rank test. Also samples taken 5 and 10rmin after UAL treatment did not show any statistical significance in the increase of malondialdehyde equivalents. The median malondialdehyde values were 3.35 nmol malondialdehyde per gram of adipose tissue at 0 min, 2.64 nmol malondialdehyde per gram of adipose tissue at 2 min, 4.26 nmol malondialdehyde per gram of adipose tissue at 5 min, and 4.07 nmol malondialdehyde per gram of adipose tissue at 10 min.

38.5 Discussion

The effect of UAL differs between in vitro and in vivo studies. An exponential generation of TBARS (peroxidation products as an indicator for the presence of free radicals) as a fulminant radical attack was not usually detected in the study presented, even though the individual responses were quite variable. In some individuals, a steep increase in TBARS was observed in response to the treatment, whereas in some patients, a decline was noted. The reason for this is not clear at present but may lie in a different effective defense system of sufficient antioxidants, such as vitamin E and Q10, which could prevent peroxidation.

The findings of the in vivo study suggest that UAL generally does not severely oxidize lipids. This assumption is in line with the findings of Grippaudo et al. [16], who could not find evidence for changes in triglyceride molecules when using high-intensity UAL specimens of domestic pigs; however, these were in a much less reliable assay and an animal model.

Millions of years of evolution have formed equilibrium in many systems, such as hemostasis, acid–base balance, and the formation of and defense against free radicals, which are produced millions of times a day in a life of a human body. It is therefore feasible that the energy generated by UAL is not sufficient in most cases to overwhelm the antioxidative system of adipose tissue.

With respect to more extended procedures and longer application times of this treatment, further investigation should also focus on the influence of high-intensity ultrasound energy on protein and nuclear acids in tissue.

38.6 Conclusions

A number of technologies are available to measure lipid peroxidation in tissue samples and body fluids. The analytical method used depends on the exact goal of the measurement and the required specificity and sensitivity, but for the general purpose of detecting lipid peroxidation the TBARS assay is the first choice [11]. Even so, measuring lipid peroxidation in clinical settings is complicated. The lack of evidence for lipid peroxidation reported does not necessarily mean that free radicals were not produced. It may be that free radicals were generated at very low doses or that the free radicals were destroyed by host defense mechanisms and antioxidants before they could initiate fatty acid oxidation. The study presented reassures that UAL is a safe procedure but calls for further investigations.

A final and definite answer to the question of the impact on human tissue and long-term effects in the next 10 or 20 years is still to come. As in medicine everything is also a matter of probability.

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External Ultrasound and Superficial Subdermal Liposuction

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39.1 Introduction

Liposuction has undergone a considerable evolution since it was first described by Fischer and Fischer in 1976 [1]. At the beginning the instruments were quite different from the ones used today. Fischer used a vacuum system and a special blunt cannula with a window on one side named cellusuctiotome. It had an electric device that cut the fat that penetrated inside its lumen. In 1978 Kesselring [2] proposed the aspiradeps, another instrument that was a sharp cannula that permitted one to cut and aspirate at the same time.

The drawbacks of these techniques were mainly due to the cutting instruments that caused blood and lymphatic collections. Also the large gauges of these instruments did not permit an even removal of fat, giving rise to waves and depressions visible on the skin surface after the edema subsided. Illouz introduced a blunt cannula derived from the Karman uterine cannula with no cutting device that allowed preservation of blood vessels, lymphatic vessels, and the fibrous connections between skin and muscle [3, 4]. The real advantage of his technique was that blood and lymphatic collections were significantly reduced and that the skin connections with the muscles were not severed, permitting a more physiological healing with fewer skin depressions caused by scarring in the subcutaneous layer. One of the main concerns of Illouz was to treat only the deep layer of fat and respecting the superficial layer to avoid skin irregularities. In fact the use of big cannulae close to the skin surface could lead to irregularities. Illouz recommended going deep into the adipose tissue, 1–2 cm below the dermis, to respect the integrity of the superficial fat and to avoid adhesions that might cause unaesthetic dimples or furrows. These considerations led the authors to think of a new way of performing liposuction using more refined instruments with smaller gauges in order to successfully treat also the superficial layer of fat.

In 1989 the author presented subdermal superficial liposuction (SSL), opening a new path for liposuction [5, 6]. In the following years quite a few authors published papers on this new subject, which represented a revolution of the liposuction technique [7–12]. The technique consists of suctioning the superficial subdermal fat through small-gauge cannulae (1.8–2.0-mm diameter) and then proceeding with the same thin cannulae to aspirate the deeper fat as well. The procedure is started with a thin cannula and the cannula is gradually increased in gauge. There are many advantages using this technique, including the following: (1) suction of the subdermal fat layer making it possible to obtain effective skin retraction, (2) the treatment of all the layers of fat is made in such an even way that good results are predictable, (3) it is possible to treat patients with slight adiposities as well as areas with small thickness of the fat layers such as the ankles, and (4) the procedure is similar for patients with large adiposities and for those with small ones.

39.2 Anatomy

The subcutaneous tissue is composed of two fat layers, the superficial or areolar layer and the deep or lamellar one. The fat is encased in a fibrous network called the superficial fascial system (SFS) (Fig. 39.1) that is made of horizontal and vertical components. The horizontal framework is parallel to the skin and is named fascia superficialis. In most areas the fascia superficialis is just one sheet, but in the abdomen there are two horizontal sheets, Camper's fascia and Scarpa's fascia, and as reported by Avelar [13] in the obese the fascia superficialis is composed of many sheets intermingled with fat. The vertical septae are fibrous connections between the skin and the muscle. The septae that are superficial to the fascia superficialis are rather vertical, while the ones deep in the fascia superficialis are arranged in an oblique fashion. The fat layer located above the fascia superficialis is called the areolar layer, while the one located under it is named the lamellar layer. So the areolar fat is encased in vertically oriented compartments, which are normally stiff. Its "fattening" stretches the septae that pull the skin surface causing visible dimples, the so-called cellulitis (Figs. 39.2, 39.3).

The increase of volume of the areolar layer, due to weight gain, may just double its thickness [13], so this fat should be regarded more as structural fat that is present almost all over the body (also in areas where it is difficult to gain weight like forearm, ankles, calves, etc.), than as an energy-storage place. The lamellar fat, located under the fascia superficialis, is arranged in large fat lobules that are looser than the areolar fat, and may increase its thickness much more than the areolar layer, even 10 times in the obese. This layer is therefore to be considered the real energy-storage place of the body. Moreover the SFS shows several variations between the sexes, implying some differences in male and female contours and adiposities [14]. In some areas the SFS adheres tightly to the underlying muscle fascia or periosteum forming a zone of adherence. The SFS is most adherent in the posterior and anterior thoracic midline and in the inguinal, gluteal, and inframammary creases. In the iliac crest region, the SFS adheres tightly to the periosteum in men and loosely in women (the adherence zone is several centimetres below the iliac crest in women), causing the different lateral truncal contour [14].

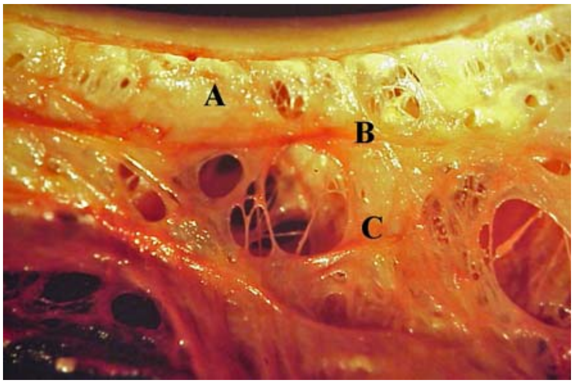

Fig. 39.1. Closeup view of the superficial fascial system (*SFS*) of the abdomen after liposuction of all the fat. *A* vertical fibrous septae of the areolar layer, *B* horizontal fibrous framework named fascia superficialis, *C* oblique fibrous septae of the lamellar layer

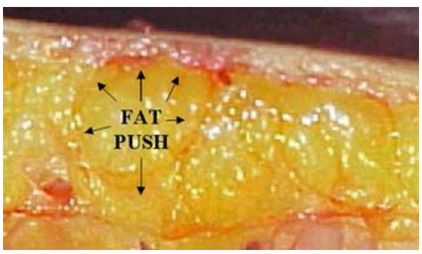

Fig. 39.2. Specimen of skin and areolar fat from the abdomen. The increased volume of the areolar fat pushes the skin that is held by the vertical fibrous septae of the SFS

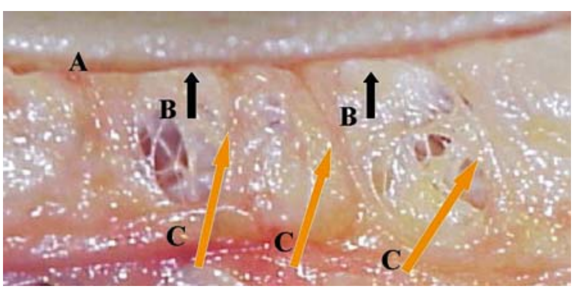

Fig. 39.3. Closeup of fibrous septae of the areolar layer after total suction of the fat. *A* skin, *B* bumps caused by increase of volume of fat, *C* pull exerted by vertical fibrous septae that cause dimples visible on the skin surface, the so-called cellulitis

39.3 Procedure

39.3.1 Patient Selection

The patient's health condition must be good and special attention should be given to general diseases such as diabetes, cardiovascular diseases, or coagulation disorders. An accurate evaluation of the adiposities and skin conditions is of utmost importance to select the areas to be operated on and the amount of fat to be removed. Patients with very poor tissue tonicity are inadequate candidates for liposuction as well as those with excessive obesity. The candidate to liposuction should not be on a low-protein diet because a hypoprotein status can impair the healing process and favour prolonged oedemas.

Weight loss before the operation should be discouraged and may contraindicate the surgery. The aesthetic outcome of liposuctions performed on patients after moderate to major weight loss is of poor quality owing to the flabbiness of the tissues. Flabbiness renders it difficult to treat the areolar layer because tissues are not firm and it is hard to maintain the cannula in the subdermal layer. After thinning, the areolar fat layer is persistent because it is barely affected by diets, if compared with the lamellar one that is able to greatly lose volume. The areolar layer, which is immediately subdermal, should also considerably reduce its thickness to allow the skin to retract smoothly, but this does not happen when the patient just loses weight and this is the main reason for the unaesthetic skin redundancy after a considerable weight loss. SSL permits us to achieve good-quality body remodelling when performed before dieting because skin retraction is favoured by the subdermal fat removal ahead of the reduction of the deeper fat. This feature of SSL is crucial in those cases where a conspicuous skin retraction is desired. After SSL with any subsequent diet there is a more harmonic weight loss, and a much better body shape is achieved if compared with that achieved by liposuction performed after the diet. Patients with previous massive weight loss and skin redundancy are thus poor candidates for liposuction and it is preferable to perform the suction before a diet if the patient needs considerable weight loss.

If the amount of fat to be removed is supposed to be more than 4 kg [15] an autologous blood transfusion should be considered, or the operation should be scheduled in two or more stages, in order to lessen the amount of trauma. Also the number of areas to be treated must be reduced if large volumes must be aspirated. Multiple adiposities can be treated in the same operation if the total amount of aspirated fat is thought not to exceed 4 kg. This quantity may vary depending on the bleeding during the procedure, being less in patients that show tendency to bleed, or more when the bleeding is limited.

One gram of Xylocaine is enough to give a complete analgesia in slight or moderate adiposities when two to three areas are planned to be treated under local anaesthesia plus sedation, and it is preferred not to exceed that amount in average-weight patients [15]. If the estimate of the anaesthetic exceeds the amount to obtain a proper analgesia, aspiration should be performed under general or peridural anaesthesia.

39.3.2 Patient Examination

The patient is examined to assess the areas to be treated, and the skin tone. If the abdomen is considered for liposuction, the patient is asked to contract the muscles of the abdomen (lying down the patient is asked to lift the legs) to judge with palpation the thickness of the fat layer and the integrity of the abdominal muscular wall. This manoeuvre is very important because any abdominal wall defect, such as a muscular diastasis or the presence of hernias, can be detected. In fact performing a liposuction when one of these pathological conditions is present can be very dangerous because of possible risk of abdominal wall perforation.

To evaluate the fat layer in the calves, the patient is asked to stand on the tips of the toes and the skin is grasped permitting the surgeon to assess if the muscle is hypertrophic or the fat thickness is disproportionate.

In the case of edematous fatty ankles the foot is also observed for the presence of edema. Its presence permits the differential diagnosis with lipoedema, which is edema of the fat [16], while involvement of the foot indicates the possibility of cardiovascular disease, venous insufficiency, or lymphatic stasis. Lipoedema may be successfully treated by liposuction, while in other instances the internal disease should be investigated and liposuction is probably not indicated.

39.3.3 Patient Information

Patients are given information concerning the preoperative phase, details about the procedure and the immediate postoperative period. Acetylsalicylic acid as well as any other drug intake interfering with the coagulative processes is prohibited. Also other drugs like monoaminooxidase inhibitors must be discontinued before scheduling the operation. Anticonvulsants, antihypertensives, as well as any other drugs used should be evaluated by the anaesthesiologist.

General information about the operation is given, including the length of the surgery, the instruments used, and anaesthesia. Patients are also informed about the postoperative period. The recovery time depends on the amount of aspirated fat and the type of anaesthesia. Small liposuctions especially if made under local anaesthesia have a recovery time of a few days. After a large fat extraction the patient will experience asthenia owing to the acute anaemia consequent to blood loss, and normal activities may be resumed gradually in a few weeks. Early mobilization the following day is mandatory to prevent venous thrombosis. Bruises and edema are always present in a variable amount. Bruises subside in about 3 weeks and swelling lasts for months. The use of elastic stockings and garments is prescribed for approximately 6 weeks. Early postoperative diet includes drinking about 2 l/day and a well-balanced diet including proteins to build up haemoglobin [4]. Walking is mandatory for those patients that have had the inferior extremities operated upon. Exercising may be beneficial but strenuous activities should be avoided. Postoperative physiotherapy such as Endermologie and lymphatic vein massages may be started after 20 days.

Patients are informed that if the amount of fat to be removed is more than 4 kg, the operation should be performed in two or more stages. Minor revisions to further enhance the result may be needed after 6 months once the recovery can be considered complete, and irregularities become evident.

39.4 Equipment

39.4.1 Cannulae

Straight cannulae with diameters ranging from 1.8 to 3.0 mm with a bullet tip are used. There are two basic cannulae: Grazer-Grams “Mercedes” cannulae, whose tip has three slits oriented in the same plane at 120° with gauges of 1–2 mm and cannulae showing two lateral openings that lie at 180° with gauges ranging from 2 to 3 mm. The length of the shaft of both types of cannulae varies from 16 to 30 cm. In addition, scavenger cannulae of 3–5 mm and shafts of 30–40 cm with a three-hole tip oriented in helicoidal fashion or a cobra tip plus a third hole facing downwards (Souza Pinto tip) [17] are used. All these cannulae do not have a handle, but a direct connection with the tube or the syringe (Gasperoni multipurpose cannula) [15]. Cannulae with no handles are easier to use compared with those with a handle: the hand holds the tube, which is elastic, so the wrist movements are more physiological and the junction between the cannula and its connection to the tube is not solicited. In fact thin cannulae may show a tendency to break because sometimes it may happen that the movement of the hand pushes the handle laterally too much, forcing and breaking its junction with the shaft.

39.4.2 Tube

A silicone tube connects the cannula to the suction machine. The vacuum that permits the suction may be created not only by the machine but also with the syringe that may be connected to the multipurpose cannula.

39.4.3 Suction Machine

The suction machine must ideally achieve the vacuum and an aspiration pressure of at least 700 mmHg is considered ideal.

39.4.4 Balance

The quantity of the extracted fat should be measured. It is important to weigh the aspirated fat especially in small adiposities to make it easier to evaluate symmetry.

39.4.5 Bottle

A spray bottle filled with saline is used to sprinkle cold saline on the cannula to reduce the trauma that results from the passage of the cannula through the skin incision [18].

39.4.6 Ultrasound Machine

The external ultrasound (EU) machine works with two totally independent channels that allow the use of two different probes at the same time. It delivers at maximum power a continuous wave of 3 W/cm^2. The machine may work with three different probes that include (1) a 1-MHz probe that delivers ultrasound to the deep fat (its depth of action is around 3–4 cm), (2) a 2-MHz probe that delivers ultrasound to an intermediate depth of fat (10–20 mm), and (3) a 3-MHz to treat the subdermal fat (whose depth of action is 5–10 mm). EU may thus be delivered with one probe to one area of the body and simultaneously with another probe to another region. It is possible to treat the first one superficially with the 3-MHz probe and the other one deeply with the 1- or 2-MHz probe, or with two hands holding different probes, to treat the same area with two different frequencies (Fig. 39.4).

EU is delivered in a sterile manner. The probe is sterilized and a thin film of sterile ultrasound gel is used to improve the conduction of ultrasound.

39.5 Preoperative Pictures and Markings

Pictures are taken in frontal lateral and posterior perspectives. With a skin marker, the areas to be treated are demarcated with the patient in a standing position. The boundaries of the areas to be aspirated are drawn. More prominent points are signed with a cross, and depressed areas with small circles. These markings help to recognize prominences and hollows when the patient lies down (Fig. 39.5).

Fig. 39.4. External ultrasound delivery with two probes used simultaneously

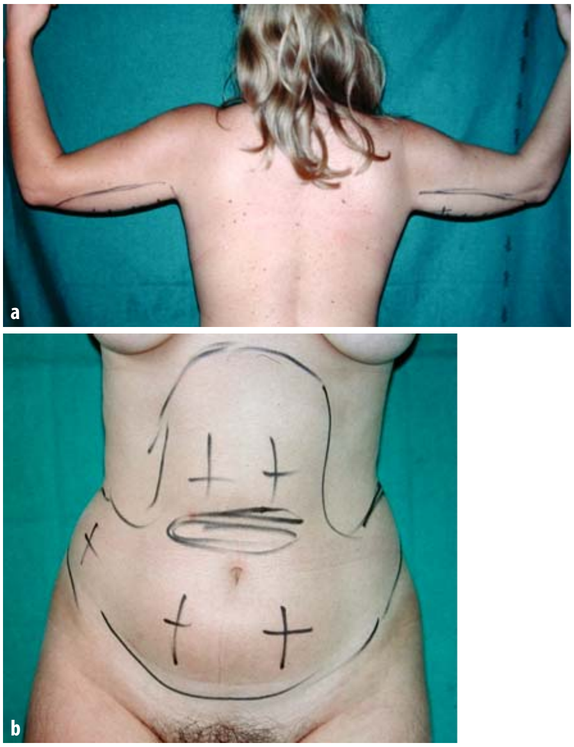

Fig. 39.5. **a** Skin markings on the arms. **b** Skin markings on the abdomen

39.6 Anaesthesia

Patients may be submitted to local anaesthesia plus sedation or general anaesthesia, depending on the number and the extent of the areas to be treated. Caution should be used not to inject excessive lidocaine and the authors prefer to maintain the level under 20 mg/kg to avoid the risk of lidocaine toxicity, even if in the literature high doses of 35 mg/kg or more are reported [19, 20]. When it is estimated that the dose should be exceeded to obtain proper analgesia, aspiration is performed under general or peridural anaesthesia. The authors prefer general anaesthesia because it has fewer complications compared with peridural anaesthesia.

39.7 Positioning the Patient

The patient is positioned prone or supine depending on the area to be treated. The patient is not usually placed in a lateral decubitus position and the limbs are moved while suctioning to see the changes made from many points of view. When the patients are under local anaesthesia, they are asked to contract the local muscles to check the effectiveness of the suction.

39.8 Infiltration

At the beginning of the surgery all the areas are infiltrated with a superwet solution (i.e. the volume of the wetting solution almost equals the estimated volume to be aspirated) [21]. When local anaesthesia is planned, the solution is made with saline plus adrenaline in concentrations of 1:500,000 and 0.2–0.3% lidocaine . When general anaesthesia is used, the solution contains adrenalin in a concentration of 1:1.000.000 and 0.05% lidocaine [22, 23].

The infiltration is performed with the Gasperoni multipurpose cannula connected to a 60-ml syringe. Other means of infiltration such as the Klein pump may be used, but with this device there is a tendency to infiltrate more fluid than is necessary.

39.9 The Operation

39.9.1 Rationale

With liposuction, fat reduction should be accomplished with the best aesthetic quality possible, so fat removal must be performed in a even manner to achieve stable results. Appropriate techniques should also be used to favour skin retraction over the reduced volume area [5, 6, 24]. From the physiological observations regarding the lamellar layer, it is evident that as it is capable of increasing its volume even 10 times during fattening, so it must be reduced as much as possible. This must be done not only to achieve a good immediate result, but also to prevent a subsequent recurrence of fattening of the treated area. The areolar layer must also be reduced for two different reasons: (1) in some regions it is the only layer of fat conspicuously present, as in the anterior thigh, and (2) in those regions where the lamellar layer is more represented to allow a more effective skin retraction. The areolar layer, which is immediately subdermal, must also be reduced to allow the skin to retract smoothly [24]. It is a general observation that defatting flaps and dog ears allow the skin to retract in a better manner. This is because if the subdermal fat is left intact, the retraction force is opposed by an arch of fat that does not cede to this force. The weakening of the arch annuls the force that opposes the retraction force of the skin, rendering its possible shrinkage (Fig. 39.6). Defatting the subdermal layer is necessary to permit the skin to retract, as pointed out by the author since the first presentation of this technique, the subdermal liposuction, in 1989, at the ISAPS Congress in Zurich, where it was stated that SSL should be applied whenever a better skin retraction is desired [5]. Following our presentation many authors started using the concepts exposed in SSL to achieve better results [7, 8, 11, 12, 25].

In contrast to the other techniques we perform the aspiration by progressively increasing the gauge of the cannulae instead of decreasing it [15]. There are several reasons for reversing the order of the gauge of the cannulae . Using big cannulae first we give rise here and there to irregularities that must afterwards be treated with smaller cannulae; this means we are creating defects and then trying to get rid of them! Starting with small gauges, the suction is more progressive and uniform, less force is needed, and it is less painful. The penetration of bigger cannulae after some suction has already been performed is easier and less traumatic, as they slide better among the fibrous septae of the SFS.

In the case of hard fat with "cellulitic" skin, in fibrous areas such as the thoracic adiposities, and in secondary cases, EU can be delivered before aspiration to help crush the fat. The suction with the small cannulae, after the application of EU, is smoother because the fat has been softened by the ultrasound [23, 24].

39.9.2 Technique

The cannula is introduced through a 2-mm stab incision. We start the SSL with the treatment of the subdermal layer of fat with 1.8–2-mm Mercedes cannulae. Their locations should be those that allow the surgeon to do his or her best work. The Grazer-Gram Mercedes cannula has a three-hole tip that guarantees a 360°-oriented liposuction. The small diameter allows its superficial use with an effective suction of the subdermal fat layer. Cannulae with only downwards-facing orifices are not suitable for suctioning the subdermal fat, because the "defatting " immediately under the dermis must be uniform and radical to be effective on skin retraction. EU may be applied to the area to be suctioned to help to perform the aspiration of the subdermal fat. The fat under the dermis is softened and crushed by the waves and may be aspirated even more smoothly with the Mercedes cannulae.

After the subdermal layer of fat has been treated, it is less firm as for "softening" of the subdermal fat. We then use the same cannulae to treat the deeper fat layers evenly. The gauge of the cannulae is subsequently increased to 2.5–3 mm (up to 3.5 mm in the abdomen) to aspirate more fat quickly. These bigger cannulae also permit the suction of the fat already crushed by the thin ones but not yet aspirated (therefore we named them "scavenger cannulae") [15].

A spray bottle is used to sprinkle cold saline on the cannulae to reduce the trauma caused by the passage of the cannula through the stab incision. The use of thin cannulae implies hundreds of to-and-fro movements through tiny skin incisions that damage the skin edges. In fact the passage of the cannula produces erythema and bruises the skin surrounding the incisions. In addition, the heat generated by the friction of the cannula on the skin margins eventually burns them. In our opinion trauma and heat cause inflammation during the healing phase of the wound, resulting in hyperpigmentation of the scars and surrounding tissues. The saline is sprayed by an assistant or scrub nurse throughout the length of the cannula and on the stab incision many times during the procedure. The cannula is kept cold by the cold saline, which reduces the heat generated and, because it acts as a lubricant, prevents friction lesions [18].

Stitches are not needed to close the little stab incisions that are made to introduce the thin cannulae.

39.9.2.1 SSL in Different Areas

Not all the areas are treated in the same way because of their different characteristics.

In the arms the fat layer is not very thick but skin shrinkage after the suction is very effective. As the deep lamellar fat is thick in this area, it must be radically aspirated. The subdermal layer is thinner but must be treated to allow good skin retraction (Fig. 39.7). We

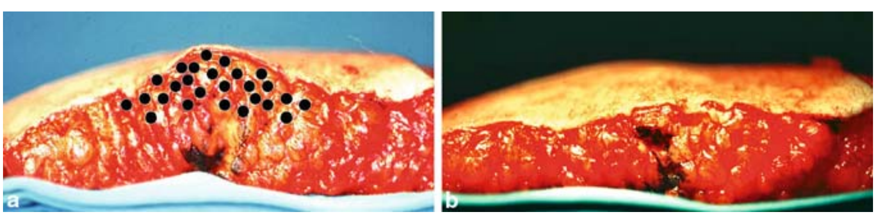

Fig. 39.6. a The weakening of the arch annuls the force that opposes the retraction force of the skin rendering its possible shrinkage. **b** Once the subdermal fat has been aspirated the arch structure is weakened and collapses. Skin may retract over the collapsed arch

start the aspiration with 2-mm Mercedes cannulae and then switch to the 2.5-mm two-hole tip cannula. We called this way of performing the suction massive all-layer liposuction (MALL) [26].

In the abdomen we also perform MALL to aspirate as much fat as possible, expecting a conspicuous cutaneous retraction. We start with the 2-mm Mercedes cannula in the subdermal layer to be sure that the skin may shrink without forming waves, then the cannulae are directed towards the deeper layers, increasing progressively their gauges. Multiple incisions are needed to be sure to treat evenly all the abdomen. We use 3–3.5-mm cannulae to suction as much fat as possible throughout the whole thickness of the abdominal fat, then we utilize a 4.5-mm cannula as a scavenger to remove quickly more fat including that already crushed but not aspirated. At the end of the procedure the abdominal skin is very loose and smooth at the pinch test.

A similar procedure is used for the inner thigh but using small-gauge cannulae ranging from 1.8 to 2.5 mm. The indication for the suction of the inner thigh must be appropriate because skin redraping in this area may be difficult. The best candidates are those with good elasticity of the skin (Fig. 39.8), but if the amount of fat to be removed is not too much also patients with less tonic skin may be successfully treated.

In the trunk subdermal liposuction is recommended to promote skin retraction; the deeper fat can be removed with 2.5-mm two-opposite-hole tip cannulae. The use of EU helps suction from this frequently fibrous area [22, 23].

In the external thighs the deformity is usually great and good-quality skin shrinkage is important to obtain a good result. In this region the correct application of the SSL technique is of paramount importance to allow the skin to retract well. The aspiration

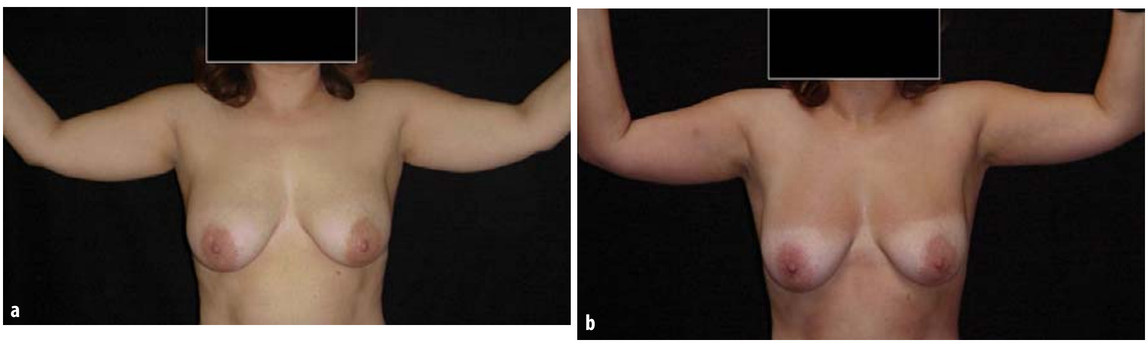

Fig. 39.7. **a** Preoperative view of liposuction of the arms. **b** Postoperative view of liposuction of the arms

Fig. 39.8. **a** Preoperative. **b** Eighteen months postoperatively following liposuction of the inner thigh and abdomen

of the subdermal layer must be performed with small-gauge Mercedes cannulae, with the aim (1) to reduce its thickness, improving the cellulitic aspect of the skin because the tension of the vertical septae of the areolar layer is reduced, and (2) to weaken its rigidity. The decrease of the superficial fat resistance to the retraction force permits a better retraction of the skin.

As in this region the deep fat is usually more fibrous than in the other areas, the suction must be started with thin cannulae ranging from 1.8 to 2.5 mm and should be carefully performed throughout both the superficial and the deep layers. In cases where the consistency of the fat is hard, the application of EU is of utmost benefit to soften it, allowing a smoother penetration of the cannulae. The extraction of the fat after the delivery of EU is simpler, more even, and less traumatic. In fact when the subcutaneous tissue is already somewhat crushed by the EU, the cannula encounters less resistance when pushed through the fat, sliding more easily among the fibrous septae with less trauma to them and the blood vessels. The characteristics of the fat aspirated with a 1.8-mm Mercedes cannula when the EU is applied before the suction compared with those when EU is not used are that it is less bloody and that more liquid fat is present in the aspirated material. The presence of more liquid fat means that a greater number of fat cells are broken when EU are used. So the use of EU in the external thigh region is advisable whenever cellulitis is present, and when at the palpation we feel the fat is hard.

During the operation the position of the limbs must be changed many times to vary the direction of the penetration of the cannulae. It is moreover necessary to change the points of penetration of the cannulae to be sure that the suction is carried out in a progressive and uniform way.

The external thigh, in women, is one of the main energy-storage points of the body so the lamellar layer, that is the one that greatly increases its volume during fattening, is particularly abundant (Fig. 39.9). This deep layer must therefore be radically suctioned to prevent subsequent recurrences of the adiposity. When a massive suction is carried out by aspirating both superficial and deep fat we have named it MALL [26].

The flank region is a "forgiving" one because the fat and overlying skin have a spontaneous tendency to accommodate very well, even without a real subdermal aspiration. This happens because it is loose fat, never hard (Fig. 39.10). We routinely start the suction with a 2.5-mm two-opposite-hole tip cannula and increase the gauge just until 3 mm.

Fig. 39.9. The external thigh on the right side has been radically aspirated

Fig. 39.10. a Preoperatively. **b** Four years postoperatively after subdermal superficial liposuction of flanks and thighs

In the anterior thighs the fat is basically represented by the areolar fat and being lamellar fat is very thin. It is not necessary in this area to do a subdermal defatting, but the aspiration that practically involves just the areolar layer must be carried out evenly. The suction may be started with slightly bigger cannulae than in most other areas (2.5 mm), and during the procedure the gauge is gradually increased. We are aware that we have the advantage that in the anterior thighs there is no tendency for further thickening in the future because the lamellar fat, that is the only fat that may increase greatly its thickness, is very thin. The disadvantage instead is that any irregular suction of the anterior thigh becomes evident after the edema has subsided.

In the knee the skin retraction during the operation is conspicuous even if the aspiration is performed only in the deep layers with 2.5–3 mm cannulae. The effect of the suction is immediately evident so it is possible to judge without any delay the result obtained.

In ankles and calves circular aspiration on the whole leg is typically performed to diminish the thickness of the fat, leaving only a really very thin layer of fat. We normally start with a 2-mm Mercedes cannula and then increase the gauge switching to 2.5-mm cannulae with a two-opposite-hole tip. In patients affected by lipoedema it is very important to be very radical to avoid a possible residual edema that may affect even a thin layer of fat.

39.9.2.2
EU in Conjunction with SSL

When the areolar fat increases its volume, the vertical septae of the areolar layer are stretched, pulling the dermis, thus giving the skin the so-called cellulitic aspect. Other skin dimples and hollows may be due to considerable irregularities of firm deep fat or may be iatrogenic. In these cases and in regions where the fat is fibrous and hard, EU is indicated to soften the fat by crushing it with the mechanical impact of its waves [27–30]. EU may be applied not only to the superficial fat but also to the deep fat. This layer should be treated whenever the deep fat is fibrous and hard. When EU is used, care should be taken to infiltrate immediately under the dermis to facilitate the propagation of EU waves in the superficial layer of fat. When the deep fat must be effectively reached by the EU waves, it must be infiltrated conspicuously to allow a successful cavitation induced by the EU. A thin layer of ultrasonic gel is spread on the skin of the areas to be treated with ultrasound. The ultrasound is then delivered through a 3-MHz probe to treat the superficial fat and through a 1-MHz probe to treat the deeper layers. A 2-MHz probe may be additionally used when we must be sure that all layers are treated. The hand-held transducer delivering the EU is slowly moved on the marked area with slow circular movement or up-and-down movements for 10 min in each abdominal quadrant, 15 min for flank or dorsal flank, 20 min for each external thigh, 15 min for each knee, 20 min for each ankle ,and 15 min for each inner arm. During the delivery of the EU the skin becomes slightly warmer. The movement of the probe is never stopped to avoid prolonged contact with the skin always in the same place, because the heat caused by the energy delivered by the probe might burn it. When treating cellulite and slight irregularities of the skin, the probe for the superficial fat (3 MHz) is applied, but when facing fibrous areas also involving deeper tissues the probes for the deeper fat (1 MHz) should be applied. With the EU machine, with one hand the 3-MHz probe may be used and with the other hand another probe with the same power or with a different one can be used. So superficial and deep fat can be treated at the same time. If we feel it is necessary to treat also the 1–2-cm deep fat a 2-MHz probe may be used, adding some time to the procedure.

When EU is applied prior to the suction, the to-and-fro movements of the cannula are easier and quicker because of decreased resistance of the fat to the penetration through the tissue, the extracted fat is less bloody, more crushed, more emulsified, and oilier. In the early postoperative period the patient shows fewer bruises and less swelling [23, 24].

We do not apply EU to all patients and to all areas because the hand that holds the probe becomes painful after about half an hour. This might raise questions on the safety of the EU for the surgeon's hand. The application of EU adds 15–45 min to the surgery, corresponding to the time needed to deliver it to the first area. Additional time to deliver EU to other areas is not needed because an assistant may apply the EU to the next area while the surgeon starts suctioning. So the use of EU increases operating time and related costs. These considerations led us to restrict its use to the indications mentioned before.

39.9.2.3
Errors of Technique

Irregularities may become evident during the execution of the suction. This is very rare if the progression of the gauge of the cannulae is from small to big, this being a fundamental feature of the SSL technique. In a correctly performed SSL the suction is progressive and thus easier to control than in the classical technique. Anyway if too much fat has been aspirated from a localized point, a depression is visible on the skin. It is possible to correct this problem by simply injecting some fat where needed. It is advisable to aspirate some fat with a syringe at the beginning of the procedure and to keep it there until the end to use it to correct any depression that might become evident. It is advisable to let the collected fat separate from the fluids present in the syringe before injecting it. The fat temporarily stored in the syringes must be aspirated from an area where EU has not been applied, otherwise the fat to be grafted would be less useful, having been crushed by the ultrasound wave.

39.10 Dressing

A small Band-Aid is applied to every stab incision. Reston foam is applied to treat areas of the trunk for 2 days. Elastic stockings for the lower limbs and elastic garments for the trunk are applied at the end of the surgery.

39.11 Postoperative Care

Antibiotics are given routinely at the beginning of the surgery and are continued 6 days after surgery. Early ambulation is encouraged to prevent venous thrombosis. Elastic garments are worn for 6 weeks as already described in the section “Patient Information”. Endermologie treatment and/or lymphatic vein massages are routinely indicated after 20 days. A well-balanced diet is prescribed including 2 l of fluid intake.

39.12 Complications

Complications of SSL are very rare. Parasthesias is the more frequent (0.5%) and is the consequence of nerve injury when performing the suction. It sometimes may be permanent and is more frequent in the limbs. Waves and irregularities require further touch-ups after many months, at least six, when it is possible to evaluate the result and correctly indicate the treatment.

Infections are also very rare, and include two cases of slight inflammation with erythema of the skin that healed in a few days after antibiotic therapy. Two patients that had been grafted with between 200 and 300 ml of fat developed an inflammation after the first week and were also successfully treated with antibiotics. We had no cases of thrombosis. Two seromas formed in abdominal liposuction after an attempt to use larger-gauge (1-cm) cannulae to speed the suction time. This confirms that if the SSL technique is correctly performed there is no seroma formation and the procedure is highly reliable.

No complications were ascribed to the use of EU.

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40 External Ultrasound Before and After Tumescent Liposculpture

William R. Cook Jr.

40.1 Introduction

Ultrasonic medical devices have been used as a diagnostic and therapeutic tool for a number of years. Ultrasound has been used in neurosurgery, otolaryngology, ophthalmology, and urology, to name a few specialties, and has proven to be extremely useful and safe [1, 2]. Its use in physical therapy applications is well established [3]. Ultrasound has been used by cosmetic surgeons postoperatively to reduce swelling after liposculpture, and more recently it has been used intraoperatively or preoperatively as well.

After the development of tumescent liposculpture by Klein [4], the application of ultrasound to liposuction surgery became a possibility, because ultrasonic energy requires a fluid medium to be transmitted and the tumescent fluid provides such a medium. Zocchi [5–7] of Italy first conceived the concept of applying ultrasonic energy to adipose tissue in the late 1980s.

Ultrasound may be applied either internally or externally. Internal ultrasound, such as that used by Zocchi, utilizes a special probe or cannula, which generates the sound waves while inserted in the patient's body through the liposuction incisions. Thus, internal ultrasound is applied during the actual liposuction procedure. External ultrasound uses a flat, round transducer that is held against the skin in the areas to be treated. External ultrasound may be used on tumesced areas immediately before liposuction to facilitate the procedure, or on follow-up visits during the postoperative period to speed healing.

The application of ultrasonic energy to the adipose tissue effectively liquefies the fat, releasing a combination of triglycerides, normal interstitial fluid, and the infused tumescent solution. These components form an emulsion, which can be removed using vacuum suction. Because of the predilection of the ultrasonic waves for low-density tissue such as fat, there is felt to be a selective targeting of the fat cells without affecting the intervening connective tissue and neurovascular structures. The depth of penetration is inversely proportional to the frequency used. It is felt that ultrasonic energy affects the adipose tissue via several mechanisms: thermally, micromechanically, and through the phenomenon of cavitation. Internal ultrasonic liposuction primarily utilizes the principles of cavitation. The exact mechanism by which external ultrasound affects fatty tissues is not currently clear; however, it is felt to be a micromechanical effect [8].

The author has utilized internal ultrasonic liposuction in the past; however, there have been many reports of complications with this technique [9–13]. Reported complications have included perforation of the abdomen, burning of incisional sites and overlying tissue, seromas, poor cosmetic results, and a variety of other complications. It is also cumbersome to use the ultrasonic cannula and specialized microcannulas are preferred, which produce consistently excellent results and do not have the side effects associated with internal ultrasound. For these reasons many surgeons have largely abandoned the internal technique. However, some practitioners have had success with limited use of internal ultrasound. For example, Narins [14] reports good results using internal ultrasound for up to 2 min prior to traditional liposuction in fibrous areas such as the abdomen.

Because of the problems associated with internal ultrasound the author has worked to develop the concept of external ultrasound [15]. External ultrasonic energy may be used preoperatively to produce a more favorable result without the side effects and complications associated with internal ultrasound. External ultrasound may also be applied postoperatively to reduce swelling and shorten the recovery course.

Any surgeon utilizing ultrasonic energy for any purpose should be knowledgeable about its usage and side effects as well as possible complications. Also, any ancillary personnel should be adequately trained and experienced in the use of ultrasonic devices.

40.2 Preoperative External Ultrasound

40.2.1 Infusion

Before being treated with external ultrasound prior to liposculpture, the patient must be thoroughly infused with tumescent solution to provide a medium for the conduction of the ultrasonic waves. The author uses two solutions for tumescent infiltration [16].

1. A 0.1% lidocaine solution containing 1,000 mg/l lidocaine (0.1% concentration), 1 mg/l epinephrine (1:1,000,000 concentration), 10 mEq/l sodium bicarbonate, and 10 mg/l triamcinolone acetonide (Kenalog). This solution is made up by taking 1,000 ml of sterile normal saline solution (0.9% NaCl) in an infusion bag and adding 10 ml of 8.4% sodium bicarbonate (1 mEq/ml) and 50 ml of 2% lidocaine (20 mg/ml). Immediately before infusion add 1 ml epinephrine (1 mg/ml or 1:1,000) and 1 ml triamcinolone acetonide (Kenalog, 10 mg/ml).
2. A 0.05% lidocaine solution containing 500 mg/l lidocaine (0.05% concentration), 1 mg/l epinephrine (1:1,000,000 concentration), 10 mEq/l sodium bicarbonate, and 10 mg/l triamcinolone acetonide (Kenalog). This solution is made up by taking 1,00 ml of sterile normal saline solution (0.9% NaCl) in an infusion bag and adding 10 ml of 8.4% sodium bicarbonate (1 mEq/ml) and 25 ml of 2% lidocaine (20 mg/ml). Immediately before infusion add 1 ml epinephrine (1 mg/ml or 1:1,000) and 1 ml triamcinolone acetonide (Kenalog, 10 mg/ml).

The sodium bicarbonate and lidocaine can be added to the infusion bag up to 24 h in advance of surgery. However, the epinephrine and triamcinolone are added just prior to infusion. This is important to ensure the effectiveness of the epinephrine as a vasoconstrictor.

Each bag must be carefully labeled with its exact contents with the date and the initials of the individual who made the solution. Also, the infusion bag is heated to approximately 39–40°C in either a warm-water bath or a microwave oven prior to infusion.

It is important to plan the amount of lidocaine that will be infused in a particular case. The estimated maximum allowable amount of lidocaine should be between 55 and 60 mg per kilogram of body weight. The physician should be well versed in the use of lidocaine, the lidocaine levels that are achieved, and the toxicity of lidocaine [17].

40.2.2 Technique

The liposculpture patients receive external ultrasound preoperatively to all body and neck areas, with the exception of very thin necks. The Rich-Mar external ultrasound unit (Rich-Mar, Inola, OK, USA) is used (Fig. 40.1). The energy applied is 1.0 W/cm^2 to body areas and 0.5 W/cm^2 to the lower face and neck, using a continuous wave at 1 MHz. The unit pictured has two transducers, one 10 cm in diameter for body areas and the other 5 cm in diameter for neck areas.

The transducer should never be static. It should always be moved slowly and continuously in a circular fashion over the areas to be treated. Ultrasound is applied for 10–15 min per body area (Fig. 40.2). To achieve the best conductivity of the ultrasonic energy between the transducer and the patient, a sterile ultrasonic gel is used (PolySonic Ultrasound Lotion, Parker Laboratories, Fairfield, NJ, USA). In particularly fatty areas, moderate pressure can be applied to the transducer. Care should be taken never to apply

Fig. 40.1. Rich-Mar ultrasound unit

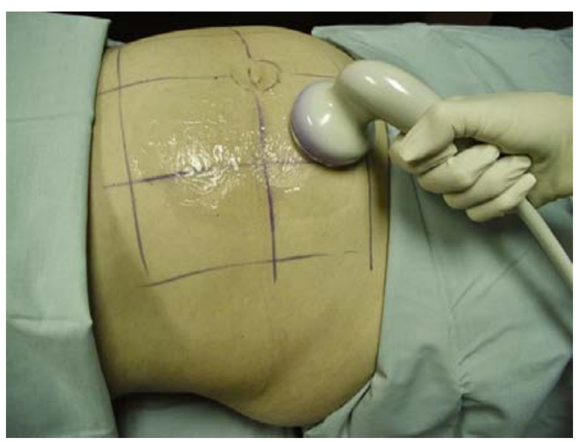

Fig. 40.2. Applying external ultrasound before tumescent liposculpture

the ultrasonic energy to bony areas or to areas that have not been tumesced. The probe should never remain still on the body.

In one study of 30 patients [15], preoperative external ultrasound was administered to one side of the body and not the other. Only the nursing staff was aware of which side had been treated with the external ultrasound. Both the surgeon and the nursing staff recorded their observations as to swelling, bruising, discomfort, and recovery time comparing the treated and untreated sides. The surgeon also noted the comparative ease of cannula movement, time of surgery, and consistency of the fatty aspirate. The cannulas proved to be easier to move and the time needed for the surgery was slightly less on the treated side. Patients had equally good cosmetic results on both sides. There was less bruising and swelling on the ultrasound-treated side, and the majority of patients reported less discomfort on the treated side. A temperature probe was utilized during this study because of an initial concern that the temperature might rise owing to the ultrasonic treatment. However, the temperature was actually slightly lower on the treated side. It was felt that this was probably due to decreased circulation in the area caused by the vasoconstrictor in the tumescent solution. No complications were noted during this study, and no complications were observed during continuous use of ultrasound in the years since the study [18–22].

The use of preoperative external ultrasound has been an important advance in liposculpture surgery. It facilitates the procedure for the surgeon, causes no demonstrable side effects, and gives the patients a rapider recovery with less postoperative swelling.

40.3 Postoperative External Ultrasound

40.3.1 Indications

The author has used external ultrasound treatment postoperatively for selected liposculpture patients since 1990. The use of postoperative ultrasound decreases swelling and discomfort, promotes rapid healing, and is high in patient satisfaction. The author has experienced no complications from the postoperative use of ultrasound.

Only patients who are symptomatic and show firm or persistent swelling are treated with postoperative ultrasound. Treatment is begun 1 week postoperatively on average and is continued on a weekly basis as necessary. In areas that are significantly indurated, the sites may be injected with 1–5 ml triamcinolone (Kenalog), 1–5 mg/ml, prior to treatment with ultrasound. If induration does not respond to this treatment, the concentration of the triamcinolone may be increased.

40.3.2 Technique

For postoperative application of ultrasound the Rich-Mar ultrasonic unit is used. For body areas, 1.0 W/cm^2 is used and 0.5 W/cm^2 is used for the face and neck, using a continuous-wave setting at 1 MHz.

The ultrasonic probe is moved in a gentle slow circular rotation. No excessive pressure is required. To conduct the ultrasonic waves, a clear ultrasonic gel or lotion is utilized. The gel provides a more fluid surface to facilitate movement of the probe; however, patients prefer the less sticky feeling of the lotion.

The application of ultrasound to a given area should be started at one point and continuously moved through slow rotations to other points until the entire body area has been treated, then the application should be started again at the original point and the process repeated for 5–10 min per treatment session. Treatment is generally given on a weekly basis until swelling and/or discomfort are resolved. It is important to avoid bony areas and neck cartilage while applying ultrasound.

This technique has been shown to reduce postoperative discomfort and swelling and to improve the recovery process in patients with firm or persistent postoperative swelling (Fig. 40.3). There may be other benefits as well. Narins [14] has reported that postoperative external ultrasound can help to eliminate postoperative vertical folds in the neck.

There have been reports that postoperative external ultrasound may not be useful for all liposuction patients [23]. However, the consensus is that this is a very useful modality for properly selected patients, namely, those with firm or persistent induration or swelling [24]. In such patients, postoperative external ultrasound can speed recovery and improve patient comfort.

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Fig. 40.3. a Prior to procedure. **b** Two months postoperatively

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Part VII
Power-Assisted

Powered Liposuction Equipment

Timothy Corcoran Flynn

41.1 Introduction

The practice of tumescent liposuction involves refinement in technique and improved technology. New equipment is developed almost yearly, and old designs are regularly improved upon and modified. For example liposuction was initially performed using large (approximately 6–10 mm in diameter) cannulas. Over the years, thinner and thinner cannulas were used with many procedures now being performed using 2–3-mm diameter cannulas. A variety of cannulas are available in different designs, and newer very small cannulas (e.g., 20 gauge) are now available for small areas such as the face. Yet not all new developments are ultimately proven superior. Many authors believe Ultrasound technology was applied to liposuction without any significant improvements. In fact, the use of cannulas outfitted with ultrasound transducer tips was associated with an increased instance of seromas as well as cutaneous burns. Most dermatologists have largely abandoned ultrasound technology.

One advancement which is a nice addition to the practice of tumescent liposuction is the use of powered instrumentation [1]. This chapter discusses the development and current status of powered liposuction instrumentation.

41.2 Development of Powered Liposuction Technology

The concept of using mechanical instrumentation with liposuction technology is actually as old as liposuction itself. The brilliant surgeons Giorgio and Arpad Fischer introduced the concept of liposuction in combination with instruments they developed, which they called the “cellusuciatome” [2]. The Fischers’ early instruments contained blades with moving internal components designed to cut fat when it was aspirated into the cannula. Later, blunt cannulas were developed with side ports and other designs that aspirated fat with little blood loss. The idea of powered instrumentation lay dormant.

Charles Gross revisited the idea in the 1990s. Using an existing cannula which had an exposed internal blade driven by a motorized handpiece, he modified the instrument for use in fat removal. His “liposhaving” procedure was an open technique in which the fat-harvesting unit was used for neck liposuction using submental incisions. Fat cells could thoroughly be removed from the platysma to allow for an even and complete fat extraction.

William Coleman, working with the Xomed Corporation, furthered ideas in this realm. Other designs explored the use of a rotating blade found within liposuction cannulas. Experiments revealed that an oscillating system in which the blade made several revolutions clockwise and several revolutions counterclockwise worked better than one with continuous unidirectional revolutions. There was a theoretical concern about increased bleeding. It was also found that these techniques tended to occasionally trap fibrous tissue which could become lodged and restrict blade movements. A few possible complications such as seromas or bleeding from a small varicosity were reported.

The oscillating cutting cannulas however did demonstrate decreased work on the part of the liposuction surgeon. This led to the development of a number of reciprocating cannula systems. These instruments contained a motor, driven either electrically or by air, which moved the tip of the liposuction cannula forward and backward. These designs have been found to decrease the work of performing liposuction on the part of the surgeon and increase the rate of fat removal.

41.3 Current Instrumentation

Several powered liposuction instruments are currently available. Most are driven by electric motors but air-driven models are also available (Fig. 41.1). All of these instruments use motors to drive the cannula in a forward-and-backward motion, assisting the cannula in removing fat. The author published a paper evaluating currently available instrumentation in 2002 [2]. Instruments were assessed clinically by the author, and an independent engineering firm measured each instrument. Laboratory measurements such as the degree of torque, amount of heat produced, size and weight, amount of torque force, and degree of vibration were among the measurements taken by the independent engineering firm. A concise practical description of each instrument was featured.

Stroke force was variable, with instruments having a range of 9.5 30 lb. The noise of the units varied between 60 and 87 dB. Units produced variable heat with surface temperature measurements ranging from 77 to 102°F. Build quality and reliability varied from instrument to instrument. The air-driven devices were not preferred by the author owing to clumsiness in use and loudness of operation. The cost of the units varied, with Byron's disposable plastic handles

Fig 41.1. Two examples of powered liposuction instruments. NuMED's electric hand piece is shown *above*, with Byron's ARC disposable air-driven hand piece *below*

Fig 41.2. The Medtronic PowerSculpt console and hand piece. Note the power cord attached to the electric hand piece and the vacuum aspiration hose attached to the dual side port blunt-tipped cannula

costing as little as US $50 per handle and complete well-built electronic systems such as the Medtronic-Xomed Powersculpt unit costing around US $10,000 (Fig. 41.2).

Coleman [3] evaluated the efficacy of powered liposuction in collaboration with several different authors. Liposuction surgeons had been reporting that they felt there was an increased efficiency in fat removal. This concept was documented in their study, which looked at liposuction performed by surgeons at four different locations. A variety of electrical and air-driven instruments were used. All cannulas were 3 mm in outside diameter. The amount of fat extracted was measured using a mucous specimen trap, widely used by respiratory therapists, in series between the cannula aspiration hose and the aspirator.

The amount of fat aspirated within a 60 second time period was recorded when the cannulas were used in either the "power on" or the "power off" mode. In this study, an overall 30% increase in extraction rate was noticed in the powered versus the non-powered mode. The data were subdivided to indicate that the increased amount of fat extracted was higher for surgeons who had experience with the powered instrumentation. For those surgeons who had performed eight or more powered liposuction cases, there was a 45% increase in fat extracted in the powered mode compared with the non-powered mode.

As an additional component to the study, patients were queried as to their preference of powered versus non-powered liposuction. Fifty patients responded with 27 (54%) preferring powered liposuction and 23 (46%) not having a preference. Importantly, no patient preferred the non-powered technology. The patients commented on the "comforting" feeling that the vibration gave them during the procedure.

In Coleman's study, differing sties had different improvements in the amount of fat harvested using powered liposuction. The hips demonstrated a 62% increase in extraction rate with the power on. The upper thighs and abdomen exhibited less of a difference with a 48 and a 35% increase in extraction using power, respectively.

Katz et al. [4] performed a powered comparison analysis in 21 patients. Powered liposuction was compared with traditional liposuction by performing powered liposuction on one side of the body and traditional liposuction on the contralateral side. True tumescent liposuction was performed using 0.075% lidocaine with 1:1,000,000 epinephrine. For the powered liposuction side, the NuMed powered device was used fitted with a 3- or 4-mm accelerator-type cannula. The instrument was set to operate at 5,500 strokes per minute. On the traditional liposuction side, identical cannulas were used without power.

Equal amounts of fat and supranatant were harvested on either side. The study documented that the amount of time taken to perform powered liposuction was 35% less than that for traditional liposuction. Intraoperative pain was 45% less for powered liposuction than for traditional liposuction. Surgeon fatigue was 49% less for powered liposuction than traditional liposuction. Interestingly, at 5 days postoperatively, pain, ecchymosis, and edema were 32–38% less when powered liposuction technology was employed over traditional liposuction. At 2 weeks, pain, ecchymosis, and edema were 27–48% less for the side where powered liposuction had been employed than for the side where traditional liposuction had been used. Patient satisfaction with the results was greater for the side where powered liposuction had been employed than for the side where traditional liposuction had been used; however, the surgeons felt that there were no significant differences between the sides.

One seroma was found in the powered liposuction group at 2 weeks and 35 ml of fluid was drained without sequelae. The authors commented that their patients found the vibration of the powered liposuction cannula gentler and more relaxing than the shearing sensation of the traditional liposuction cannula.

Fodor and Vogt [5] compared their technique of power-assisted lipoplasty with traditional lipoplasty. They felt that the powered liposuction technology was better in the ease of fat extraction. They did not find additional benefit. Fodor and Vogt were using a power cannula, which was driven by nitrogen gas, and having a stroke distance of over 2 mm. This nitrogen-driven instrument is loud and somewhat difficult to control. Perhaps the authors may have found other benefits if they had used the newer electrically operated devices, which are more elegant and easier to use.

41.4 Advantages and Disadvantages

Those liposuction surgeons regularly using power instrumentation have found an increased rate of fat harvesting. This makes the performing of liposuction more efficient in that a greater amount of fat can be harvested per given time period. When several cases are performed on the same day, this time-saving is greatly appreciated. There is decreased physical work on the part of the liposuction surgeon. These vibrating systems allow the cannula to move through the tissue with greater ease. The vibration seems to assist the cannula in moving through fibrofatty areas such as male pseudogynecomastia. Patients seem to prefer the comforting feeling of the vibrating cannula, and it may be that the vibratory sensation produces counterstimuli that reduce the perception of pain.

Disadvantages include the expense of the instrumentation. Instruments can range from a few thousand to up to US $10,000. Some instruments are loud but the well designed more expensive units are fairly quiet when operating. Initial concerns about vibrational injury to the hands of the liposuction surgeon have been unfounded. When more than one case is done on the same day, the handle which contains the motor to drive the cannula must be sterilized between use. The author has solved this bottleneck by owning one electronic console and two motorized hand pieces so that two cases can be performed in one morning or afternoon.

41.5 Summary

Powered liposuction technology is a nice addition to the practice of tumescent liposuction. Benefits include decreased work on the part of the liposuction surgeon, increased ease and efficiency of fat harvesting, and a patient's preference for the comfort of the vibration. It is a nice instrument for difficult fibrofatty areas. The busy liposuction practice can find multiple benefits from the use of powered liposuction technology.

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42 Power-Assisted Lipoplasty

Ângelo Rebelo

42.1 Equipment

Vibroliposuction is a power-assisted lipoplasty technique. From December of 1997 until June of 2003 over 6,000 vibroliposuctions were performed with this technique by the author.

The system used is the Lipomatic (Euromi, Ensival, Belgium) (Fig. 42.1) that works with compressed air. It is switched on and off by a foot pedal, is very easy to handle, weighs less than 600 g, is easy to clean and wash, and can be sterilized in an autoclave or other system. Specific cannulas of different lengths and diameters (3–5 mm) can be connected. The passage of air induces movements of "go and come," with a frequency of 10 Hz at 3 bar, and a course of 6 mm [1]. These technical characteristics are one of the main reasons for the author's preference in using vibroliposuction. The cannulas vibrate and have a rotation and translation movement, called nutation. A frequency of 10 Hz corresponds to 600 "go and come" movements each minute. It is very important that the frequency does not exceed this value too much because for higher frequencies the course of the piston must be smaller than 6 mm. This combination of higher frequency and smaller course results in higher potency, which is very dangerous when working in small and delicate areas (knees, chin, etc.), and a smaller nutation, which is not convenient because the system becomes very slow and very time consuming in big areas. Lipomatic has a lower frequency and longer course. Any kind of source for the air (compressor, bottle, or any other) can be used. The goal is to break down the fat so that it is emulsified and aspirated at the same time.

Fig. 42.1. Lipomatic vibroliposuction equipment

42.2 Strategy

Vibroliposuction is mostly used under local tumescent anesthesia since general or epidural anaesthesia contains the drugs that may affect bleeding. Local tumescent anaesthesia is safer and much better vasoconstriction can be achieved. Risks are reduced to a minimum, the patient can collaborate making the surgery more easily, and the costs are lower. Generally, the patient comes to the clinic and 3 h later leaves with the surgery completed.

Liposuction of more than one anatomical region depends on the amount of lidocaine to be used according to Klein's [2–6] formula which is the basis for our local tumescent anaesthesia. The maximum dose of lidocaine we have used is well below the maximum dose recommended by Klein. It is safer and more comfortable for the patient to perform vibroliposuction in more than one session, if indicated. Patients recover quickly and are returned to normal activity sooner than with traditional liposuction. It is rare for the author to spend more than 2 h on a surgery even with large-volume liposuction or associated procedures. The mean time between administrating the anaesthesia and completing the vibroliposuction is between 45 min and 2 h.

Patients are prepared for surgery with premedication that consists of 50 mg hydroxyzine, 2.5 mg lorazepam, and 250 mg lisine clonixinate taken orally 1 h before the surgery.

42.3 Procedure

42.3.1 Preparation

Preoperative photographs are taken as well as measurements and weight prior to surgery. The patient's skin is sterilized with a solution of povidone-iodine (wash solution and dermal solution 50/50). For vibroliposuction of the abdomen the patient lies down on the surgical table and the disinfectant is applied with the aid of sterilizer forceps. For other areas, where the patient is to move during the operation (waist, flanks, arms, legs, etc.) the disinfectant is applied in the with the patient in the standing position and the patient lies down on the surgical table previously covered with a sterile field.

42.3.2 Tumescence

The tumescent fluid used is based on the Klein formula. To each 1,000 ml of 0.9% saline solution that is heated to 37°C the following are added: 1 ampule of 1 mg/ml adrenaline , 800 mg lidocaine without adrenaline, and 5 ml sodium bicarbonate

More than 2 l of solution is rarely used per surgery. For very good vasoconstriction the surgeon should wait at least 30 min. A closed pressure system from Byron with infiltration needles of 1.7-mm diameter is used for tumescence.

The infiltrated volumes are measured and depend on the area to be infiltrated:

- Submental region: 25–50 ml on each side
- Arms: 100–200 ml into each arm
- Breasts: 100–500 ml into each breast
- Flanks: 250–500 ml into each flank
- Abdomen: 200–2,000 ml into each area dividing the abdomen into two or four parts (lower right and left and upper right and left, depending on whether you do the abdomen superior, inferior, or both)
- Gluteus: 80–200 ml into each side
- Hips: 100–500 ml into each hip
- External thighs: 100–400 ml into each side
- Internal thighs: 100–400 ml into each side
- Knees: 60–200 ml into each side

42.3.3 Vibroliposuction

For vibroliposuction different cannula types are used, including Rebelo, Mercedes, and Cellulites, and these may be covered with Teflon or Titaneo. Depending on the area, the different types of cannulas used include:

- Submental region: Mercedes-type cannula (15 cm × 3 mm) and Cellulite-type cannula (15 cm × 3 mm) if necessary.
- Arms: Mercedes- or Rebelo-type cannulas that are 20-, 25-, or 30-cm long and 3 or 4 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.
- Breasts: Mercedes- or Rebelo-type cannulas that are 15-, 20-, or 25-cm long and 3 or 4 mm in diameter.
- Flanks: Mercedes- or Rebelo-type cannulas that are 20-, 25-, or 30-cm long and 4.0 or 4.5 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.
- Abdomen: Mercedes- or Rebelo-type cannulas that are 20-, 25-, or 30-cm long and 3, 4, or 4.5 mm in diameter. A Cellulite type cannula with the same dimensions can be used if necessary.
- Gluteus: Mercedes-type cannulas that are 15-, 20-, or 25-cm long and 3 or 4 mm in diameter. A Cellulite-type cannula with same dimensions can be used if necessary.
- Hips: Mercedes- or Rebelo-type cannulas that are 20- or 25-cm long and 4 or 4.5 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.
- External thighs: Mercedes- or Rebelo-type cannulas that are 20-, 25-, or 30-cm long and 4 or 4.5 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.
- Internal thighs: Mercedes- or Rebelo-type cannulas that are 20-, 25-, or 30-cm long and 4 or 4.5 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.
- Knees: Mercedes-type cannulas that are 10- or 20-cm long and 3 or 4 mm in diameter. A Cellulite-type cannula with the same dimensions can be used if necessary.

As vibroliposuction emulsifies the fat it can be seen that the aspirated volumes are smaller than the ones in the traditional methods; nevertheless, it depends on the size of the area to be treated.

The areas that have been treated by the author are in Fig. 42.2. The medium infiltrated, the fluid aspirated, and pure fat aspirated are in Fig 42.3. The median time spent doing the vibroliposuction is in Fig 42.4.

42.4 Postoperative Care

Immediately after the surgery and in the postoperative period patients use moderate compression. They can take a daily shower. On the day after the surgery they are started on a program of 12 manual lymphatic drainages, three times a week. This helps the recovery: it reduces swelling and bruising faster.

Medication after surgery consists of an oral antibiotic, an anti-inflammatory, and an analgesic (rarely used). Massage is recommended with an anti-inflam-

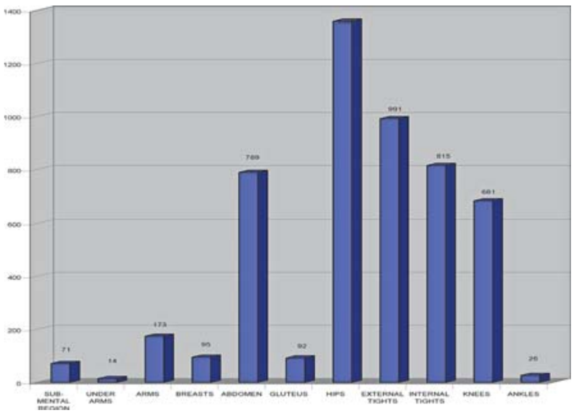

Fig. 42.2. Areas that have been treated by the author

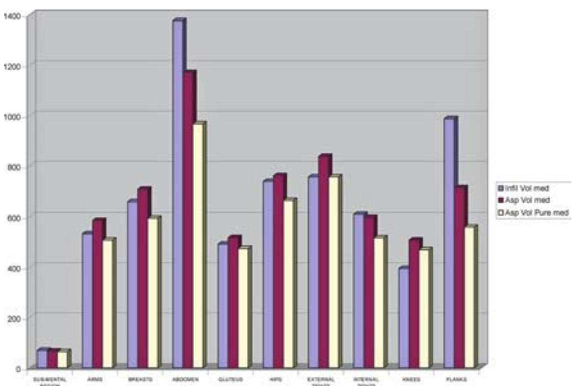

Fig. 42.3. The medium infiltrated, fluid aspirated, and pure fat aspirated

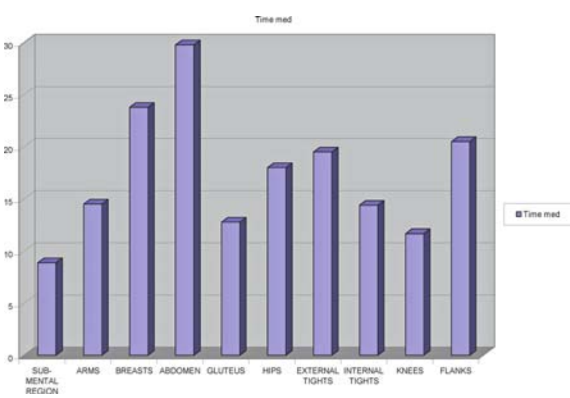

Fig. 42.4. The median time spent doing the vibroliposuction

matory cream twice a day until the bruising disappears or for a period of about 2 months. Sun-block protection is recommended on the small scars and ecchymoses.

42.5 Discussion

The best indicator for vibroliposuction is localized fat and localized lipodystrophy regardless of size. Genetic origin of fat accumulation in women is localized in the abdomen, hips, thighs, and knees and in men in the chin, hips, and breast. All other regions can be treated by vibroliposuction but the results are better in the genetic accumulation regions (Figs. 42.5–42.6).

Liposuction requires excessive physical effort to be expended by the surgeon and this reflects on the number of patients that can be operated on in a working day. The surgery is long and tiring in the ultimate analysis and this can jeopardize the final results.

Many surgeons refuse to perform liposuction/liposculpture because of the sheer physical effort involved, while age and physical disability can be factors. Vibroliposuction solves all those problems because the surgeon is not fatigued even after three or four vibroliposuction procedures. This allows more daily surgeries.

Vibroliposuction is without a doubt an important development. It is safe and efficient with no contraindications and no special maintenance. It is easy to perform, results are good, there are fewer problems and risks, and there are no technical problems. There is less swelling and bruising, with faster and better recovery for the patient.

42.6 Conclusions

Over the past few years, the most important aspects in liposuction/liposculpture are the syringe, the tumescence, the diameter of cannulas, and the level of depth and technology. Technology does not replace the surgeon but it helps resolve situations with better results and fewer complications. Regardless of the technique used, the clinical history, preoperative examination, correct and recent diagnoses, surgical proposal, and good planning are important. Good results are a combination of the happiness of the patient and surgeon and realistic expectations achieved by both.

Vibroliposuction has the following advantages:

1. For the patient:
   - Less traumatic
   - Less swelling
   - Less ecchymosis
   - Quicker recovery
2. For the surgeon:
   - Less tiring
   - More versatile
   - Easy to execute
   - Technically easy

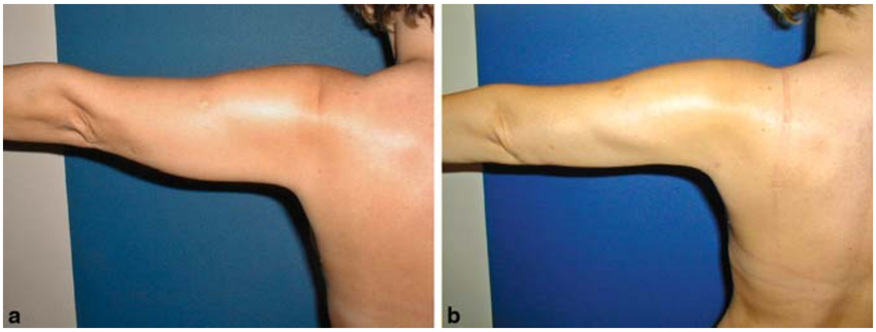

Fig. 42.5. **a** Preoperative 40-year-old female patient with fatty arms. **b** Postoperatively after vibroliposuction of the arms removing 50 cc of emulsified fat

Fig. 42.6. **a** Preoperative 30-year-old female patient. **b** Postoperatively following vibroliposuction of the hips, external thighs, internal thighs, and knees with removal of 1,600 ml of emulsified fat

Acknowledgements Portions of this work are reprinted from Rebelo [7] with permission from the *International Journal of Cosmetic Surgery and Aesthetic Dermatology*, Mary Ann Liebert, Inc.

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43 Safety Protocols for Power-Assisted External Ultrasonic Liposculpture

Robert A. Shumway

43.1 Introduction

Safety is no accident! A well-planned liposculpture surgery always requires thorough preparation and forethought. Therefore, it only makes sense that a liposuction safety protocol should exist. These guidelines should be based on experience, facts, and sound judgment in order to help achieve excellent clinical results. There truly have been great technological advancements in liposuction and this necessitates education and caution. Technology has a way of complicating things. As a result, a "useable" safety protocol is particularly important when aesthetic surgeons couple power-assisted lipoplasty (PAL) with external ultrasound-assisted lipoplasty (E-UAL) technologies. To understand the importance of liposuction safety, a review of the history of its evolution is most appropriate.

43.2 History

In the early 1970s, suction-assisted lipoplasty began to appear in peer-reviewed literature. Several physicians are cited with being the "first" to develop this popular cosmetic procedure. Yves-Gerard (Paris, France) and Giorgio Fischer (Rome, Italy) were certainly great contributors to the art of liposuction [1]; however, Joseph Schrudde (Cologne, Germany) is often called the "father of lipoplasty" for his work published in 1972 [2]. To their credit, by the year 2000 more than 375,000 liposuction procedures were being performed each year in the USA, making liposuction the most popular cosmetic surgical procedure performed in America. As liposuction became more popular, the US Food and Drug Administration (FDA), in 1984, requested clinical proof that liposuction devices were indeed safe and effective.

In 1985, Klein developed a revolutionary tumescent technique [2], which largely eliminated the risk of blood loss or the need for general anesthesia. He discovered that by infusing normal saline with low concentrations of lidocaine and epinephrine into localized fatty deposits, a physician could perform liposculpture safely under local anesthesia. The "super wet" technique (preinjection of tumescent fluid volume equal to the volume of fat to be removed) was used in 1986 to help increase the safety of the tumescent approach [1]. It was understood that serious electrolyte and body fluid imbalances were less likely to occur by eliminating overinjection of the anesthetic solution. By 1989, another liposuction milestone occurred, the FDA actually reclassified liposuction equipment into a lower risk category of medical devices.

By 1995, UAL started a new era of high technology in liposuction surgery [2]. E-UAL technology and techniques were soon to follow which offered advantages in removing fat from fibrous tissues, increasing skin contracture and reducing tissue trauma. In 1998, PAL appeared which reduced surgeon fatigue and decreased operating time when compared with traditional techniques [3]. Today, VASER-assisted lipoplasty, another version of UAL, is presently being developed [3, 4]. New modalities under investigation include low-level diode laser assisted liposuction and internal Nd:YAG laser assisted liposuction [5]. However, the most important question that we all must ask ourselves regarding any new technology is, "Is it safe?"

43.3 Safety History

As new techniques and instrumentation were introduced, physicians began removing greater amounts of fat with a greater incidence of complications in some groups of physicians. Also, as the popularity of lipoplasty increased, the media, state medical boards, and some physicians questioned the safety of the procedure. By 1997, several task forces from different medical organizations were created by liposuction surgeons to investigate current lipoplasty safety and to develop guidelines of safety [6]. Their research led to increased efforts to educate physicians who perform liposuction about risk-reduction protocols when performing these operations. In general, the research supported the following safety protocol concepts: (1) using strict patient selection criteria, (2) limiting operating room time, (3) avoiding extensive volumes of tumescent fluid, (4) removing less fat, (5) avoiding combination procedures with lipoplasty, and (6) using careful preoperative and postoperative monitoring [1].

43.4 External Ultrasound-Assisted and Power-Assisted Liposuction Safety

Using E-UAL and PAL together simultaneously is a topic that will be discussed and debated for years. However, close adherence to the existing 2003 Guidelines for Lipo-Suction Surgery (Table 43.1) formulated by a joint ad hoc Committee of the American Academy of Cosmetic Surgery (AACS) and the American Academy of Lipo-Suction Surgery will definitely help insure patient safety when performing these or other types of liposuction procedures. The safety guidelines help establish specific physician protocols that can also work well with other types of surgical contouring procedures, including skin "tucks" and abdominoplasty. Since combination procedures do increase the overall risk of having surgical complications, strict observance of these guidelines becomes even more relevant. For example, using high-technology liposuction techniques and fusing E-UAL with PAL with abdominoplasty require operator caution and surgical drains to eliminate the possible development of a seroma or hematoma. Be aware that this ultrasonic power approach can remove fat very quickly and produce a potential dead space that needs drainage. It is a very wise idea to follow the 2003 AACS guidelines of removing less than 5 l of supernatant fat to lessen the chance for any form of complication [6].

43.5 External Ultrasonic Lipoplasty

For safety and simplicity, I generally use E-UAL technology rather than internal ultrasound probes. For this technique to be effective, use an external ultrasonic device that can generate between 1 and 3 W of energy per square centimeter of skin surface. Ultrasound can be used before tumescent injection, during tumescent infiltration, and postoperatively to promote healing (Fig. 43.1). Ultrasound was first used as a therapeutic agent in 1955 [7]. More recently, external ultrasound has been shown to accelerate tissue repair and wound healing [7]. There are two types of ultrasound: continuous and pulsed. The continuous mode heats tissue and the pulsed variety does not. Both techniques cause acoustic microstreaming in the tissues, which can result in cell membrane alterations. Because of this, ultrasound selectively destroys the liquid fraction of adipocytes, which accounts for 90% of the adipose volume. This "change" in fat tissue is a result of both the thermal and mechanical effects of ultrasound.

Draper et.al. [7] discussed a protocol of heating fat with external ultrasound that I often use when infiltrating tissue with tumescent fluid. After ultrasound-coupling gel has been applied to the tumesced area, use 3-MHz ultrasound on continuous mode at 2 W/cm^2 for 10 min. The sound applicator is traced back and forth at 2–3 cm/s. The study showed that the average tissue temperature increase from baseline to peak was 7.5°C. The authors also commented that the frequency of the ultrasound beam determines the depth of penetration: the lower the frequency, the deeper the absorption of sound energy [7]. Typically, 1-MHz ultrasound heats tissues 2.5–5-cm deep while 3-MHz ultrasound heats tissues that are less than 2.5-cm deep. Since adipose tissue usually lies over muscle,

Fig. 43.1. a Ultrasound can be performed before and during tumescent infiltration as well as postoperatively to promote healing. Ultrasound warms and drives fluid into the fat and has a warming effect. **b** External ultrasound works well for fibrous areas, previously liposculpted areas, and male gynecomastia

Table 43.1. 2003 Guidelines for liposuction surgery by the American Academy of Cosmetic Surgery

1. Training and education

Physicians practicing liposuction surgery should have adequate training and experience in the field. This training and experience may be obtained in residency training, cosmetic surgery fellowship training, observational training programs, CME accredited post-graduate didactic and live surgical programs or via proctorship with trained credentialed surgeons experienced in liposuction techniques. Post-graduate training should include completion of CME accredited didactic and live surgical training courses approved by the American Academy of Cosmetic Surgery. In addition, training and education should include one-on-one or observational training experiences, in a proctorship or preceptorship setting with qualified practitioners of liposuction techniques.

Surgeons of multiple specialties perform liposuction surgery. Qualified surgeons who practice liposuction surgery should have the necessary skills to perform the procedures and the knowledge to diagnose and manage cardiovascular, surgical, or pharmacological complications that may arise. Surgeons who have received adequate training and surgical experience as either a primary surgeon or co-surgeon as part of their residency do not require attendance at didactic courses, live surgical workshop, or preceptorship. If residency experience is not adequate, the surgeon should complete the three levels of education.

2. Preoperative evaluation

An appropriate documented medical history, physical examination, and appropriate laboratory work based upon the patient's general health and age must be performed on all patient candidates. It is recommended that the guidelines of the American Society of Anesthesiology should be followed for liposuction candidates. Special attention should be given to bleeding disorders, potential drug interactions, history of thrombophlebitis, and other common risks of surgery. Informed consent must be obtained prior to surgery.

Thorough clinical examination should include a detailed evaluation of the regions to be lipocontoured including a notation of hernias, scars, asymmetries, cellulite and stretch marks. The quality of the skin and, particularly, its elasticity, and the presence of striae and dimpling should be evaluated. The underlying abdominal musculofascial system should be evaluated for the presence of flaccidity, integrity and diastasis recti. The deposits of body fat should be recorded. Standardized photodocumentation is strongly recommended.

3. Indications

Indications for liposuction or use of liposuction techniques include removal of localized deposits of adipose tissue. These would include:

1. Body contouring, including the face, neck, trunk and extremities
2. Treatment of diseases, such as lipomas, gynecomastia, pseudogynecomastia, lipodystrophy and axillary hyperhydrosis
3. Reconstruction of the skin and subtissues in flap elevations, subcutaneous debulking, and helps in mobilization of flaps or other conditions
4. To harvest fat cells for transfer (grafting) to provide tissue augmentation, correction or scar defects, etc

Note: Weight loss is not considered an indication for liposuction surgery.

4. Techniques of liposuction

Tumescent: Tumescent infiltration has been shown over the past 15 years to be an important adjunctive technique for liposuction and lipocontouring, with the improved safety, fastest recovery time, and the least number of complications in the liposuction patients. Not only has infiltration of large volumes of dilute local anesthetic (lidocaine 500 mg/l) with epinephrine (0.5 mg/l) has been clinically shown to significantly decrease blood and intravascular fluid loss, it is believed to facilitate lipocontouring. (The dosages and amount of the above agent may vary within recognized safe limits. Most recognized authorities define tumescent infiltration as placement of a 1:1 or higher ratio of subcutaneous infiltration to total aspirated volumes. When using the tumescent technique and other forms of infiltration of lidocaine with epinephrine, studies recommend a maximum range of 45–55 mg/kg. The limit of 55 mg/kg should rarely be exceeded. The safe dosage is dependent on the total volume of body fat and size of patient. Small patients with minimal body fat should receive doses at the lower range level. Larger volume patients may receive doses approaching the 55-mg/kg level.

Ultrasonic: Ultrasonic-assisted liposuction (UAL) is a recognized technique that appears to be safe, based on current reported clinical experiences. It is common to use ultrasonic-assisted liposuction in conjunction with conventional liposuction techniques (machine or syringe). Use of ultrasonic liposuction technique is recommended for use by surgeons who have extensive previous experience with use of conventional techniques, and who have received additional education dedicated to ultrasonic-assisted liposuction.

5. Megaliposuction

Megaliposuction is single stage removal of more than 6,000 ml supranatant fat. The American Academy of Cosmetic Surgery recommends serial liposuction for the removal of large volumes of fat, rather that utilizing megaliposuction. Until sufficient data is collected on megaliposuction, its use should be restricted to experienced surgeons performing clinical research in a hospital setting and under the supervision of an IRB (Institutional Review Board).

Table 43.1. *Continued*

6. Recommended volumes of removal

Liposuction surgery, using the tumescent technique, has been demonstrated to be safe for the routine removal of volumes up to 5,000 ml (supranatant fat). Volumes exceeding 5,000 ml should be removed in select patient without comorbidities in an approved operating facility. Recommended maximum volumes should be modified based on the number of body areas operated on, the percentage of body weight removed, and the percentage of body surface area covered by surgery.

Liposuction may be safely performed utilizing tumescent local anesthesia only, local plus IV sedation, epidural blocks, or general anesthesia on an outpatient basis. Liposuctions within the recommended volume range typically do not require use of autologous blood transfusion.

7. Surgical setting

Liposuction surgery may be commonly performed on an ambulatory, outpatient basis in clinic-based surgical facilities, free-standing surgical facilities, or hospital settings. The procedures must be performed using sterile technique. Elimination of microorganisms is vitally important in preventing the spread of infection. It may be achieved by various physical or chemical means, such as boiling, steam, autoclaving, ultraviolet irradiation, or X-radiation. Cold sterilization may not be adequate for liposuction instrumentation. Additionally, the procedures must be performed with routine monitoring of vital signs, oxygen saturation, EKG monitoring, end tidal CO_2 monitoring (if under general anesthesia). IV access is recommended for removal of volumes greater than 100 ml of fat.

The surgeon or other health care provider administering tumescent local anesthesia should be properly trained and qualified to provide the required level of anesthesia. At least one health care provider in the operating room should have adequate training in cardiopulmonary resuscitation techniques (ACLS). In the immediate post-operative period, as long as the patient remains in the facility, there should be an individual immediately available to provide appropriate level of cardiopulmonary resuscitation.

It is recommended that operating facilities have AAHC certification (or equivalent) or function under equal guidelines as those required for such certification. Appropriate and safe management of waste products must be in compliance with current OSHA regulations.

8. Expected sequelae

(a) Common side effects: Edema, ecchymosis, dysesthesia, fatigue, soreness, scar, asymmetry, and minor contour imperfections are expected sequelae

(b) Occasional side effects: Persistent edema, long-term dysesthesia, hyperpigmentation, pruritis, hematoma, seroma, and drug or tape adhesive reactions

(c) Uncommon complications: Skin necrosis, severe hematomas, recurrent seromas, nerve damage, systematic infection, hypovolemic shock, intraperitoneal or intrathoracic perforation, deep vein thrombosis, pulmonary edema, pulmonary embolism (ARDS) and loss of life have been reported.

9. Postoperative care and medications

Post-surgical compression garments including binders, girdles, foam tape, closed cell-foam, and other specialized equipment have been effectively utilized. The use of compression is considered optional, but appears to be most helpful in the first 7 days following surgery. Some surgeons also prefer to facilitate drainage of tumescent fluids after surgery.

Prophylactic antibiotic therapy may be indicated in cases of liposuction surgery. Reasonable early ambulation of liposuction patients is advisable to avoid venous stasis and shorten the post-operative recuperation period.

10. Documentation of care

Patients should have standardized pre-operative and post-operative photographs to document patient condition. Patient's weight should be operative record should include, at a minimum, the following information:

1. Quantity of tumescent fluid infused
2. Total dosages and drugs utilized
3. Total volume of fat and fluid extracted
4. Volume of supranatant fat
5. Technique utilized
6. Type of anesthesia
7. Anatomical sites treated
8. Use of ultra-assisted technique (internal or external)
9. Drains (if placed)
10. Complications should be noted
11. Post-operative garments utilized

Surgeons should review and compare before and after photographs to objectively evaluate the quality and extent of final outcomes. Critical outcome analysis is valuable for surgeon and patient perspectives.

Table 43.1. *Continued*

11. Privileging for liposuction surgeons
Privileging in hospital, ambulatory surgery center, or clinic-based surgical facilities should follow appropriate guidelines required to grant privileges for adding any surgical procedure. The granting of privileges and the determination of competency should be based on a surgeon's education, training, and experience. Surgeons seeking privileges in liposuction should be prepared to submit evidence of completed accredited CME didactic coursework, live surgical conferences, and clinical case experience. Clinical experience may be derived from proctoring or preceptorship training with a qualified, experienced liposuction surgeon for a reasonable number of procedures to adequately determine satisfactory technique and patient management. The proctor or preceptor should have current privileges at an accredited facility (peer review/quality assurance reviewed) to perform such procedures, and be willing, without bias, to observe and evaluate the applicant surgeon. The number of procedures required may be determined at the local facility according to published guidelines, and should be adequate to evaluate pre-operative, intra-operative, and post-operative case management. Confidential case evaluations should be provided, in writing, to the appropriate committee or board granting surgical privileges. Any conflict that may arise between proctor and applicant surgeon should be resolved according to regulations and by laws of the facility and/or hospital. Annually, liposuction surgeons are encouraged to obtain continuing medical education (CME) credits specifically in the field of liposuction and related surgery. This may be in the form of current scientific publication review, videotapes, scientific conferences, courses, or workshops.
12. Recording adverse events
It is the surgeon's duty and responsibility to report any adverse event, including, without limitation, significant morbidity and mortality as required by local or state requirements. Report should also be provided to the surgeon's respective professional organizations, such as the American Academy of Cosmetic Surgery and/or American Society of Liposuction Surgery in order to provide statistical tracking of such events.
13. Disclaimer
The recommendations contained in this document are not intended to establish a standard of care, but serve only as a guideline. The ultimate responsibility of the patient's well being rests on the clinical judgment of the attending physician and surgeon.

I use 3-MHz ultrasound on continuous mode since it will be absorbed in shallow structures, which includes the patient's fat. The extracted fat has the appearance of a liquid cream after external ultrasound has been applied while non-heated areas appear more solid and bloodier in form. In summary, thermal ultrasound appears to make adipocyte cell membranes more permeable, which improves infiltration and liposuction results. Clinically, this advantage over non-ultrasound techniques translates into a very thorough fat extraction, less surgeon fatigue, smoother skin, and less postoperative ecchymosis and discomfort.

Always be careful with the ultrasound applicator headpiece. The diameter of the contact piece will determine how much energy is delivered per unit area. Move the sonophone headpiece across the skin at the rate of 2 cm/s in either a circular or a back-and-forth motion for proper ultrasonic penetration into tissues. There is some general soft tissue heating and fat softening as explained before, so be cautious not to burn skin. Always use ultrasound gel (K-Y jelly is also effective). Fat extraction can be made easier by driving tumescent fluid into fat and by the warming effect. Tumescent fluid can be infiltrated as a cold or a warm solution. I have treated patients successfully with cold injections on one side of the body and warm solutions on the other. My findings have shown that the warm side is easier to liposculpt without an increase in ecchymoses. Warm injections are less painful and can help control core body temperature. Always monitor your patient's body temperature when performing tumescent liposculpture (with or without ultrasound).

External ultrasonic therapy tends to correct minor irregularities, decrease edema, and help prevent long-term induration. Ultrasonic therapy is generally begun 1 week after liposculpture, which helps decrease ecchymosis and can reabsorb tiny hematomas. Use an intensity of 2 W/cm^2 on continuous mode for 10 min per area. Use 20 min for large areas like the abdomen or back. This ultrasound therapy is performed by my staff and allows them to be part of the patient's postoperative recovery. Best of all, it has been shown that fibroblasts are stimulated to increase collagen formation with external ultrasound. The collagen formation helps to accelerate a patient's rate of healing [5].

There are a number of safety protocols to follow when performing E-UAL. Be careful with ultrasound around the carotid artery and always listen for preoperative carotid bruits before any ultrasound procedure. Make a thorough and complete history and physical examination a routine part of your patient selection or elimination protocol. This will reduce the chance of cerebral embolism from loose carotid artery plaques, which is especially true for liposculpture of the neck. Furthermore, neck E-UAL may reduce the need for a facelift according to some authors, but use caution in and around any thin-skinned areas like the neck, brachium, and antibrachium [8]. Thin-skinned areas of the arm or neck can be tightened effectively with external ultrasound techniques, but when extreme laxity is present, lifts and brachioplasties with liposculpture may be required.

43.6 The Need For Power

The development of a user-friendly PAL system has evolved swiftly. The initial systems were gas-driven and noisy. However, more recent electrically driven devices are much quieter [5]. There are two types of power-assisted devices currently in use. The earlier apparatus uses a small, variable-speed motor that reciprocates the liposuction cannula 2–4 mm back and forth at the tip, as if liposhaving fat [9]. The reciprocating motion varies between 800 and 8,000 cycles/min [5]. I like the newest oscillating electric-motor-driven system that can be advanced between 60 720° with an adjustable rotation speed range between 0 and 275 rpm. This oscillating system is highly effective and lightweight [10].

Power E-UAL works well for fibrous areas like the upper abdomen, flanks, previously liposculpted areas, and especially male gynecomastia. A number of physicians use UAL with excellent results in patients with gynecomastia [11, 12]. I have enjoyed enthusiastic results when treating male gynecomastia by using power-assisted E-UAL. However, protocol dictates extreme caution. Do not remove too much fat in men because areolar depression or skin folds can occur. Do not allow men to wear their compression garments for long periods of time. Three weeks is usually sufficient. Create a comfortable compression system to minimize possible seroma pockets, especially if more than 1 l of supernatant fat has been removed. Use small, 2-mm diameter cannulas and a good commercial-grade postoperative compression garment. Follow up with the patient often during the first 4 weeks following the operation.

The PAL technique is no cure-all, but there are certain advantages (and disadvantages). First of all, you must not perform megaliposuction with PAL. Instead, use a staged approach [13]. Remember the AACS 2003 guidelines. Large-volume liposuction in one sitting is too risky. Break up large liposuction operations into smaller, more manageable procedures. Smaller procedures carry many fewer associated complications. Because there is easy fat removal and less surgeon fatigue with PAL, one may be tempted to remove more than 5 l of supernatant fat. Do not take more than 5 l of supernatant fat (see AACS guidelines). Interestingly enough, a number of surgeons believe that PAL actually increases safety by decreasing operative time and lowering the length of postoperative healing time [14, 15]. Also, there is less likelihood for touch-up procedures in one's practice because PAL can be very thorough. Therefore, in the long run, fewer operations are performed.

43.7 The Future: Should We Melt Fat?

Although the use of internal UAL is not covered in this chapter, it will be discussed elsewhere in this book. There are advantages to UAL, but there are also definite limitations associated with this procedure. Cavitation and liquefaction of fat by internal UAL can melt adipose tissue, but it can also produce burns, cause scars, require larger skin incision sites, and destroy non-fatty tissues such as nerves and blood vessels. As with all tools, when used appropriately, UAL can produce great results. And, speaking of melting fat, what about performing multiple injections into our patients using phosphatidyl-chlorine? This involves injecting the product Lipostabil into a patient's fatty tissue over a period of three office visits. The desired effect is to dissolve or "melt" fat. However, the long-term results are "subtle," at best, and Lipostabil is not FDA-approved for the aforementioned use. Unfortunately, the treatments are costly and repetitive. Also, swelling and bruising is very significant the first week after each injection. In short, this rather innovative injectable, "fat melting" therapy will not replace liposculpture.

43.8 Conclusions

What can we conclude about liposuction technologies? First and foremost, always use a thoroughly written preoperative and postoperative liposuction instruction packet to help your patients prepare for surgery. Spend plenty of time with them during the consultation and preoperative sessions. A thorough consent is invaluable to you and the patient. Second, make sure that the patient has properly consented as discussed very nicely in *Medical jurisprudence for the physician, surgeon, and office staff* [16]. Do not make "promises" to the patient about what you can produce or create. If a patient has cellulite, do not promise them entirely smooth skin. Although superficial PAL can improve the skin's appearance, currently there is no permanent cure for cellulite even if you use ultrasound and Endermologie techniques. Thirdly, become good at what you do, take your time, be moderate in your consultation discussions regarding results, and then deliver a better-than-discussed product. Do not make liposuction promises regarding the volume of fat that will be removed or any guarantees regarding postoperative body shape. Make sure your patients have realistic expectations for themselves. Always break up large-volume liposuction operations into smaller ones. On the other hand, small-volume facial liposculpting with small-diameter cannulas of less than 2 mm is an important aspect of the art of surgical shaping. Do not remove too much facial fatty tissue or overinfiltrate your tumescent fluid. It is not what you take out, but what you leave behind that will determine the final result and shape. Finally, observe the 2003 AACS Guidelines for Lipo-Suction Surgery.

Yes, it is true that the use of E-UAL with PAL techniques will allow you to remove fat quickly, more efficiently, and smoothly with less fatigue, but these technologies may not make your liposculpting and body contouring results any better. Excellent results in liposculpture are really up to the individual medical doctor's training, experience, judgment, expertise, attention to detail, and most importantly, the commitment to follow established safety protocols. (Figs. 43.2, 43. 3) Please, always remember *safety is no accident*. We have the power to safely shape our patients and our future by the "quality" of our work.

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Fig. 43.2. a Preoperative patient. **b** Postoperative external ultrasound-assisted liposuction

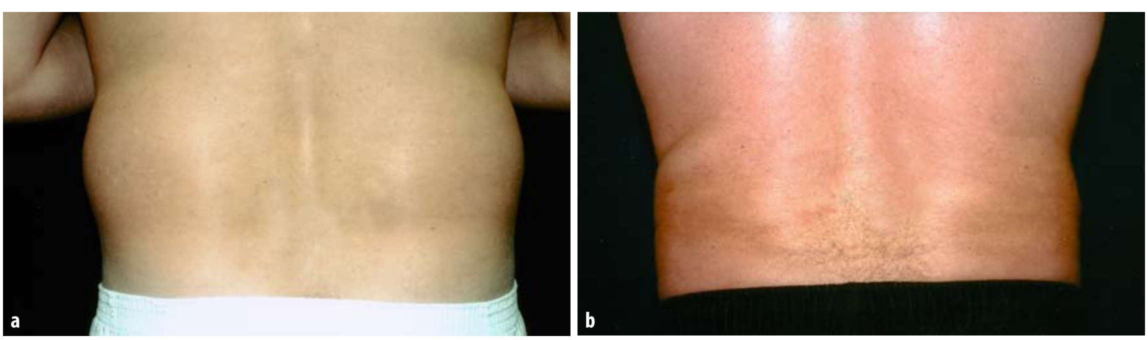

Fig. 43.3. a Preoperative patient. **b** Postoperative external ultrasound-assisted liposuction

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Part VIII
Newer Techniques

Reduced Negative Pressure Liposuction

Michael V. Elam

44.1 Introduction

Never has the interest in liposuction been greater than the present. While tumescent techniques [1] have facilitated the procedure, in some instances patient safety has been compromised. Regrettably, much of the recent media attention has focused on postoperative bleeding, infections, and death associated with liposuction [2]. Even with such unfortunate cases, the overall number of liposuction procedures is so vast the percentage of serious complications probably makes it one of the safest cosmetic surgical procedures.

Today, liposuction is still the most popular cosmetic procedure performed in America. As we enter the twenty-first century, our efforts must be to preserve what we have developed as surgeons while we look cautiously toward the future. A review of the history of liposuction is presented with a simple modification of our past techniques, which has shown enhanced results. By reducing the negative suction pressure to 20 in. of mercury (negative pressure), we have clinically observed a significant improvement in our liposuction results. In a consecutive series of 300 patients, reduced negative pressure liposuction has improved our results and led us to believe that “less is really more.”

44.2 History

The early import of the Illouz technique of lipolysis, or liposuction, was shrouded in mystery, confusion and, in some cases, misinformation [3]. Technical factors that made the French technique of lipolysis effective were sometimes unclear. To inject or not inject and with what solution was the earliest center of controversy. In these early stages, there was a myriad of cannulas available to the American surgeon. The initial 10-mm French cannula imported by Illouz was gradually reduced in size and modified in design. In addition, a number of companies stepped forward and produced vacuum machines of varying degrees of capacity and horsepower to enable American surgeons to reproduce the European results. Since the mid 1980s, certain principles of liposuction surgery have been clearly established and remain consistent over the last decade. The use of tumescent injection with epinephrine, smaller cannulas, and postoperative pressure garments is probably universal in the practices of most liposuction surgeons today. While liposuction has gained universal acceptance, the search continues for improvement.

Over the years, there has been experimentation with a number of different cannula shapes and sizes. American physicians were never pleased with the early French instruments, which were large and difficult to use. The reduction in cannula diameter was both necessary for the surgeon and beneficial to the patient. Small-diameter cannulas are easier to use and are less likely to produce significant postoperative irregularities. The single cannula port was modified, multiplied, and relocated from the shaft to the tip of the instrument. These changes increased the efficiency of the cannula. The predecessor of the modern liposuction cannulas and among the most popular cannulas sold in America today is variations of the Cobra Accelerator type (Byron Medical, Tucson, AZ, USA) developed by American surgeons.

In America, liposuction was extended to treat larger-volume cases. Unlike the early French cases of isolated “saddlebags” treated by Illouz, the American patients often required an overall volume reduction, which treated the entire body. Higher-volume aspiration required more efficient methods of fat removal. Moving the port to the tip of the cannula and reducing the diameter of the instrument definitely increased efficiency. While effective when used aggressively, however, such instruments are also traumatic.

A protracted postoperative clinical course due to swelling is often disturbing to patient and surgeon alike. Prolonged postoperative swelling, edema, and pain are a direct result of tissue trauma. With larger-volume cases, swelling, third-space fluid shifts, and bruising are often a problem. The question of how to best use existing principles of cannula design, tumescent injection, operative technique, and postoperative management is critical in high-volume cases.

44.3 Clinical Evaluation

The objective clinical evaluation of liposuction surgery is sometimes difficult. To accurately measure the results of liposuction surgery requires analysis from many parameters. Postoperative weights, measurements, and skin contour should all be used. The surgeon must often rely on his own subjective parameters to evaluate the patient. Patient satisfaction and revision rate can also provide a key to an individual surgeon's success. While most liposuction patients are pleased, the surgeon must always objectively inspect and evaluate his or her patients in an effort to improve the results.

The final result of liposuction is often impossible to assess until postoperative swelling subsides. This process may require up to 6 months. While postoperative swelling can often mask the final results, excessive bruising, swelling, pain, and edema in the early postoperative period are often hallmarks of the traumatic fat removal. Patients who suffer with such sequelae are sometimes not pleased when the swelling subsides.

Intraoperative fat removal is easier to assess. Each experienced surgeon has his or her own method of intraoperative assessment to use as a guide. Whether they design tunnel patterns, count strokes, measure volume, or palpate tissue all surgeons strive for even removal. Unfortunately, tissue defects created by the overaggressive suctioning, even if recognized intraoperatively, are not always corrected by immediate reinjection techniques [4]. Smooth, even contour should always take precedence over volume of fat removal. In the words of Illouz [5], "It is not so much what is removed that is important, but what is left behind."

Without a doubt, the single most important factor in liposuction is smooth, even removal of fat without damage to the surrounding tissues. Most patients are unwilling to trade reduction of volume for uneven contour or skin that appears loose and wrinkled. Since patients are usually most troubled by the appearance of the skin over their excess fat (which they refer to as cellulite), surgeons who make the skin look worse will not achieve patient satisfaction. Reduction of volume goes unnoticed when the skin over treated areas appears saggy. The surgeon must attenuate fat removal from patient to patient and area to area depending on the skin's ability to contract after surgery.

44.4 Theory

While physicians have attempted to improve the shape, size, and method of the cannula used, little attention has been paid to the ideal aspiration pressure to be used during liposuction. Most of us assume that more vacuum is better. This has always been the American philosophy. So, like teenagers of the 1960s in their muscle cars, we have merrily sped along with our suction machines at full vacuum—the "pedal to the metal" philosophy.

From the introduction of liposuction to America, most, if not all, surgeons have assumed that absolute vacuum or the closest possible level was necessary to make liposuction really work. What if less vacuum is more? What if, by reducing the negative vacuum pressure to less than 29.95 in. of mercury, the process of liposuction worked better? Syringe fat aspiration works quite well. The aspiration retrieved with syringes is usually very clear. With the syringe aspiration technique, surgeons could not even be approaching absolute vacuum. The fact that the effluent from syringe aspiration [6] is transplantable means less trauma must be occurring. Using these related facts, it seemed perfectly reasonable that reduced negative pressure could work.

44.5 Method

In order to test the hypothesis of reduced negative pressure liposuction, all other factors remained constant. Tumescent injection of 1:500,000 epinephrine with 0.1% lidocaine in 0.45% NaCl solution was used. Between 1 and 3 l was injected using a pressure drive device by Byron with an approximate 1:2 ratio of injection to aspiration. General anesthesia was utilized using a combination of intravenous narcotic, Diprivan, N_2O, and paralytic agents. Intraoperative systolic blood pressure was maintained below 100 mmHg. All postoperative factors, including medications, garments, bandages, and patient care, remained the same.

Using a 3.5-mm Cobra Accelerator cannula and a Unitech variable-pressure liposuction pump, the aspiration negative pressure was varied between 15 and 30 in. of mercury during liposuction. It was obvious after a single case that indeed less is more. It was immediately apparent that our cannula worked much better when the vacuum was reduced. In fact, at negative 20 in. of mercury, the 3.5-mm Cobra Accelerator cannula not only removed more fat efficiently but faster with less intraoperative bleeding. The quality of aspiration was essentially a yellow milky emulsion, which contained little blood or air bubbles. The surgeon could quickly fill the suction hose (8 ft in length) with a clear unbroken stream of yellow aspiration. In comparison to the aspiration seen in previous tumescent liposuction surgeries, this aspiration was even cleaner with less blood. While some bleeding occurred with crosshatch tunneling, there was far less bleeding than experienced in the past. Even with aggressive tunneling, it was difficult to produce any significant bleeding from the areas treated (Figs. 44.1, 44.2).

To the surgeon, there was far less resistance as the cannula advanced through the tissue. There seemed to be less grabbing of the surrounding tissues by the cannula port. As the negative pressure was increased from negative 20 in. of mercury to negative 25 in. of mercury, the surgeon felt a greater resistance to tunneling. Above negative 25 in. of mercury an obvious amount of blood appears in the aspiration along with air bubbles. When the machine was turned to full vacuum, the aspiration soon turned to a blood-tinged mixture of fatty globules with significant amounts of dark venous blood. It did not take long to titrate the ideal negative suction pressure for liposuction. To our delight, our hypothesis was confirmed in the first case.

44.6 Observations

The advantages of reduced negative pressure became immediately obvious. It would not be difficult for any experienced liposuction surgeon to reach the same conclusion. Using clinical assessment, the ideal vacuum pressure at sea level is felt to be negative 20 in. of mercury. In 300 consecutive liposuction cases using reduced negative pressure we have seen a remarkable decrease in the amount of bruising, pain, swelling, skin irregularities, and need to touch up treated areas.

There is no question that reducing negative pressure reduces the intraoperative bleeding. Skin in-

Fig. 44.1. a Lipolysis aspiration (tumescent technique) with milky quality aspirate that is almost blood free. **b** Dry liposuction aspiration. Note the blood

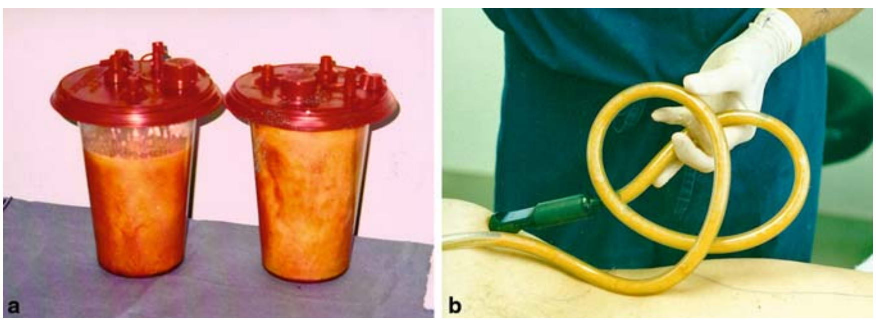

Fig. 44.2. a Reduced negative pressure liposuction aspiration. The aspirate is similar to that produced from the tumescent technique. Note the minimal blood. **b** The aspirate in the suction tubing is essentially blood-free and air-free

cisions bleed far less after the suction operation is complete. It was often difficult to express any blood through the skin incisions after areas had been completely suctioned. Patients have far less seepage from the incisions after surgery. Postoperative bleeding still occurs but to a lesser degree. Intraoperatively, the removal of fat also seems to be much smoother with reduced negative pressure.

In the postoperative phase, far less swelling and third-spacing fluid accumulation occurs with reduced negative pressure. There is less edema and probably less damage to the surrounding tissue. In all patients observed in our study, there was a shorter recovery period with less swelling, bruising, and pain. We have all but eliminated the excessive use of volume expanders (Hespan) in our patients. One hundred percent of the patients treated appreciated the results. Patient gratification was much rapider with far less patient disappointment due to swelling when reduced negative pressure was used.

Patients in our study who underwent revision liposuction all related the new experience with reduced negative pressure as much easier with far less pain, bruising, and swelling than their initial experience with liposuction. More than one patient uttered the words "like night and day" when comparing the experiences. While our observations are subjective in nature, the degree of difference with our past clinical experience is so great as to leave us no doubt.

44.7 Discussion

The vapor pressure of liquids by nature is less than that of solid media. This basic principle of physics can interfere with effective use of liposuction. At high pressure, liposuction seems to favor the removal of blood or liquids over the thicker fat emulsion. If intraoperative bleeding becomes brisk, the surgeon is unable to complete the aspiration process. This concept is especially true in the vascular fat deposits of the chest, arms, back, and hips. Ironically, with reduced negative pressure, these areas of more vascular fat deposits can be treated because the cannula is more efficient in removing fat and not blood during the procedure. Bleeding is rarely reached even at the end point of treatment with reduced negative pressure liposuction.

With reduced negative pressure, the cannula seems to only remove fat in the close proximity to the cannula port. This effluent is without doubt the clearest we have seen. Less damage to the surrounding tissues occurs, especially to the blood vessels. This is evident by the fact that intraoperative bleeding and bruising is reduced. More operator precision is possible because the cannula is easier to use.

44.8 Conclusions

Why negative pressure liposuction is better is not exactly clear. Admittedly, we report our results but lack a precise scientific explanation. By lowering the negative suction pressure, we create more effective fat removal with less surrounding tissue trauma. At near absolute vacuum, the boiling of the aspirate in the collector jar and the hose may actually lower the cannula's efficiency. Above 25 in. of mercury of negative suction pressure, the quality and quantity of the aspirate changes dramatically and the process of liposuction is hampered.

With reduced negative pressure, the cannula glides through the tissue and there is less pull and tug experienced by the surgeon. This fact alone would lead one to believe that the overall process is less traumatic. Whatever the reason, in our hands, reducing the suction pressure to negative 20 in. of mercury has meant significant improvement for our patients.

This chapter should encourage all surgeons to try to find the optimal pressure to use in treating their patients. While cannula designs vary, many surgeons are using a 3–4-mm cannula with a Cobra Accelerator type cannula. We would encourage all surgeons who use such cannulas to reduce the negative suction pressure. Hopefully, like us, they will discover that "less is more."

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Tissue Stabilization in Liposuction Surgery

Gerhard Sattler, Dorothee Bergfeld

45.1 Introduction

Liposuction is a surgical procedure to selectively remove fat tissue. Since its first description in 1975 the method has constantly been improved [1–3]. Today liposuction should rather be called "liposculpturing" as the precise forming of body areas (body contouring) is possible. It is the most commonly performed procedure in cosmetic surgery worldwide. Liposuction surgery has reached a point today where the surgery can offer a predictable, cosmetically highly satisfactory result combined with minimal risk [4, 5].

Patients' expectations today are high. They include hardly any intraoperative or considerable postoperative pain. Postoperatively extensive hematomas or other complications should not occur. Furthermore, patients expect little or no downtime. Postoperative swelling should be minimal and there should not be any skin irregularities.

For successfully reaching the therapeutic goal of complete patient satisfaction and a perfect cosmetic result certain aspects need to be achieved. First of all the main goal is an improvement of the body contour in the meaning of a harmonized body sculpturing.

Besides the contour, the aspect of the skin is essential. The result is only perfect when a corresponding shrinking and tightening of the overlying skin can be achieved.

This means a biophysical challenge to remove fat tissue in a way that should aim at a perfect result and at the same time for the lowest degree of distress of the patient. To reach this aim it is crucial to recognize the various tissue factors (Table 45.1).

Table 45.1. Factors in fat removal

Differing consistencies of the fat lobules intraindividually and interindividually
Thinning dermis over time of aging
Reduced elasticity of the subcutaneous collagen fibers
Different individual changes of bodyweight
Different thickness of the fat layer that needs to be removed

Other important aspects that should be considered are the latest technical standards of liposuction surgery as well as the physiodynamic concept of tumescence liposuction [4].

45.2 Standards of Liposuction Today

Today liposuction in tumescent local anesthesia is the most commonly performed cosmetic procedure worldwide [6–8]. To achieve an ideal healing process with corresponding perfect results, the use of a standardized operation technique is recommended.

Thin, blunt-tipped atraumatic cannulas or vibrating cannulas should be preferred to save the subcutaneous fibrous and connective tissue as well as blood vessels. Powered liposuction with vibrating cannulas has shown to lead to less intraoperative trauma and distress and consequently to better cosmetic results [9–12].

The rationale of the use of vibrating cannulas is the different inertness of the different materials: Whereas the cannula passes fibrous tissue without hurting it, the homogenized fat can be aspirated. Since the speed of the vibrating movement is higher than the speed of the suction force of the cannula, the cannula will escape the tissue structures that have tight attachments.

Vibrating cannulas facilitate the treatment of fibrous or pretreated areas. As they pass easily through the tissue without tangling with the fibres they are making the procedure more comfortable for the patient.

To achieve the necessary interstitial tissue pressure, "supertumescence" with the establishment of high tissue turgor should be reached. Infiltration of the tumescent solution should be done slowly; to save time infiltration can be done parallel with multiple ports at different sites (e.g., by using the Stenger–Sattler distributor) (Fig. 45.1). The solution must be allowed to soak in for at least 30–60 min [4, 5, 13].

During and after infiltration of the tumescent solution certain stages of distribution of the fluid can be recognized (the current concept of physiodynamic and wound healing after tumescent liposuction) [5].

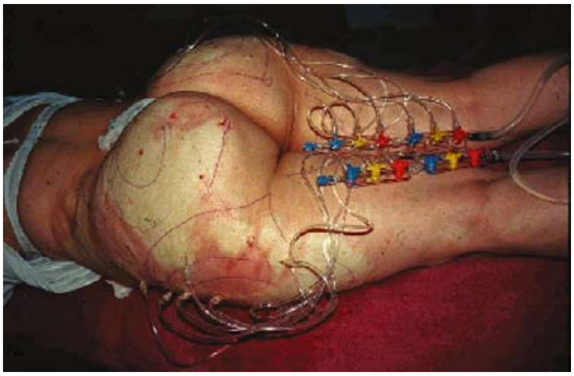

Fig. 45.1. Infiltration of the tumescent solution should be done slowly. To save time infiltration can be done parallel with multiple ports at different sites (e.g., by using the Stenger–Sattler distributor)

Initially there is a suprafascial hydrodissection along the septae of the fibrous tissue. The solution then starts to gather around the fat lobules in the paralobular space. Allowing a penetration time of 30–60 min for the solution will lead to a hydrodynamic intralobular infiltration, which will, as a result of the interstitial pressure and diffusion forces, finally lead to a homogenization of the adipose tissue. This effect is important to facilitate the suction process and to get regular postoperative results. The softened, prepared fat can be aspirated with small non-traumatic cannulas, thus reducing tissue traumatization and destruction of subcutaneous connective tissue, blood and lymph vessels. These structures are essential for wound healing and skin retraction and help create a predictable cosmetic outcome.

When all tumescent solution is drained from the surgery site postoperatively, a process of gradual adherence and shrinking of the subcutaneous wound is initiated that results in a global three-dimensional wound contraction and finally a horizontal subcutaneous scar. Maximum shrinking is normally seen after 4 months; the total time of wound healing continues for up to 18 months. This must always been taken into account when judging the final outcome. In the same process, the shrinking of the connective tissue fibers leads to the retraction of the skin. As a consequence a liposuction surgery with tumescent technique with the correct suction process in all layers of the subcutaneous tissue will cause an "interstitial skin reduction flap." The whole process of healing is significantly determined by the operation technique.

Liposuction must be done in all layers of the subcutaneous space. The correct use of tumescent local anesthesia in combination with atraumatic cannulas reduces friction as far as possible.

45.3 The Role of Tissue Stabilization

The biomedical influence of correct tension of tissue is one of the most important factors in the performance and outcome of a superior liposuction surgery.

After 20–30% of tumescent fluid has been removed during the suction process, the stabilizing effect on the subcutaneous tissue decreases. As a result tissue traumatization rises, which can lead to more pain for the patient intraoperatively as well as cosmetic complications postoperatively.

To compensate the gradually decreasing mechanical stabilization effect of tumescence the concept of a manual skin stabilization technique was developed in cooperation with Guillermo Blugerman from Buenos Aires. The technique is called the manually assisted skin stabilization technique (MASST) and describes the required condition that is needed to serve the intraoperative needs of the surgical field.

A well-trained assistant stabilizes the tissue manually by horizontal fixation. It is important not to distort the tissue or change the anatomical correct conditions to prevent oversuctioning of certain areas (Fig. 45.2).

The ideal effect is to create a constant tension and a maximum of tissue stabilization of the subcutaneous tissue in the area treated. The assisting person must avoid distorting the tissue as this might lead to uneven results.

45.4 Side Comparison Study to Demonstrate the Effects of the MASST

When using the MASST we have seen a number of positive effects on the course of the operation and the postoperative outcome. To verify our observations we investigated certain aspects of the course of the operation in a pilot study with 20 patients. The study was designed as a side comparison using in the same session and the same patients the MASST on one side vs. a non-MASST conventional liposuction technique on the other.

The following criteria were evaluated:

1. Comparison of contralateral sides (areas)
2. Amount of fat removal (liters of supranatant fat)
3. Pain score evaluation by the patient: every 15 min, score from 1 (minimum) to 10 (maximum)
4. Amount of ancillary medication
5. Length of surgery (minutes)

In the study different body areas were treated: nine hips and flanks, seven lateral thighs, two upper arms and two knee and calf areas. The amount of fat removed on average was 1.15 l on the MASST side versus 0.95 l on the non-MASST side.

The individual pain score evaluation of the patients led to an average of 2.9 on the MASST side versus 3.5 on the non-MASST side. When treating the area with the MASST there was a reduced demand for ancillary medication (MASST side 1, non-MASST side 2).

The end point of liposuction surgery is reached when blood starts to dominate the fat aspiration or when the patients start to feel uncomfortable. When using the MASST the surgery could be continued for 35 min on average. In the non-MASST side the end point of surgery was reached after 25 min on average.

With the help of endoscopic liposuction the effects on the tissue of MASST and non-MASST liposuction could be visualized and evaluated. The endoscopic findings confirmed the clinical findings: when using the MASST less trauma to tissue was documented.

45.5 Conclusions

The manual tissue stabilization with the MASST (is a promising new technique and can be recommended in tumescence liposuction. The MASST leads to less tissue trauma, especially vascular structures; therefore there is a greater potential for fat removal. The surgery becomes less painful for the patients. We experienced fewer cases of postoperative circulation instability.

In the postoperative phase less traumatization of fibrous tissue leads to more compact skin texture after wound healing. As a consequence improved cosmetic results can be achieved (Fig. 45.3).

Fig. 45.2. Correct handling of the manually assisted skin stabilization technique (*MASST*) procedure: The aim is to stabilize and fixate the tissue while preserving the correct anatomy of the surgical site

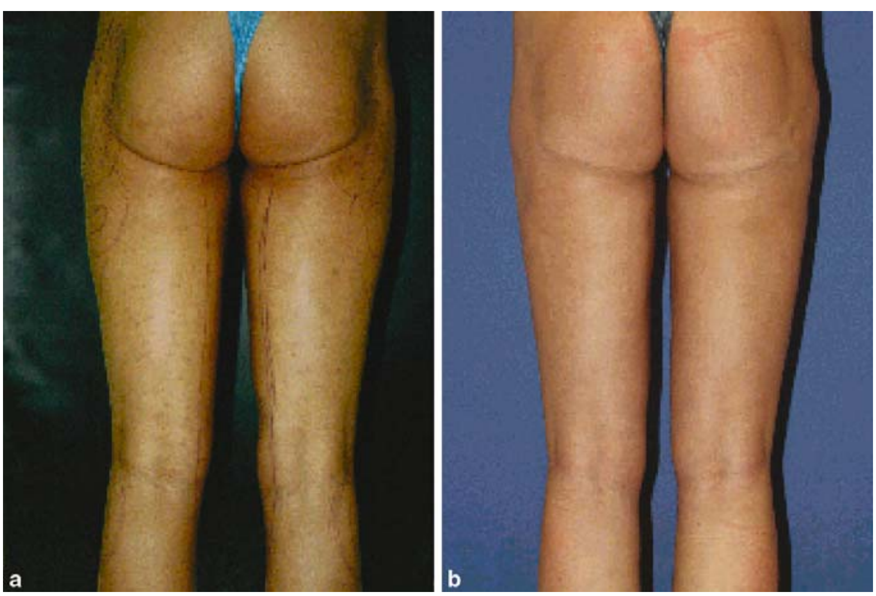

Fig. 45.3. a Patient treated with conventional liposuction with unsatisfactory outcome. **b** Same patient after correction liposuction using vibrating cannulas in combination with the MASST

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External Percussion Massage-Assisted Liposuction 46

Melvin A. Shiffman, Sid Mirrafati

46.1 Introduction

There have been multiple types of instruments utilized to disrupt the fat-connective tissue globules in order to make the task of liposuction easier. Internal ultrasound (ultrasound-assisted liposuction), laser-assisted liposuction, external ultrasound, reciprocating cannulas, rotating cannulas, and even vibrating cannulas have been tried. All of these instruments are expensive, require maintenance, and have their own dangers. The ultrasonic devices cause the fat to appear emulsified and thus it is easier to suction the fat. The reciprocating devices reduce the effort to perform the liposuction. Instead of spending thousands of dollars to purchase machines that emulsify fat globules, the same effect can be achieved with a simple, inexpensive (under US $100) double-headed percussion massager (model PA-1, HoMedics, Commerce Township, MI, USA) (Fig. 46.1) which is made for muscle massage. The percussion massager is used for 5 min over each area to be liposuctioned after tumescent fluid has been infused and prior to liposuctioning. With this technique, the fat can be liposuctioned at low vacuum pressures to avoid injury to vessels and keep bleeding at a minimum.

Fig. 46.1. Double-headed percussion massager

46.2 Preoperative Care

The procedure is thoroughly explained to the patient, including the placing of incisions, the expected size of the incisions, and the areas to be liposuctioned. The risks and complications and alternatives are carefully reviewed with the patient. Postoperative care is discussed.

The patient is started on Keflex, 500 mg, the night before surgery and takes another dose early on the morning of surgery or intravenous cephazolin can be given 30 min before surgery. A prescription for pain medication, usually Vicoden, is given for postoperative use.

46.3 Technique

The patient is marked presurgically in a standing position to outline the areas to be suctioned. General anesthesia, intravenous sedation, sedation-assisted local tumescent anesthesia, or local tumescent anesthesia may be used depending on the patient's tolerance and preference. Intravenous antibiotics are not given if the patient has started the oral antibiotics preoperatively.

The regions that may be included in liposuction are the upper and lower abdomen, hips, and flanks (in order to give the waist a smaller appearance), upper and lower extremities, breasts, arms, and back. Smaller areas of liposuction can include the face (jowls) and neck. The authors' limit for the amount of aspirate is approximately 3,000–4,000 ml in one sitting, although 5,000 ml has been removed in rare instances.

After skin preparation with betadine, each of the points at which the infusion cannula is to be inserted is injected using 0.2–0.3 ml of 0.5% lidocaine with epinephrine (1:1,000) and a small stab wound is made with a no. 11 or a no. 15 scalpel blade. The areas are infused with a solution of 1,000 ml lactated Ringer's solution containing 250–500 mg lidocaine (the smaller dose used for general anesthesia or deep sedation), 12.5 mEq sodium bicarbonate, and 1 mg epinephrine, using enough to cause adequate tumescence. Each area is covered with a sterile towel and the double-headed percussion massager is used over each region for 5 min (Fig. 46.2).

Liposuction is performed with 3.0–4.0-mm cannulas with a Cobra or Mercedes tip in the deep fat layer and 2.5–3.0-mm cannulas with a Cobra or Mercedes tip in the superficial fat for refining the results with a suction machine. Small-volume liposuction of the face and neck or fat removal for fat transfer requires the use of smaller cannulas, 2.0–2.5 mm, and a syringe. The vacuum is kept at 250–300-mmHg negative pressure with a suction machine or, if with a syringe, the syringe is vented by inserting a few milliliters of air or saline prior to use. There is almost no blood in the aspirate with this technique and the liposuctioned fat has an emulsified appearance (Fig. 46.3). The total aspirate from each area and each side is recorded. Usually the ratio of total aspirate to infused tumescent fluid is 1:1. The results are checked with the pinch technique to be sure all areas are equal in width (leaving 1 cm of subcutaneous fat in most areas except face and neck) and softness. Any residual prominent areas are carefully liposuctioned with a 2.0–2.5-mm cannula. The wounds are not sutured except if they are over 5 mm in length. If they are over 5 mm, then a subcuticular suture of 4-0 chromic is used in the mid portion of the incision.

Fig. 46.2. HoMedics percussion massager used for 5 min in each region over a sterile towel

When the procedure is completed, the wounds are covered with sterile 4×4 gauze pads and padded with 1-in. soft polyurethane sheets for distributing the compression equally and at the same time almost eliminating postoperative bruising. There is added compression with a wide abdominal binder to cover the abdomen and all the other areas have a compression garment. Areas not covered by the garments are taped for a few days with stretch tape. Ambulation is begun before the patient leaves the facility.

46.4 Postoperative Care

The patient is seen on the first postoperative day to make sure the garment and tape have not slipped out of position, the wounds are not inflamed, and the amount of drainage is decreasing. Dressings are changed and reapplied with the garment and tape. The patient is given 4×4 gauze pads to apply to any wound that has excessive drainage.

On the next visit, 3–4 days postoperatively, the dressings are changed and the garment reapplied without the padding. If there has been no drainage for 24 h, the patient is allowed to start taking daily showers, changing the bandaid over each wound following the shower. The garment is used for 3 weeks. The patient is then seen at 7 days, 14 days, 1 month, 3 months, and up to 12 months for final evaluation. (Figs. 46.4, 46.5). The examination at 3 months includes evaluation of the results of the liposuction with discussion of any touchup procedure that might be necessary.

Fig. 46.3. Emulsified appearance of the fat following use of the massager prior to liposuction

Fig. 46.4. **a** Bulging abdomen preoperatively. **b** One week postoperatively using external massage-assisted liposuction

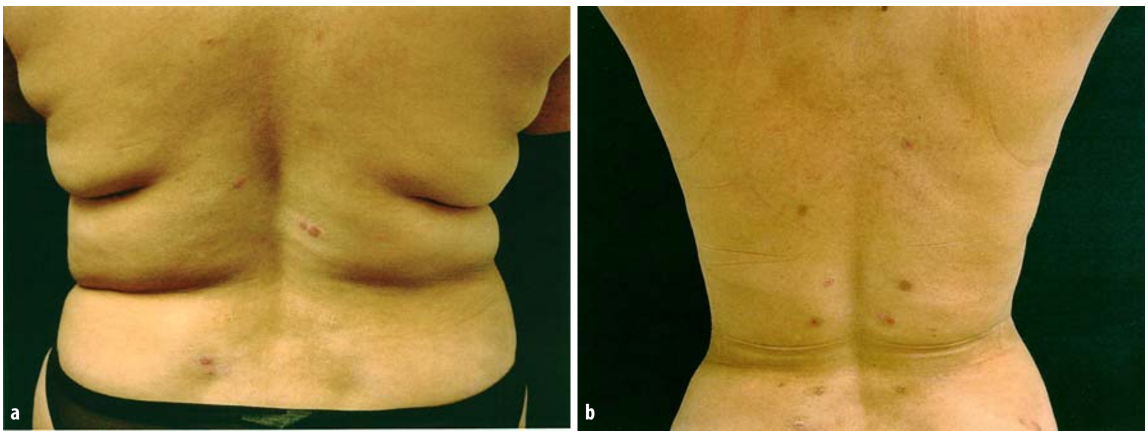

Fig. 46.5. **a** Fatty flanks preoperatively. **b** One week postoperatively following external massage-assisted liposuction

46.5 Discussion

The use of the massager prior to liposuction results in emulsification of the fat and a reduction in the force necessary to perform liposuction. The cost of a double-headed percussion massager is nil compared with the other equipment that is being utilized to do the same thing.

With preoperative massage and low-vacuum liposuction, there is less bruising and postoperative discomfort.

47 Low-Level Laser-Assisted Liposuction

Rodrigo Neira

47.1 Introduction

It is human nature to strive for and look for the best method to obtain an ideal and a human's well-being. In this anxious seeking to find answers to many questions for what is the best for our patients, the author, in collaboration with a multidisciplinary group, has attempted to gain knowledge and research the equipment to elucidate the interaction between low-level laser energy and adipose tissue. All the answers have not been resolved but in the near future and with the collaboration of others, liposuction techniques will be developed that have less risk to the patient.

47.2 History

The author began using low-level laser-assisted liposuction (LAL), large and small volumes, to liquefy the fat and reduce inflammation and pain as well as to have a better and faster recovery of the patients. Low-level laser energy has been used increasingly in the treatment of a broad range of conditions and has improved wound healing, reduced edema, and relieved pain of various etiologies. The laser used for liposuction is an external-beam cold laser, electric diode, with 635-nm wavelength that irradiates adipose tissue at 1.2, 2.4, and 3.6 J/cm^2 [1–5] at 2, 4, and 6-min exposure in each area.

Samples were taken from abdominoplasty tissues treated with a laser and studied by light microscopy, magnetic resonance imaging [6], scanning electron microscopy (SEM), transmission electron microscopy (TEM) [7], physics quantum optics studies, and human cell culture studies [7, 8]. Different biophysical effects were noted in the laser effects on the adipose tissue. After using SEM and TEM, the fat could be seen coming from the inside to outside of the cell [4, 5]. The same effect was noted on treating human cultured cells with a laser. The pores in the adipocyte membrane were noted and an interesting phenomenon with the laser light was seen [7, 8]. It was concluded that the laser light did not destroy the adipocyte but just permitted the mobilization of the fat, keeping the cell membrane in very good condition [7]. This same number of cells could be cultured in vitro. The penetration of laser light, the different effects such as scattering, diffraction, and penetration, and conjugate effects were studied [1–3].

The use of low-level LAL was then tried with the traditional techniques [9]. All of the procedures were performed under local anesthesia assisted by the anesthesiologist [10, 11].

47.3 Laser Energy

Many studies have been conducted on the most efficient use of and the most effective application of laser energy, the results of which were dependent on three factors:

1. Coherent light verses non-coherent light
2. Power
3. Wavelength [4]

47.3.1 Coherent Light

Frohlich [12], in 1968, predicted on the basis of quantum physics that the living matrix (i.e., the sets of protein dipoles) must produce coherent or laserlike oscillations if energy is supplied. The coherent radiation field of a laser and the biochemical energy form the surrounding which provides that energy. Frohlich deduced the existence of an acousto-conformational transition, or coherent photons [13, 14], giving a Bose–Einstein condensate [15].

47.3.2 Optimum Wavelength

Research supports 630–640 nm as the optimum wavelength [16]. Such coherent vibrations recognize no boundaries at the surface of a cell or organism and they are a collection of cooperative properties of the entire being. As such, they are likely to serve as signals that integrate processes such as growth, repair, defense, and the functioning of the organism as a whole. Research on electrically polarized molecular arrays of biological systems reveals that interactions repeated by the millions of molecules within a cell membrane give rise to huge coherent or Frohlich-like vibrations [16–22]. This singular response shows that the components of a living matrix behave like a coherent molecule radiating and receiving signals. In this way, coherent Frohlich excitations in cytoskeletal microtubules have been suggested to mediate information processing [15–17, 21–23].

Similar mechanisms could be evoked to explain low-level laser therapy (LLLT) effects. Nevertheless, the successful use of LEDs in LLLT in the last few years proves apparently that coherence is not an essential light property for the clinical effects of laser therapy [24–26]. It seems to be more important for light propagation and diffusion, producing speckle patterns from inhomogeneous tissues which leads to local heating [27].

47.3.3 Optimum Power

The photochemical energy conversion implies generally the light absorption by special molecular light acceptors. But also the light absorption by non-specialized molecules plays a significant role in medical applications, because of the capacity of molecules to absorb light at certain energies and the possibility of energy transfer between molecules. An activated molecule can cause biochemical reactions in the surrounding tissue. Karu [27–29] established the most essential mechanisms of light–tissue interaction. She noted that, "The photo acceptors take part in a metabolic reaction in a cell that is not connected with a light response. After absorbing the light of the wavelength used for irradiation this molecule assumes an electronically excited state from which primary molecular processes can lead to a measurable biological effect in certain circumstances." Karu analyzed and discussed the most important findings concerning LLLT. In explaining the experimental results, she concluded "that one key event among the secondary reactions of cellular responses was the change in overall redox state of the irradiated cell," so "that the cellular response is weak or absent when the overall redox potential of a cell is optimal or near optimal for the particular growth conditions, and stronger when the redox potential of the target cell is initially shifted to a more reduced state." [25, 27, 30–35].

The author studied adipose tissue samples according to the literature [36–41]. The tissue samples were irradiated for 0, 2, 4, and 6 min with and without tumescent solution, and were studied using TEM and SEM (Fig. 47.1). Non-irradiated tissue samples were taken as references. An excess of 180 images were recorded and professionally evaluated.

SEM and TEM show that without laser exposure the normal adipose tissue appears as a grape-shaped node. After 4 min of laser exposure, 80% of the fat is released from the adipose cells, and at 6 min of laser exposure, almost all of the fat is released from the adipocyte [5]. The released fat is collected in the interstitial space. TEM images of the adipose tissue taken at ×60,000 magnification show a transitory pore and complete deflation of the adipocytes [4].

Low-level laser energy has an impact on the adipose cell consisting in opening a transitory pore in the cell membrane, which permits the fat content to go from inside to outside the cell. The cell's interstice and capillaries remain intact. After 4-min exposure, partial disruption of the adipose cell was observed, but in vitro human adipocyte culture was performed and showed that the adipose cells opened a transitory pore after they have been irradiated, and also that the cell membrane was deformed and lost its fat content [5].

The irradiated cells were recultured and showed that they recovered the normal anatomy and were alive. After this, samples were taken of adipose tissue from lipectomy and were irradiated for 0, 2, 4, and 6 min and were then submitted to visible-light microscopy. Although the initial results of the optical studies were inconclusive owing to the initial sample testing procedures, the clinical team decided to continue the case study because the preliminary clinical evidence obtained was clearly impressive.

Both SEM and TEM were performed on superficial and deep fat samples to establish cellular effects correlated to the penetration depth of the laser beam after application of the tumescent technique. Samples without tumescent technique and exposure to a laser for 0, 4, and 6 min were also taken. The results indicated that the tumescent technique facilitates laser beam penetration and intensity; fat liquefaction is thus improved.

Fat samples were processed as follows and sent to be analyzed by SEM and TEM. The adipose cell membrane was also studied in detail with TEM in order to study the transitory pore.

Twelve healthy women who had undergone lipectomy were selected for random fat sampling. The abdominal fat was analyzed after 0, 2, 4, and 6 min of external laser exposure. Patient follow-up was 24 h after surgery and up to 12 months after the procedure.

The tumescent technique was applied followed by external laser therapy using a low-level-energy diode laser, with a nominal wavelength of 635 nm, and a

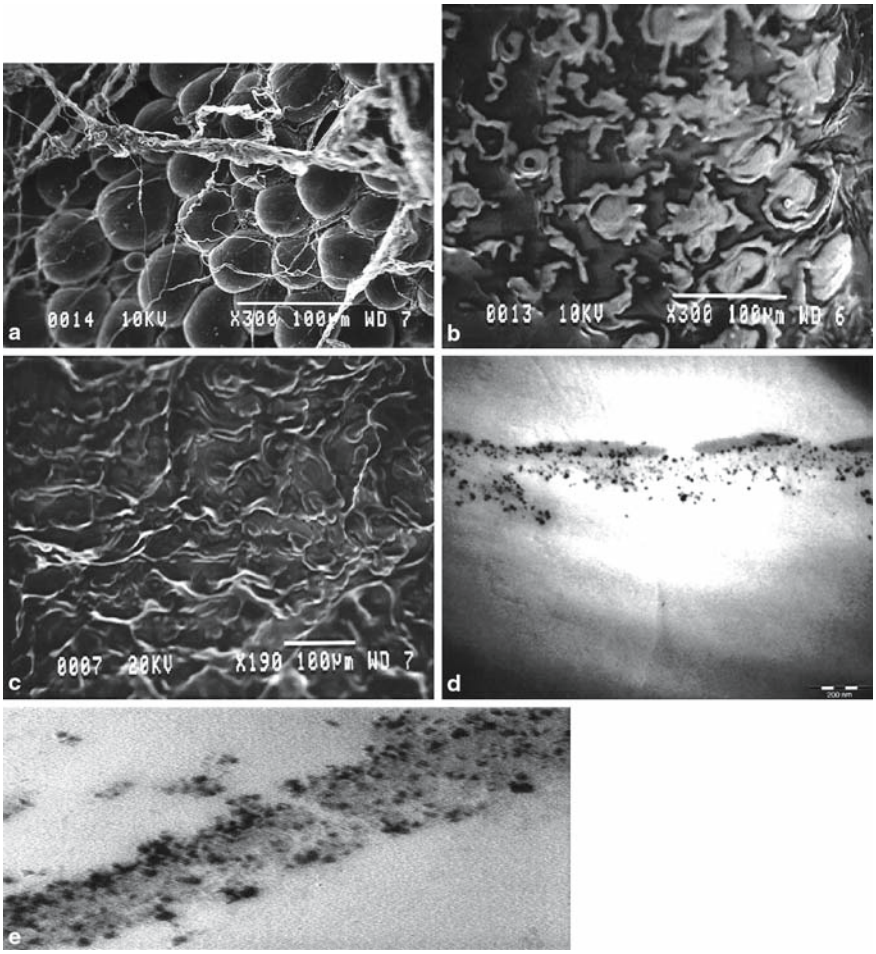

Fig. 47.1. **a** Round adipose cells with the surrounding connective tissue. **b** Scanning electron microscope image at 4-min of laser exposure. It can be seen that 80% of the fat is coming out from the adipose cell through the disrupted membrane; there are fat particles inside and outside the cells **c** Scanning electron microscopy findings at 6 min of laser exposure. The fat is almost completely (100%) liquefied outside the cell. Adipose tissue has externalized the fat from the cell with 6-min exposure. Fat cells and cell membrane appear intertwined and their distribution is irregular. **d** Transmission electron microscopy findings after 6 min of laser exposure, ×60,000. There is a disrupted site of the cell membrane. **e** Pore visualization. The adipocyte cell has a diameter of 100,000 nm and the pore size is 40 nm

maximal power of 14 mW. The laser had a diffractive optical system with a line generator, and allowed four power settings. The line generator produced a 60° fan angle, with a maximum width of 3 mm. The length of the line generated is factored at an average of 23.7 mm/in. of the line generated for each 25 cm of distance from the patient.

As the dose is the magnitude generally used to define the laser beam energy applied to the tissue, it is useful to reduce the aforementioned total applied energies to these normal units, which are given in joules per square centimeter. In this case, dose is calculated as the laser power measured in watts, multiplied by treatment time in seconds and divided by area in square centimeters of the laser spot directed toward the tissue. Considering the properties of the laser output optics , and a normal laser-to-target distance of 6 in., the aforementioned energies correspond to doses of a 1.2 , 2.4, and 3.6 J/cm^2.

Superficial and deep fat samples of laser-treated tissue were taken from the infraumbilical area in all patients studied. Biopsies were taken with a scalpel from extracted abdominoplasty tissue and then introduced into a 0.1 ml glutaraldehyde phosphate 2.5% buffer at pH 7.2 and 4°C. Furthermore, fat samples extracted without the tumescent technique were also taken and irradiated following the aforementioned sequential procedure.

These samples were then submitted to SEM and TEM to study the laser beam effects on fat cells. Regarding the changes in the adipose tissue, there were no major observable differences between samples exposed to 2 and 4 min of laser radiation. The samples were to be standardized to those taken for 4- and 6-min exposure time, where cell effect differences could be observed under SEM (Fig. 47.1a–c) and TEM (Fig. 47.1d)

The SEM and TEM findings, after 6-min laser exposure, in samples taken without the use of tumescent solution, correspond to those observed in samples exposed to 4-min laser irradiation of equal intensity (10 mW) combined with the use of a tumescent solution. Laser penetration through adipose tissue decreased when the tumescent solution was not utilized, suggesting that the application of the tumescent solution is an important enhancement factor.

Special effort was used in studying the membrane in order to clarify the suspected pore in the membrane. Figure 47.1e shows a ×40,000 magnification photomicrograph of the adipose membrane taken of a non-irradiated sample. The membrane remains intact when the laser is not applied. Figure 47.1d shows a cell membrane at ×60,000 magnification, taken of a tissue sample with 6 min of laser exposure. It is possible to see that after irradiation the membrane is temporarily disrupted, creating a transitory pore (Fig. 47.1d), which allows the fat to come out of the cell and be released into the interstitial space.

In summary, without laser exposure the adipose tissue remains intact and adipocytes maintain their round shape (grapelike shape) as shown in Fig. 47.1a. After 4-min laser exposure, the membrane of the adipocyte is partially disrupted, and 80% of the fat outside the cell. Fat particles build up, forming a “cell helmet.” Adipocytes suffer partial disruption of their membrane, exposing fat bodies outside the cell (Fig. 47.1b). At 6-min laser exposure, SEM shows almost total disruption of the adipose cell membrane and evacuation of fat (Fig. 47.1c). Over 180 photomicrographs were recorded in order to study and to demonstrate the resulting technique described herein. SEM and TEM verified the suspected lipolysis.

To our knowledge, to date, the use of low-level laser energy to open a transitory pore in the adipose cell membrane has not been reported [35]. Therefore, the technique described in the following is a new application in the field of plastic surgery and this chapter provides the scientific support for it. We also demonstrated the effect of the laser beam on the adipose cell through in vitro human adipose culture.

47.4 Discussion

Liposuction techniques and coadjuvants have been used for many years. However, each time a new method or procedure appears, there are expectations about its potential benefits. The scientific evidence provided in this chapter suggests that the LAL technique will serve as a valuable contribution to this specific field of medicine and generate the same expectations as other techniques previously described by other authors. Among its benefits are the reduced risk and improved quality of life for patients.

Random samples taken from 12 patients and submitted to SEM and TEM studies demonstrated that the application of the tumescent technique is an important coadjuvant to laser beam application because it facilitates beam penetration, and as a result, fat extraction.

Certain findings were consistently observed with use of the laser (Fig. 47.1). The SEM and TEM results indicate that the results from 6-min exposure to the laser beam with application of the LAL technique and without the tumescent technique were comparable to the recorded result from 4-min exposure to the laser beam combined with the application of the LAL technique and the tumescent technique. The tumescent technique therefore empowers the laser beam to impact the cell. Transitory pores were also observed in the cell membrane with the subsequent spillage of fat into the interstitial space.

In samples from the tumescent technique, and without laser exposure, SEM shows that the adipocyte retained its original shape in this three-dimensional picture. Several collagen fibers can be observed in the interstice. At 4-min laser exposure, without tumescent technique, liquefaction of only a few adipocytes occurred. At 6-min laser exposure, without tumescent technique, SEM showed liquefaction of a higher number of adipocytes but not all.

When the traditional tumescent technique was combined with 4-min laser exposure, SEM showed partial disruption of the adipocyte membrane with 80% of the fat extruded from the cell (Fig. 47.1b). By increasing the laser exposure to 6 min, SEM showed almost total disruption of the adipocyte membrane, which is empty and flexed with irregular contours (Fig. 47.1c).

Samples obtained from the traditional tumescent technique without laser exposure showed with TEM adipocytes completely saturated with homogeneous fat. When the LLLT was applied with 4-min laser exposure, TEM showed partial loss of intracellular fat and increased intercellular space with loss of the round cell shape (Fig. 47.1b). Capillaries remain completely intact after 4- and 6-min laser exposure.

When the LAL technique was applied with 6-min laser exposure, TEM shows almost total disruption of the regular contours of the adipocyte, intracellular fat is completely removed from the cell, and, therefore, the adipocyte is deformed and does not preserve its original shape (folding, and disruption of the adipocyte membrane) (Fig. 47.1c).

An explanation of the study findings, regarding the biological performance in the adipose tissue, is that the interaction between the laser light and the tumescent solution creates new environmental and different properties in these tissues, and experimental studies show a 0.3–2.1% transmittance of red laser light in 2-cm-thick normal skin, depending on the laser wavelength [36]. Further, it was found that the transmittance of granular tissue is 2.5 times higher than that of the normal skin. Moreover, in the search for a method to increase light transport well into target areas of tissue, the effects of a hyperosmotic agent on the scattering properties of rat and hamster skin were investigated and a transient change in the optical properties of in vitro rat skin was found [37]. A 50% increase in transmittance and a decrease in diffusive reflection occurred within 5–10 min of introducing glycerol [23]. In our case, it is known that fat contains glycerol; therefore, laser transmittance through the adipocyte could be very effective. In addition, the tumescent solution has two action mechanisms:

1. It is a polar solution that destabilizes the adipocyte membrane, thus facilitating the penetration of the laser beam. This was demonstrated by the findings in samples subjected to SEM and TEM.
2. The aqueous portion also serves as a coadjuvant to laser action . These effects are coadjuvants to the laser action, making the low-level-energy laser a powerful tool in liposuction procedures.

The adipocyte membrane is activated by different cyclic AMP concentrations, which stimulates, in turn, cytoplasmic lipase that triggers the conversion of triglycerides into fatty acids and glycerol, both elements that can easily pass through the cell membrane. The adrenaline, also found in the tumescent solution, stimulates adenylcyclase, which, together with the effect of the laser beam on the internal and external media of the adipocyte, changes its molecular polarization. The exit and removal of fatty acids and glycerol into the extracellular space enhance this effect.

The effectiveness of low-power laser light to produce changes in biological tissues and laser action on cells, even by low doses, was recently reported by different authors [38–40]. Reproducible light-induced changes in the transmission spectrum of human venous blood under the action of low-intensity radiation from a He–Ne laser was found, showing not only that laser light induces the changes, but the possibility of their spectrometric studies [38]. Besides these, the influence of low-level laser irradiation on the mast cell degranulation process was investigated on mesentery mast cells of the rat intestine and showed that laser radiation (890 nm in this case) stimulates mesentery mast cell degranulation [39]. This study also shows that the effect is dose-dependent, and maximal degranulation was registered after laser irradiation with power of 25 mW, and an exposure time of 15–30 s.

Confocal microscopy has been used for irradiation and simultaneous observation of low-power laser effects in subcellular components and functions, at the single-cell level [39, 40]. Cultures of human fetal foreskin fibroblasts (HFFF2) were prepared for in vivo microscopic evaluation. Cells were stimulated by the 647-nm line of the Ar–Kr laser of the confocal microscope (0.1 mW/cm^2). Laser irradiation caused alkalization of the cytosolic pH and an increase of the mitochondrial membrane potential. Temporary global Ca^{2+} responses were also observed. The effects were localized to the irradiated microscopic fields, and no toxic effects were observed during experimentation [27].

Low-level laser-assisted lipoplasty consists of the tumescent liposuction technique with the external application of a cold laser (635 nm and 10 mW in intensity, for a 6-min period). This technique produces a transitory pore in the adipocyte membrane, preserving the interstice, particularly the capillaries. When adipose tissue is exposed to the laser beam for 4 min, 80% of the adipocyte membrane is disrupted and this increased to almost 99% with 6-min laser exposure as demonstrated by SEM and TEM.

The laser facilitates the release of fat and contributes to the disruption of the fat panicles, allowing the fat to go from inside to outside the cell, placing it in the interstitial space. With easier fat extraction, surgical trauma is reduced as well as ecchymoses and hematomas and patient recovery is facilitated.

The transitory pore formation induced by the laser occurs exclusively at the level of the adipocyte membrane. When tumescent solution was used as a coadjuvant, almost 99% of the fat was released into the interstices, while capillaries and the remaining interstices were preserved. The result of this development is a safer, more effective procedure as the need for pretunneling has been eliminated [14, 15, 35].

47.5 Low-Level Laser-Assisted Liposuction Procedure

1. The completely naked patient is washed with Isodine in the standing-up position. The Isodine is also sprayed on the body, including hands and feet.
2. Two blankets of sterilized rubber are placed on the operating table, one on top of the other. These blankets are covered with sterilized fields. The patient is instructed to lie down on the operating table.
3. Local sedation [fentanyl and Dormicum (midazolam) and propofol] is used intravenously.
4. Tumefaction is performed in the different target areas, 2-mm incisions are made with a no. 11 scalpel, and cannulas for infiltration are introduced.
5. The greater the hydration of the tissue, the deeper the transmission of the laser beam. When the tissue is not well hydrated, the beam does not reach the desired depth and the results are not as good.
6. Almost simultaneously with the initiation of infiltration, the assistant begins to continuously apply the laser at 10 mW at a focal distance of 30 cm to obtain two lines of light of 20 cm until 3.6 J/cm^2 is reached.

7. Laser radiation is then applied to the different areas to extract fat, beginning with the left or right hemi-abdomen, for approximately 12 min. The infiltration may last approximately 30–40 min, time during which the assistant simultaneously lasers all tissues being infiltrated. This saves time because the surgeon begins infiltration at the same time as the assistant begins to apply the laser. After the infiltration has been completed, it takes approximately 10–12 min more to finish lasering the tissue in the target areas.
8. Maximum tumescence is sought in all tissues. Excellent tumescence is believed to contribute to the successful use of the laser. Laser penetration and effectiveness was less than expected in those cases where tumescence was suboptimal.
9. Fat is then extracted with 3- ,4-, 5-, and 6-mm Becker or Mercedes-type cannulas.
10. The back also requires the ultrawet technique to extract the greatest amount of fat possible. This fat, in particular, is extremely reticular, dense, and hard. Fat extraction is easier when the laser is applied.
11. The author always begins with 3-mm cannulas, for superficial fat, and then 4- and 5-mm cannulas are used until the fat is completely extracted. Good results are obtained only if the ultrawet technique is utilized, especially in the dorsal area.
12. Wounds are not sutured. They are covered with Micropore and the patient is completely wrapped in adult diapers, which are kept in place by the garment.

As soon as the infiltration and laser irradiation are complete tunnels are started in superficial layers without suction. Fat is extracted later with the cannula, 3 or 4 mm, with syringe or regular wall vacuum, without special machines. Deep fat is extracted, touching the deep fascia at all times, feeling the tip of the cannula “kissing” the fascia taking care to not cause any damage. Observations indicate that a smoother and more uniform surface is obtained this way.

Fat is extracted from the superficial layer first, working downward toward to the deep layer, where fat can then be extracted using 2- and 3-mm cannulas, without touching the skin. The assistant can help keep the skin stretched, thus avoiding damage. Because the fat is more liquefied, no nodules or condensed fat remains in the different tissue parts undergoing fat extraction.

During the postoperative period, 3 days after surgery, the laser can also be applied for 3 min at 5 W per area to reduce the duration of inflammation. There is also a gradual reduction of residual adipose tissue. Massage is initiated 4 or 5 days after surgery.

Improved skin retraction is observed within 3 months, and patients have expressed their satisfaction with the results obtained with this procedure.

47.6 Complications

Fluid collection in the sacral area occurs in about 20% of patients without a garment. It should be drained through the same incision with a syringe under local anesthesia.

Pain is seen in almost 20% of patients and is controlled by non-steroidal anti-inflammatory drugs and codeine.

Irregularities occur in the skin in 4% of patients and can be difficult to manage. The author uses massage and an external beam laser for a couple of weeks. Itching of the body is sometimes seen and is treated with antihistamines and olive oil.

Redness after surgery may occur and is treated with a laser for 6 min every day for 1 week (Fig. 47.2). Flap problems are treated with subcutaneous oxygen every day for 3–5 days and 3 min of laser exposure in the area. Edema of the hands and feet 3 or 4 days postoperatively is treated with 20 mg furosemide for 2–3 days. Infection, occurring in 1% of patients, is more frequent in the sacral area. If infection is suspected a hemogram, urinalysis, and hemodynamic evaluation should be performed. If these are positive the wound may still need to be drained and antibiotics, 500 mg ciproxaciline orally, started as soon as possible. There should be careful follow-up and if there is no response within 8 h, vancomycin should be administered.

Serosanguinous liquid that collects in the sacral area is extracted usually 1 week after surgery and one or two times is enough. Since the back is a declivitous

Fig. 47.2. Postoperative erythema

plane that is why the liquid is collected there, and we do not call it seroma, since it does not have a capsule.

Coadjutant techniques for liposculpture, such as external and internal ultrasound, have been innovative and the literature shows good postoperative results [11].

47.7 Conclusions

This innovative technique allows the surgeon to produce an adequate body contour in the medium and long term (Fig. 47.3). The patient is not exposed to skin burns nor risks. The time needed to extract fat is reduced as well as surgical trauma and, as a result, postoperative edema is less. Postoperative pain and medical leave from work are minimal. Ecchymoses are reduced as well as postsurgical fibrosis. The resulting skin surface is even. The results are highly satisfactory for both the patient and the surgeon. The postoperative recovery of patients is fast and it presents intraoperative and postoperative advantages. This technique is simple, easy to apply, and has low cost. There is no risk of burns and skin retraction is adequate. This is a coadjutant tool for the surgeon practicing liposculpture.

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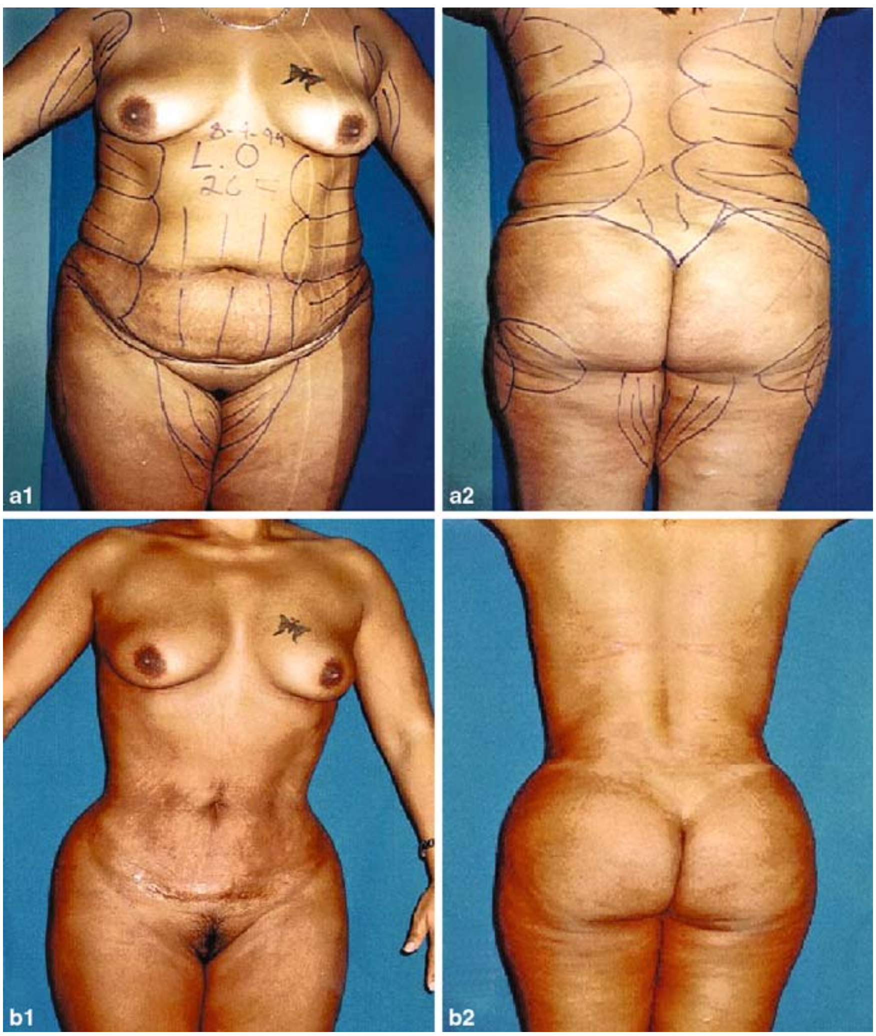

Fig. 47.3. **a** A 26-year-old woman with lipodystrophy. **b** One month postoperatively after laser liposuction with improved contours

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Laserlipolysis

Diego Schavelzon, Guillermo Blugerman, Anastasia Chomyszyn

48.1 Introduction

Laserlypolysis is derived from the terms laser (light amplification by stimulated emission of radiation), lipo, which refers to fat, and lysis, which means destruction. The procedure consists in using the light emitted by a laser to selectively produce lysis of the fat cell.

In the 1980s, Illouz [1], Fournier, and Fischer presented the traditional liposuction procedure treating fat mechanically. Laserlipolysis like other procedures destroys the fat in situ before it is evacuated from the human body and has been used since 1998. The authors have treated over 2,215 patients with this procedure using a painless ambulatory method and the results have been most satisfactory. Supported by a peristaltic pump that injects the tumescent anesthesia, this procedure benefits both the patient and the practitioner because of its comfortable application.

48.2 Nd:YAG Laser

The Nd:YAG laser is a solid laser formed by a granite aluminum yttrium crystal (the YAG) [2] contaminated with an unusual soil (the neodymium) that emits IR radiation of 1,064 nm. The authors use the EN060 model made by Deka Laser in Italy. It is a pulsed laser with 200-µs pulses. The energy is 30–150 mJ and the frequency is 10–40 Hz. The fluence is 0.3–6.0 W, it is air-refrigerated and controlled by a microprocessor.

This special laser operates by contact because the laser light is transmitted through a 300-µm silica/silica fiber optic. The penetration into soft tissue is approximately 1.4 mm. Because of its low penetration, it does not produce distant trauma, and acts locally, facilitating the progression of a very thin probe.

The laser operates through a twofold mechanism known as selective photothermolysis: photomechanical and photothermal. The photomechanical effect produces mechanical destruction of the fat cell, which can be achieved via coagulation and vaporization because of local heating. The photohyperthermia acts selectively on the proteins in the fat cell membrane producing necrosis by coagulation and denaturalization by the effect of heat on these proteins. The thin cell membrane contains a large vacuole full of liquid lipids that sheds its content into the extracellular space (Fig. 48.1).

The photothermal effect is the destruction of the fat cells that involves rapid thermal expansion [3] and causes violent cavitation from shock waves. This is produced in an indirect manner. When the lipids absorb the laser energy, the light is turned into caloric energy, causing a sudden rise in the temperature inside the fat cell and ending in its rupture.

The fatty emulsion produced remains and it is immediately identified by the immune system in order to restore the damaged tissue [4]. To reabsorb the rest of the fat cells of the oily emulsion, the immune system produces nodular lipophagic vacuoles [5].

Following the levels of triglycerides and cholesterol in the blood of ten patients, we observed no significant increase in the amount of these elements over the 10 days after surgery [6]. Apparently most of the triglycerides are eliminated through the kidneys and the rest reach the liver, where they becomes lipoproteins.

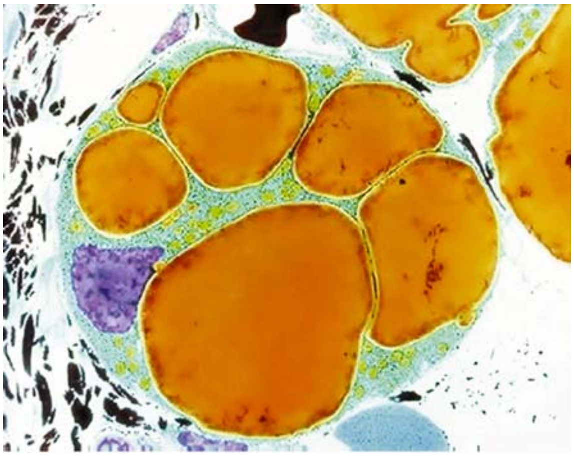

Fig. 48.1. Large vacuoles full of liquid lipids

48.3 Histological Studies

Comparative histological studies were made with the fat that was drained out through cannulas from a patient who gave her consent to be treated in one leg with tumescent liposuction and with laserlipolysis in the other leg at the same surgical time.

In conventional liposuction with tumescent anesthesia, studies show areas of involution of fat tissue with piknotic hyperchromatic nucleus and sectors in acidophilic lysis, with thickening of the cells membrane (Fig. 48.2). In the sample of fat tissue treated with laserlipolysis there was fat necrosis with loss of nucleus and large sectors of total adipose lysis (Fig. 48.2).

In another patient histological studies were performed 30 min after laserlipolysis from a piece of tissue resected in a dermolipectomy. It was possible to observe areas with necrobiotic adipose tissue with accumulation of lipophagic macrophages cells forming granulomatous lipophagic nodules.

Twenty-five days after laserlipolysis it was possible to observe adipose tissue with breakage of the cell walls surrounded by histiocytes with foamy cytoplasm. There were also areas with scar fibrosis, and the nerve threads were intact (Fig. 48.3). The use of the laser causes a destruction of the fat cell specifically protecting the nerves, while in a tumescent liposuction the fat cell is evacuated intact. The remaining tissue is immediately phagocytized by the macrophages and the immune system while fibrosis covers and retracts the empty spaces.

48.4 Surgical Technique

Laserlipolysis is an ambulatory technique supported by tumescent anesthesia. On the basis of the patient's weight, doses of tumescent anesthesia must be calculated up to 50 mg/kg. All patients are treated on an ambulatory basis.

The patient receives sublingual premedication of 2 mg lorazepam 1 h before surgery. In the operating theater 10 min before tumescent infiltration, 1–2 ml of a mixture of medications is given intravenously: 5 mg midazolam, 0.8 mg fentanyl, and 10 mg metoclopramide.

The next step consists of injecting tumescent anesthesia with a solution including [7, 8] 1,000 ml saline solution containing 30 ml of 2% lidocaine with

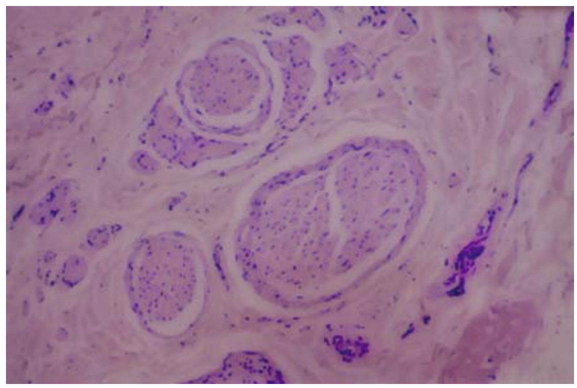

Fig. 48.3. Intact nerves following laserlipolysis (M/E stain)

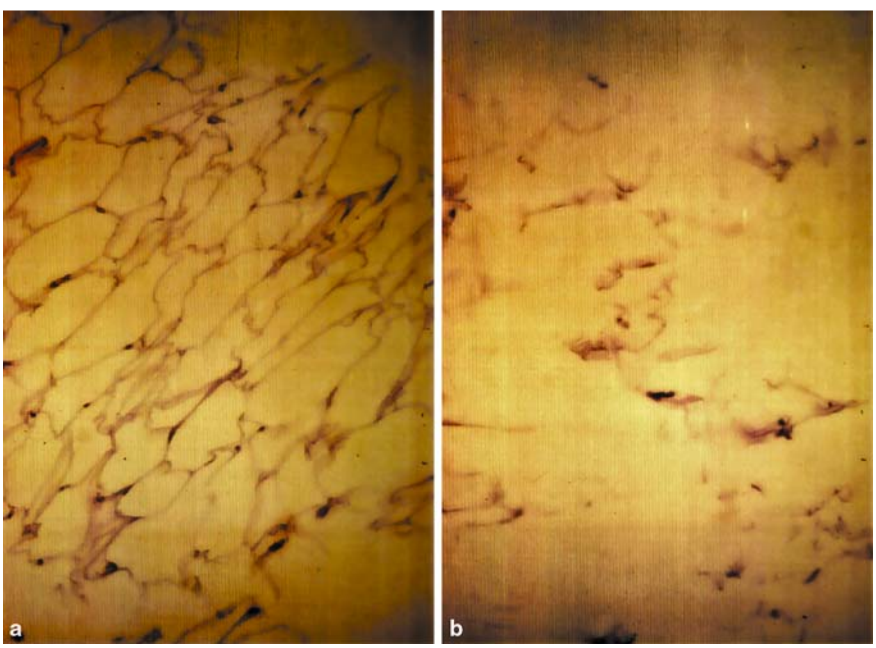

Fig. 48.2. a Fat removal without laserlipolysis showing intact fat cells. **b** Fat removed following laserlypolysis showing disruption of the cell walls

1:200,000 epinephrine , 1 ml 1:1,000 adrenaline, and 15 ml sodium bicarbonate (1 M). The saline solution is prewarmed in a microwave oven for 1 min in order to reduce the pain produced by hypothermic shock during the injection maneuver. A specially designed peristaltic pump [9] (Fig. 48.4) is used to ensure accurate filtration into adipose tissue until the expected tumescence is achieved. Beveled needles and multihole infiltration cannulae are used in this maneuver.

The tumescent fluid is infiltrated in a fanlike manner in one or two layers depending on the amount of fat. The tumescent infiltration is complete when the area of fat tissue is so firm that the interphase between fat and muscle cannot be identified. When palpating the treated area, it is harder and whiter than untreated skin. This is what is called the “tumescent point” [10].

Fig. 48.4. Peristaltic pump

When the tumescent point is reached, the optic fiber of the laser is introduced through a 1-mm diameter microprobe. Once under the dermis, forward and backward movements are performed in a fanlike manner in the area. This is done twice in each area, the first time at the level of the deep subcutaneous cellular tissue and the second time in the superficial subcutaneous cellular tissue at the subdermal level in search of stimulation of the deep dermis. While the laser is being used, it is possible to hear the so-called popcorn effect caused by the bursting of the fat cells when the laser light reaches them. The fat cell bursting determines the liberation of the triglycerides from the fragmented intra-adiposity vacuole. The tumescent anesthesia homogenizes the work of the laser and facilitates the diffusion of heat to the neighboring cells. The moment to stop the laser application is when there is no resistance to the advance of the bevel-pointed needle. At that time, the oily emulsion is drained.

When the total fat treated exceeds 500 g, we prefer to drain the fatty emulsion through a specially designed 3- or 4-mm vacuum cannula, with multiple microholes at 500-mmHg vacuum. The same peristaltic pump is inverted and the fatty emulsion is drained out of the body.

48.5 Results

In the authors’ series, from 1999 to 2002, 2,215 patients were treated with laserlipolysis. There were 1,684 women and 531 men. A total of 7,352 areas of the body were treated with the trochanteric (Fig. 48.5) and the inside of thighs most often requested by the

Fig. 48.5. Trochanteric region treated with laserlipoysis. **a** Before, **b** after

patients (Table 48.1). Gynecomastia (Fig. 48.6), double chin, and hump were also treated with this method.

Most areas of the body were treated and most often patients had three body areas treated in one procedure (Tables 48.1, 48.2). Also six to nine areas were treated and a maximum of 4 l of fatty emulsion was drained, always in an ambulatory setting. Complications were infrequent, 0.041% (Table 48.3).

48.6 Conclusions

Laserlipolysis is safe, simple, and seems to be advantageous for the patient and for the surgeon. The advantages for the surgeon are that it softens areas with hard or compact adiposity, which results in less fatigue, less force is necessary, and it also allows a softer and more relaxed surgery. More areas can be treated at the same time with the same physical effort. Correction of secondary flaws is simplified. It provides visual control through transillumination. On the other hand, it is possible to treat areas with little adiposity with less risk of overresection._

For the patient, the preservation of the fibroelastic septum is an advantage. Also fatty tissue selectivity with preservation of the nerves was demonstrated histologically. That implies less postoperative pain because it maintains the innervation integrity. Smaller incisions are necessary and there is better skin retraction in a homogenous manner owing to the delicate tunneling of the laser. Fewer ecchymoses occur.

Because it is an ambulatory treatment, recovery is quicker, hospitalization costs are lower, and no working days are lost. Retraining of the staff is necessary for the adequate use of this technique. Even though the results are promising, more clinical long-term follow-up and histopathologic studies are necessary. Besides it is a new challenge in the treatment of gynecomastia, hyperhidrosis, and cellulite [5], which has already shown good results.

Acknowledgement Portions of this work are reprinted from Blugerman et al. [11]. with permission from the *International Journal of Cosmetic Surgery and Aesthetic Dermatology*, Mary Ann Liebert, Inc.

Table 48.1. Areas and number of patients

Area	Number of patients
Trochanteric	428
Inside of thighs	394
Knees	350
Waist	314
Lower abdomen	281
Upper abdomen	231
Hips	220
Arms	94
Anterior upper leg	74
Back of thigh	48
Back	44
Buttocks	40
Gynecomastia	39
Ankles	26
Arm pits	20
Double chin	20
Hump	5
Breast	4

Fig. 48.6. Gynecomastia treated with laserlipolysis. **a** Before, **b** after

Table 48.2. Number of bilateral areas in each surgery

Surgery	Number of bilateral areas
1	63
2	52
3	160
4	88
5	52
6–9	39

Table 48.3. Complications in treated areas were low (0.041%)

Complication	Number of areas	Complication rate (%)
Seroma	26	0.009
Asymmetry	40	0.015
Hypocorrection	40	0.015
Hypercorrection	2	0.0007
Burn	1	0.0003
Iction	1	0.0003

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49 Water-Jet-Assisted Liposuction

Ahmed Ziah Taufig

49.1 Introduction

Liposuction is an operation that removes lipocytes or bands of lipocytes from the subcutaneous/epifascial area of the skin. The procedure can shape the body by the internal removal of fat. This is done with the aid of a solid hollow needle via small incisions and reduces the number of adipocytes that store fat. Liposuction is today is one of the commonest treatments in the area of aesthetic surgery.

49.2 History

About 100 years ago techniques were invented to permanently remove fat. In the beginning, the results were fairly poor because of large incisions to excise fat causing big scars. Also, serious infections and bleeding were quite common.

In 1921, Dujarrier [1] introduced a defatting technique with the use of curettement for the inner side of the knee and the calves and applied it to a Parisian ballerina. The result was disastrous because one of her legs had to be amputated later on.

Further progress was made in 1964 by Pitanguy [2]. Nevertheless, large and visible scars were still not avoidable. Also in the early 1960s, Schrudde [1] presented his lipexheresis. He removed fat with small incisions of a specialized curette. Large loss of blood and infections as well as loose skin flaps could not be prevented.

It took until the year 1975 for the idea of fat suction to emerge. The first use fat suction were Fischer and Fischer [3]. They developed a motorized suction cannula with a revolving blade just behind the opening of the cannula. There was a single copy of the machine only and it was very expensive and difficult to reproduce.

The final breakthrough came with the new technique of using a suction machine in addition to blunter and finer cannulas by Illouz [4]. He noticed that sodium chloride with added hyaluronidase applied to the tissue before the operation could significantly facilitate the fat suctioning. But high loss of blood and other complications were still a big risk.

Klein [5] (1987) increased the dose of adrenaline and lidocaine in the saline solution, originally proposed by Fischer, and this technique, now called tumescence technique, was widely spread around the world. This liquid is also required for ultrasound-assisted liposuction, which was introduced in the 1990s.

Between 1994 and 1998 496,245 liposuction procedures were performed in the USA.

A very different method to a controlled and gentle liposuction was introduced by the author in (2000) [6] when the method of water-jet liposuction was reported.

49.3 Risks

While liposuction has steadily been gaining popularity worldwide, the risk of the tumescent technique has been very much neglected. There are reports that in many liposuction deaths using the tumescent technique there was no obvious reason for the death [7, 8]. The patients were not ill, and with an age between 30 and 55 they were not old either. Some of them died during the operation, but most of them died a couple of hours later. Cardiac arrests were usually preceded by a decline of blood pressure and a reduction in heart rate. Others died of pulmonary edema, while their main cause of death were thromboembolic processes.

The chief ingredient of the solution used for tumescent liposuction is the local anesthetic lidocaine, which can only be absorbed by the body up to a certain limit. Anesthetists can hardly believe what quantities dubious or unsuspecting surgeons sometimes use. Whatever the reasons, risks and disadvantages of the tumescent technique are very often ignored or belittled by surgeons as well as patients. Reports about numerous cases of death and other grave complications pose serious questions about the safety of the tumescent technique though.

With operations that are not mandatory for health reasons, the danger of complications should not depend on the method of operation. Alongside local complications like overcorrection or undercorrection as well as dents and steps, other side effects caused by the drugs contained in the tumescent solution are a problem. Frequent publications about new cases of death after tumescent liposuctions make us search for better techniques. This is surely the main reason why many surgeons return to the "wet method" to focus all their skills and energy on reducing the dangers and risks to patients which are caused by specific methods.

49.4 Water-Jet-Assisted Procedure

The method of water-jet-assisted liposuction allows a controlled and selective removal of fat tissue within the epifascial/subcutaneous area via usage of a cannula system.

Principally every new method of liposuction should fulfill the following criteria:

- Increased safety for patient and doctor: the desired result is achievable as planned
- Improved process and results as opposed to commonly used methods
- Shorter operating times
- Reduced usage of drugs as well as application of a well-established method of anesthesia, which is reproducible

The method of liposuction is based on water-jet surgery. The water-jet technique has long been used in industry to cut all different kinds of materials. In medical science the water jet has already been used in parenchyma surgery. The method uses the energy of the pressurized fluid as well as a novel cannula system and suction unit.

49.4.1 Statistical Data

During the period from October 1999 until March 2003, 280 patients were treated with this new method of liposuction. The average age of these patients was 36 years for women and 33 years for men. The average weight was 70.5 kg (10.8 stones).

49.4.2 Cannula System

A specialized cannula is used in which an infusion tube and a nozzle are integrated as well as a suction unit. An infinitely variable force pump dispenses the fluid in a controlled manner via a nozzle at the top of the cannula system. The cannula is attached to a common and well-proven suction device for liposuction.

49.4.3 Technique

A fan-shaped liquid jet decomposes the fat tissue into fragments that can be cleanly suctioned out. At the same time the solution and detached fat particles are suctioned via the opening in the cannula. The pressure of the slightly inclined water jet can be adjusted very precisely via a foot-operated switch. As working and hydraulic fluid, a 0.9% NaCl isotonic solution plus adrenaline additive is utilized. All other preparatory steps are identical to the ones used with other methods.

After the incision into the skin and the introduction of the cannula system into the epifascial fat tissue a new and different approach is used. The fan-shaped variably adjustable high-pressure jet fragments the fat into a state in which it can be suctioned off. The suction process, which happens at the same time as the fragmentation process, enables the surgeon to watch the aspirate in the suction tube in parallel. The appearance of the aspirate is very important to be able to judge the tunneling speed of the fat tissue that is being worked upon.

The different phases in the appearance of the aspirate can roughly be categorized into the following three phases:

1. A phase rich on intact cells
2. An emulsion phase
3. A sediment phase that mainly consists of fat cell wall fragments

The cannula can be inserted into the fat tissue very easily owing to the water jet, which works on the fat tissue at the same time. Because of the slow speed of penetration of the cannula the water jet has more time to decompose the fat into fragments that can then easily be suctioned off. Placing the spare hand on the outer skin, the surgeon is able to feel the height and position of the cannula and the water jet. The simultaneous suction of the fat tissue allows the surgeon to determine, at any time, the magnitude of the fat tissue that is to be removed. Borders and margins can be harmoniously aligned by adjusting the pressure of the water jet (Figs. 49.1–49.3). This method shortens surgery times significantly.

The tumescent method does not allow such a precise correction of margins because the area that is being worked on loses its original shape owing to the tumescent solution. The postoperative leakage of fluid from the incisions with the tumescent method is largely reduced if not even stopped with the new water-jet method. A compression garment needs to be worn as usual for about 4 weeks. The operation is carried out in an outpatient setting in the presence of an anesthesiologist. On the average the patient remains

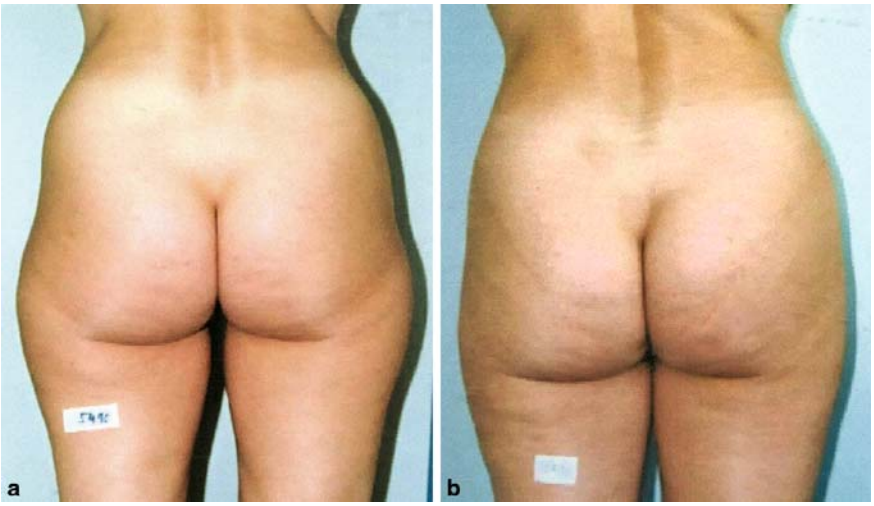

Fig. 49.1. **a** Preoperative patient with lipodystrophy of hips and thighs. **b** Postoperatively following water-jet-assisted liposuction

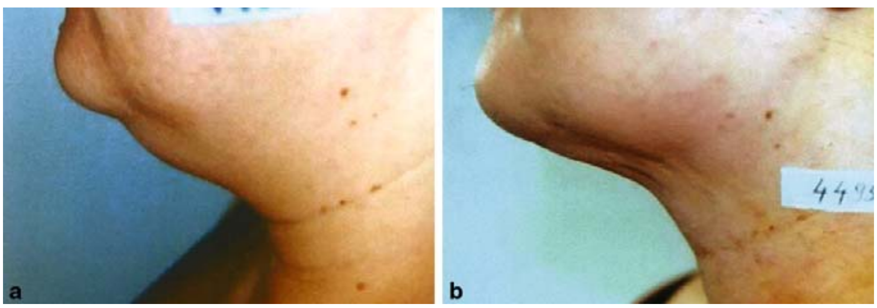

Fig. 49.2. **a** Preoperative patient with lipodystrophy of the neck. **b** Postoperatively following water-jet-assisted liposuction

Fig. 49.3. **a** Preoperative patient with abdominal lipodystrophy. **b** Postoperatively following water-jet-assisted liposuction

in the clinical center for 2-3 h after surgery before being discharged.

49.5 Results

The selective impact of the water jet in the fascio-cutaneous area on the fat tissue leads to a mechanical removal and rinse of individual fragments of tissue from their group of cells and, at the same time, a reduction of subcutaneous fat tissue in the fascio-cutaneous layer of the skin.

It has been noted by the author that surgery times can be reduced by more than 40%. This is mainly caused by the fact that the phase for the instillation of tumescent solution and the period until it takes effect with the tumescence technique does not apply for the water-jet technique. A large part of the saving in time arises from the fact that immediately after inserting the cannula and starting the water jet the suction process is started. The personal goal that was individually discussed with the patient before the operation was achieved in all but four cases. In these four cases a second operation was necessary because not enough fat tissue had been removed. These cases happened at the beginning of the introduction of the new method because the technique of operation had to be acquired in an autodidactic way.

49.6 Complications

No infections were noted in any of these cases. The occurrence of ecchymoses was very rare and in these few cases minimal. In one case a hematoma appeared in the medial area of the knee. In none of the cases was there a seroma that could be clinically established. The previous sensitivity of the skin of the treated areas returned after 3 days to 6 weeks.

In two cases (hip/upper abdomen), moderate asymmetry appeared which did not bother the patients. All transitions to neighboring areas that had not been treated could be modeled in a smooth and harmonic way. In none of the cases was there liquid that leaked from the incisions later than 24 h after the operation.

For postoperative pain therapy, an analgesic of type "Sympal" was prescribed. The average consumption was four pills until the third day after the operation.

49.7 Discussion

The targeted fragmented removal of the fat tissue allows the achievement of the desired result in a controlled and safe way. There is no direct relationship between the goal of the operation and the amount of aspirate. It is a characteristic of this method that it is possible to achieve a visible reduction in fat tissue and to contour the affected areas at the same time.

Liposuction is one of the commonest treatments in aesthetic surgery worldwide. These operations are mainly conducted with the tumescent technique and apply a subcutaneous infusion of an enormous amount of a solution made up of lidocaine or prilocaine as a local anesthetic as well as a solution with sodium chloride, adrenaline, sodium bicarbonate and more. After a period of between 30 and 60 min after infusion of the tumescent solution, the aspiration of the fat tissue is started via microcannulas.

The water-jet technique uses an isotonic sodium chloride solution with an additive of adrenaline in the ratio of 1 ml to 3 l of sodium chloride solution, which is suctioned off almost at the same time as the dissolved fat particles; therefore, no side effects are caused by the solution that is used as with the tumescent technique.

Another positive aspect of the new technique is that the pressurized NaCl solution achieves a fragmentation of the fat tissue in a very controlled manner and that the solution is suctioned off at the same time. This avoids a separate fragmentation step as with the tumescent technique. The removal of fat tissue and the molding of the surrounding area can start right from the beginning of the operation. Compared with other methods only little fluid remains in the tissue, which is perceived by the patient as being very pleasant.

One of the advantages claimed for the tumescent technique is that only local anesthetic is used and that, therefore, no anesthetist is required. This has proved to be more of a disadvantage because the risks of local anesthetics are incalculable and uncontrollable. There are no side effects from local anesthetic with the water-jet technique since local anesthetic tumescence is not used. This additionally increases the acceptance of the new method by patients. The cases of deaths reported where the operation was performed solely for cosmetic reasons are especially alarming.

Further clinical trials need to be performed for the water-jet technique of liposuction so that the first clinical experiences can be confirmed with a larger number of patients and to establish the significance that the water-jet technique will have for liposuction in the future.

49.8 Conclusions

The technique of water-jet liposuction is a safe, gentle and targeted method to remove subcutaneous fat build-ups. It offers a very good way for molding the tissue during the operation. Apart from the solution for the water jet no additional drugs are required; therefore, drug-related side effects are not to be expected. The method is simple, easily explained to the patient and quickly learned by the surgeon. It opens the door to new and safer possibilities in plastic surgery.

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Part IX
Complications

Prevention and Treatment of Liposuction Complications

Melvin A. Shiffman

50.1 Introduction

Liposuction may be associated with a variety of complications most of which can be avoided. The more aggressive the liposuction, especially in the superficial subcutaneous tissues and with large amounts of fat removal, the more likely a complication will occur. "It is not so much what is removed that is important, but what is left behind." [1]. The surgeon performing liposuction must be cognizant of the risks and complications from the procedure, how to prevent them, and how to treat them.

Early recognition of a complication is essential and treatment should be started in a timely fashion. The surgeon must inform the patient of the complication, its probable or possible cause or causes, the proposed treatment, and the length of time before complete recovery. Consultation may be obtained and should be done in a timely manner.

50.2 Complications

50.2.1 Asymmetry

If the patient has asymmetry of the abdominal wall preoperatively, this should be pointed out to the patient and recorded with adequate photographs. More fat may have to be removed from one side or one area because of the asymmetric accumulation.

Asymmetry can be avoided by being aware of the amounts of fat and fluid removed from each side of the abdomen so that there is no large discrepancy. Observing the results carefully at the end of liposuction may disclose further areas that need correction. Asymmetry can be corrected by removing more fat from the excess area, liposhifting fat into the depressed area, or reinjecting autologous fat.

Asymmetry that is present postoperatively may need revision liposuction for removal of excess fat from those areas affected. If there is a deficit in any area that needs correction, injection of autologous fat may be considered.

50.2.2 Bleeding, Hematoma

The tumescent technique in liposuction has reduced the amount of bleeding to a degree that is usually minimal. To prevent or limit bruising, the patient must be forewarned to stop taking all aspirin-containing products, non-steroidal anti-inflammatory drugs such as ibuprofen, and herbals at least 2 weeks before and for 2 weeks after surgery. Excessive liposuctioning in a single area may cause bloody fluid to appear in the tubing and this should forewarn the surgeon not to continue surgery in that area unless further tumescent solution is used. Compression over the areas of liposuctioning will help to limit bruising. This includes the use of garments, stretch tape, and foam dressings (polyurethane pads).

Bleeding following liposuction may appear as bright red blood coming from the incision site or may be hidden and appear as orthostatic hypotension when the patient tries to sit up or stand. Postoperative dizziness and feeling faint should not be considered a drug reaction or dehydration until after the hemoglobin (Hgb) or the hematocrit (HCT) is checked. Intravenous fluid resuscitation may be enough if the bleeding is not over 15% of the blood volume but some patients with more blood loss may require Hespan, dextran, albumin, or blood to restore the blood volume. Low Hgb or HCT does not necessarily require transfusion. The patient's clinical status is more important and if vital signs are stable, conservative measures may be taken, such as volume replacement. The patient who has had an acute episode of bleeding and stabilizes with low Hgb or HCT may be followed for at least 1 week, at which time the Hgb and HCT should start to rise. It may take a few weeks for the blood count to come back to normal but usually the patient can resume normal activity after the Hgb reaches 8 g. If the bleeding continues and conservative measures do not work, surgical exploration may be necessary. This is more likely with other concomitant procedures such as abdominoplasty since compression in the areas of the liposuctioning will usually stop any bleeding from small vessels.

Hematoma in the tissues can be treated conservatively with aspiration. This should be distinguished from bruising that requires no treatment. A hematoma that becomes a persistent untreated mass will form a seroma and then a chronic pseudocyst.

The pseudocyst can be treated with aspiration followed by injection of an equal amount of room air. This will usually cause the walls to adhere to each other and prevent further accumulation of fluid.

50.2.3 Chronic Edema

An infrequent occurrence, persistent edema in the area of liposuction can be distressing to the patient. This may be due to excessive trauma to the tissues but liposuction is a traumatic procedure causing so-called internal burnlike injury. Proper compression is usually the key for prevention. Remember that excessive compression of an extremity can result in venous thrombosis and possible embolic disorder.

Repeat liposuction (in an amount to break up the edematous tissues and flatten the region) of the area with the tumescent technique is usually helpful after several months but must be followed by adequate compression dressings.

50.2.4 Depressions (grooves, waviness)

Excessive or superficial liposuction too close to the skin may result in depressions (Fig. 50.1). Superficial liposuction should not get closer than 1 cm below the skin in most areas except the face and neck and smaller cannulas (smaller than 3.5 mm) should be utilized in comparison with the deep liposuction that can be performed with cannulas over 3.5 mm (3.5–5.0 mm depending on the thickness of the fat layer).

Fig. 50.1. Postoperative liposuction of thighs

Depressions can be corrected by selectively liposuctioning the areas around the depression and filling the indented area with autologous fat [2]. If the indentation is noted while performing the liposuction, autologous fat can be injected at that time. It is possible to fill defects with the "liposhifting" technique by tumescing the areas around the depression, loosening the fat with multiple crisscrossing tunnels, and molding the fat into the defect by rolling a large cannula (6–10 mm) across the prepared areas toward the depression [3].

The skin scar may become depressed and is usually due to the suction staying on when the cannula is removed and reinserted multiple times. This can be prevented by turning off the suction before removing the cannula or by having a finger vent in the handle of the cannula.

50.2.5 Dissatisfaction with Results

The surgeon performing liposuction should try to gain some insight into the patient's body image. In other words, exactly what does the patient want and expect for the results of liposuction. Some expectations are more than can be delivered by the surgeon. A detailed explanation of the limits to the procedure of liposuction, the risks and complications, and the presence of irregularities or asymmetries is an important beginning for the patient to understand that surgery, on average, does not achieve perfect results. There should be preoperative explanation that further refinements may have to be performed to better approach the patient's expectations.

Beware of the dysmorphic personality where the patient does not have a significant problem but perceives a severe problem. This type of patient dwells on a problem that does not really exist and the surgeon can never satisfy that patient.

50.2.6 Fat Embolism

Fat embolization [4–8] results from release of fat droplets into the systemic circulation. Fat embolism syndrome is an infrequent consequence of fat embolization with pulmonary distress, mental status changes, hypoxemia, pyrexia, tachycardia, thrombocytopenia, and petechial rash [9–11].

Studies that can be used for diagnosing fat embolism include computerized tomography (CT) [12–14] and magnetic resonance imaging [15, 16].

Treatment consists of general supportive measures with maintenance of fluid and electrolyte balance and administration of oxygen, and endotracheal intubation and mechanical ventilatory assistance when necessary [17]. Treatment of respiratory symptoms has been reported to improve with high-dose methylprednisolone [18]. Huemer et al. [19] felt that heparin, cortisone, and dextran have not demonstrated a beneficial effect.

50.2.7 Fibrosis

Subcutaneous nodularity following liposuction is often a fibrotic reaction, usually with an inflammatory component, that can be a residual of hematoma or seroma. Infection, especially mycobacterial, can leave a mass that will not resolve. Trauma to a surgical area resulting in a mass will usually resolve over time without treatment unless there is an inflammatory component. Normal scar formation will mature over 6 months and then soften. The complete evolution of a scar can take 1 year but the biochemical changes are complete in 6 months.

50.3 Evaluation and Treatment

A postsurgical mass should be evaluated clinically to rule out hematoma or seroma. Needle aspiration, under sterile conditions, can frequently be used to make the diagnosis. If the mass persists for more than a 3 weeks without evidence of some resolution, ultrasound evaluation should be considered even if fluid cannot be aspirated. If serous fluid is found on ultrasound examination, the radiologist should aspirate the liquid and inject an equal amount of room air. Reevaluation by ultrasound examination in 1 week will usually show resolution, but if any fluid persists, repeat aspiration with injection of room air should be performed.

If an infection is present, usually with erythema and tenderness, aspiration of the pus with culture and sensitivity (C & S) should be performed. Usually, the patient is already on antibiotics and the medication may need to be stopped for 24 h before attempting a C & S aspiration. The antibiotics may need to be increased in dosage or changed. Residual subcutaneous fibrotic changes will resolve over time if the infection is properly treated. Incision and drainage may be necessary if the abscess is large and/or does not respond rapidly to the antibiotics.

Following liposuction, folds in the garment can result in indentations and subcutaneous fibrosis. The garment should be checked on the first postoperative day and the patient informed of how to prevent or limit folds in the garment (especially an abdominal binder). If subcutaneous fibrosis occurs, early treatment for the problem should be undertaken. Early treatment will resolve the complication more rapidly than waiting for the fibrosis to mature.

The conservative course of treatment for residual fibrosis from any source consists of:

1. Start Medrol DosPak (7-day treatment taking the full daily dose each day at one time with food).
2. At day 7 start non-steroidal anti-inflammatory medication daily for at least 8 weeks.
3. Ultrasound treatment may be started at least 3 weeks after surgery to the area at 3 W for 15 min twice weekly for at least 16 treatments. Treatment within 3 weeks of surgery may cause hematoma or seroma.
4. If there is no response after 8 weeks of ultrasound treatment, injections into the fibrous tissue with 5-fluorouracil at 50-mg doses may be attempted on a weekly basis until resolution of the mass. This can be combined with small doses of steroid (10–20 mg triamcinolone).

If steroids are used, the injection should be carefully administered into the fibrous mass, and care should be taken to ensure that the fluid does not extrude into the surrounding fatty tissues. This may cause fat atrophy, which can be easily treated by tumescing the tissues with normal saline solution so that the precipitated steroid is reabsorbed. The mixture the author uses is 1 ml 5-fluorouracil (50 mg), 0.5 ml triamcinolone (40 mg/ml, total 20 mg), and 1 ml lidocaine (0.5%) with epinephrine.

Surgical intervention with resection of the mass can result in a skin scar that may not have been present previously, indentation from removal of tissue, and possibly a residual fibrous mass again. Surgery is a last resort after conservative measures have been tried for at least 6 months. Indentations that result from surgery may require autologous fat transfer.

50.3.1 Hyperpigmentation

Hyperpigmentation following liposuction can be in the scars or in the area of the liposuction. If there is bruising and the patient gets into the sun, the skin overlying the operated area can develop an increase in pigmentation.

Treatment consists of 4% hydroquinone, cream or gel, rubbed into the affected area twice daily. During the day an effective sunscreen should be utilized and unnecessary sun exposure must be avoided or protective clothing worn. Sun exposure will cause repigmentation.

50.3.2 Infection

The occurrence of infection in a clean surgery case is approximately 1% in outpatient surgery centers and office surgeries and 3% in hospital surgeries. The tendency to consider liposuction as minor surgery with minimal care about sterility in the surgery suite can be detrimental to the patient. Serious infections have been documented following liposuction [20, 21]. Necrotizing fasciitis [22–24] and toxic shock syndrome [25, 26] have been reported. The combination of both necrotizing fasciitis and toxic shock syndrome can occur in the same patient [27].

When an infection appears 10 days to 6 weeks after surgery and is in the form of a mass with overlying erythema, mycobacterium should be considered. This may be very difficult to diagnosis through cultures of the purulent discharge but the physician must be persistent. Vigorous prolonged treatment may be necessary. Rifampin, 600 mg, 2–3 times weekly combined with isoniazide, pyrazinamide, ethambutol, and/or streptomycin should be used for up to 6 months. Side effects include hepatitis, arthralgias, thrombopenia, nephritis, optic neuritis, gastrointestinal distress, and flu syndrome. An infectious disease consultant is usually necessary. Scarring is not uncommon especially if the abscesses are drained surgically through large incisions or persistent fibrous masses are excised (Fig. 50.2). If there is a persistent fibrous mass following proper antibiotic treatment and drainage is necessary, the mass can be injected with steroids.

Postsurgical infection should be diagnosed as early as possible in order to prevent more serious manifestations of the infection such as necrosis, septicemia, or toxic shock. Blisters may presage the appearance of necrosis and should be treated and observed closely. There are various dressings that may cause blisters, such as tape on the skin and Reston foam. Any significant erythema is an indication of inflammation or infection and should be treated as such with antibiotics and close follow-up.

Fig. 50.2. Liposuction with postoperative infection from mycobacterium resulting in scars on thighs after drainage procedures and excisions of masses

50.3.3 Lidocaine Anaphylaxis

The injection of lidocaine in small amounts as a local anesthetic has been associated with death from allergic reaction to the preservative methylparaben [28, 29]. Anaphylaxis has been reported with lidocaine administration [30–33]. Lidocaine is not a completely benign medication and the surgeon should be aware of and prepared for acute allergic reactions.

Treatment with ephedrine, oxygenation, and intravenous fluids can relieve the symptoms. Steroids may be necessary and if there is bronchospasm, intubation may have to be done.

50.3.4 Lidocaine Toxicity

There is very little treatment for lidocaine toxicity except for supportive measures. This problem can easily be avoided by keeping the lidocaine at a safe level through the use of less than 35 mg/kg or, when absolutely necessary, a maximum of 55 mg/kg in the total tumescent fluid. The rapider the infiltration of the lidocaine, the more likely there will be lidocaine toxicity. The epinephrine effect causing vascular contraction takes 15 min following injection; therefore, the lidocaine can be rapidly absorbed for the first 15 min. However, "just because a surgeon has infiltrated, without mishap, 50–60 mg/kg lidocaine in hundreds of cases does not necessarily imply either that such a large dose of lidocaine can be given with impunity, nor that this dose recommendation is 'safe'." [34]. If general anesthesia is used, the lidocaine total can be much less or omitted.

A careful history must be taken to make sure the patient has not been taking cytochrome P450 inhibitors that may result in lidocaine toxicity even with the total lidocaine dose within the usually accepted maximum [35]. Lidocaine occurs in the body as unbound pharmacologically active lidocaine and protein-bound inactive lidocaine. Factors affecting the protein binding of lidocaine include age, stress, obesity, hepatic function, renal function, cardiac disease, cigarette smoking, use of oral contraceptives, beta blockers, tricyclic depressants, histamine-2-blockers, inhalation anesthetics, and anorexants [36].

50.3.5
Loose Skin

Liposuction of certain areas of the body is prone to the development of loose skin because of the amount of fat that needs to be removed and the lack of complete skin retraction. Those areas most likely to have this problem include:

1. Abdomen: especially with large panniculus
2. Arms: especially elderly patients and very fat patients
3. Medial thighs: postoperative loose skin is a major problem in a large percentage of patients

Treatment for the loose skin requires a surgical approach with significant scars.

Abdominoplasty, usually modified, may have to be performed to resolve loose hanging skin of the lower abdomen, brachioplasty to resolve loose hanging skin of the arm, and thigh plasty for the loose skin of the medial thigh.

50.3.6
Necrosis

There may be skin necrosis after liposuction if the cannula comes too close to the skin and disrupts the subdermal plexus of vessels. Chronic smokers who do not stop smoking before and after surgery have a high incidence of necrosis. Necrosis is more likely to occur with the use of cannulas with sharp edges and turning the openings toward the skin surface. Combining excessive liposuction of the mid upper abdomen and full abdominoplasty increases the risk of necrosis of the abdominoplasty flap.

Necrotizing fasciitis has been reported following liposuction (Table 50.1) [22–24]. This disorder is an infection with fulminant streptococcal group A infection or mixed bacterial infection frequently with anaerobes that involves the subcutaneous tissues and deep fascia producing thrombosis of the subcutaneous vessels and gangrene of the underlying and surrounding tissues. Treatment requires surgical debridement, antibiotics, and, when necessary, hyperbaric therapy.

50.3.7
Need For Further Surgery

Since the surgeon can ordinarily improve the contour deformities by about 50%, the patient may not be satisfied with the results. There also may be need to refine or correct the original procedure because of complications such as irregularities (grooves, waviness, and indentations), asymmetries, perforation of vessel or viscus, excessive scarring, bleeding, hematoma or seroma, loose skin, necrosis, necrotizing fasciitis, and infection. The patient should be warned preoperatively of this possibility.

50.3.8
Neurologic problems

Decreased sensation or sensory loss may occur but is almost always temporary.

Chronic pain may be due to a small neuroma but is more often due to injury to the underlying fascia or muscle. Injection of local anesthetic into the area of pain will usually relieve the complaint for a short period of time. Multiple injections may be necessary to relieve the pain permanently.

A neuroma can be surgically resected. If a scar in the tissues (subcutaneous fat, fascia, or muscle) is tethered to the skin, there may be chronic unrelieved pain. The pain may have to be treated by release of the scar.

50.3.9
Perforation of Vessel or Viscus

Perforation of the abdominal wall is most likely to occur in the presence of hernia or an abdominal wall scar that can divert the direction of the cannula [37–39]. The non-dominant hand should always feel the end of the cannula. When the cannula is not palpable, the surgeon should reassess the technique and consider the possibility of perforation. Under local tumescent anesthesia, perforation can be detected at the time of surgery by the presence of abdominal pain.

If there is unusual abdominal pain or chest pain postoperatively such as increasing pain or severe pain, perforation must be considered. It may be difficult to examine the abdomen directly by pressure because liposuction alone will cause pain in the area. The presence of rebound tenderness usually indicates peritonitis. Flat plate and upright abdominal X-rays may show free air if the bowel is perforated. The patient may have to be observed in the hospital if there is the possibility of viscus perforation.

Vascular perforation that causes significant blood loss will result in abdominal pain, orthostatic hypotension, and shock. Insertion of a small catheter (Angiocath) into the abdominal cavity and the instillation of some sterile saline can produce bloody drainage consistent with vascular injury. If the blood is totally retroperitoneal, a CT scan may be necessary. Emergency exploratory laparotomy is usually indicated.

Liposuction over the ribs can be aided by the use of pressure on the lower ribs with the flat portion of the non-dominant hand that will result in the cannula easily going over the ribs instead of under with perforation into the chest. Severe chest pain, especially with dyspnea, may indicate perforation into the chest.

Chest X-ray will usually show a pneumothorax. Insertion of a chest tube will relieve the pain and dyspnea.

50.3.10 Pulmonary Edema

Pulmonary edema has been reported [40] that was presumed to be from rapid and high-volume hypodermoclysis. Pitman [41], commenting on this case, believed that the cause of the pulmonary edema was from excessive parenteral fluids being given. Ordinarily, most individuals can tolerate large amounts of intravenous fluids, up to 2,000 ml/h, since the fluids enter the extravascular tissues within 15 min of administration. However, where there is a large amount of subcutaneous fluid from the tumescent technique, the pressure of the fluid in the tissues does not allow a gradient for the intravenous fluid to diffuse out of the vessels.

50.3.11 Scars

Significant scars following liposuction are not frequent. It is rare to see hypertrophic scars or keloids. Poor placement of incisions may result in easily visible scars. Some scars may become depressed if the suction on the cannula is maintained each time the cannula is withdrawn from the incision. If using a machine for vacuum, either stop the machine before withdrawal or use cannulas with a vent hole in the thumb portion of the handle for easy release.

Incision sites may be irritated by the multiple fast passes of the cannula resulting in a reddening around or in the scar. Steroid cream will resolve the problem. The incision performed should be slightly larger than the cannula. Some surgeons use a plastic plug in the incision while performing liposuction that will prevent the cannula from rubbing on the skin.

The use of large incisions is not indicated since most cannulas are 6 mm or less and more often than not are 4 mm or less. Some surgeons use microcannulas (under 2 mm) but their use requires many more skin incisions and the liposuction takes longer to perform.

The treatment of hypertrophic or keloid scars includes steroid injection, radiation, reexcision, silicone gel sheeting, pressure therapy, or a combination of these [43]. The combination of steroid and 5-fluorouracil has been helpful in treatment. None of the treatments are permanently effective for keloids in a large percentage of patients; however, hypertrophic scars have a tendency to resolve on their own over a period of time.

Skin necrosis will usually result in a significant scar. Treatment may require excision and careful closure.

50.3.12 Seroma

The collection of serous fluid in the liposuction area may be due to irritation of the tissues by the traumatic procedure but is more frequently the result of concomitant oversuctioning of a single area with undermining of a flap allowing a cavity to form. Sometimes a hematoma may appear first and be replaced over time with serosanguinous fluid and then serous fluid.

A persistent collection of fluid following liposuction may be treated with needle aspiration followed by adequate compression dressings. This may need to be repeated every few days. If the collection can be reached through one of the liposuction incisions, a drain can be inserted to reduce the fluid and kept in place with compression dressings that need to be changed every couple of days. Prophylactic antibiotics may be used during the time the drain is in place. If the collection becomes chronic (over 4 weeks), the fluid should be aspirated and an equal amount of room air injected into the cavity to cause irritation (Fig. 50.3). Compression dressings are necessary after each such treatment. Another method that is available but that requires adequate anesthesia is curetting the lining of the cavity through a small incision or through one of the liposuction scars. If the liposuction is combined with abdominoplasty and a chronic seroma occurs, the pseudocyst may be excised through the abdominal scar but this may leave a visible deformity.

50.3.13 Thromboembolism

Superficial thrombophlebitis (an inflamed vein) appears as a red, tender cord. Deep-vein thrombosis may be associated with pain at rest or only during exercise with edema distal to the obstructed vein. The first manifestation can be pulmonary embolism. There may be tenderness in the extremity and the temperature of the skin may be increased. Increased resistance or pain on voluntary dorsiflexion of the foot (Homan's sign) andtenderness of the calf on palpation are useful diagnostic criteria.

Pulmonary embolism is usually manifested by one of three clinical patterns: (1) onset of sudden dyspnea with tachypnea and no other symptoms; (2) sudden pleuritic chest pain and dyspnea associated with findings of pleural effusion or lung consolidation; and (3) sudden apprehension, chest discomfort, and dyspnea with findings of cor pulmonale and systemic hypotension. The symptoms occasionally consist of fever, arrhythmias, or refractory congestive heart failure.

Medium- and high-risk patients for thromboembolism [37] (over the age of 40 years, prior history of thromboembolic disorder, surgery over 1 h, obesity,

Fig. 50.3. A 43 year-old patient with history of liposuction of thighs 6 years previously had circumferential liposuction of thighs. **a** Areas of seroma marked after 5 months of repeated needle aspirations and use of drains. **b** Ultrasound scan of seroma (*arrow*) in the right thigh at 5 months postoperatively. **c** Ultrasound scans of right thigh seroma (*arrow*) 1 week following one injection of room air into the seroma. This shows a marked decrease in the size of the cavity. The left thigh was injected once with room air and had complete closure of the seroma. A second injection of room air into the right seroma resulted in complete closure

postoperative immobilization, estrogen therapy) should have the necessary precautions taken in the perioperative period [43]. These include compression stockings (TEDS) or intermittent compression garments. Failure to warn female patients to stop taking estrogens (birth control pills or replacement therapy) at least 3 weeks prior to surgery and 2 weeks after surgery increases the risk of thromboembolism [44]. The combination of liposuction of the abdomen n with abdominoplasty is especially risky for the occurrence of pulmonary embolism.

Thromboembolism has to be diagnosed early if death is to be prevented. Any postoperative patient who develops shortness of breath or chest pain must be considered to have the possibility of pulmonary embolism and a ventilation–perfusion lung scan should be obtained. The use of intravenous heparin can be life-saving and, at times, may be started even before the diagnosis is confirmed.

50.3.14 Toxic Shock Syndrome

There have been reports of toxic shock syndrome, which is a potentially fatal disorder [25–27]. The syndrome is caused by the exotoxins (superantigens) secreted with infection from *Staphylococcus aureus* and group A streptococci [45]. Knowledge of the criteria for diagnosis is important in order to treat this potentially fatal disease. This includes [46]:

1. Fever (above 102°F)
2. Rash (diffuse, macular erythroderma)
3. Desquamation (1–2 weeks after onset, especially of palms and sole)
4. Hypotension
5. Involvement of three or more organ systems:
   (a) Gastrointestinal (vomiting, diarrhea at onset)
   (b) Muscular (myalgia, elevated creatine phosphokinase)
   (c) Mucous membrane (conjunctiva, oropharynx)
   (d) Renal (blood urea nitrogen or creatinine more than 2 times normal)
   (e) Hepatic (bilirubin, serum glutamic-oxaloacetic transaminase, serum glutamic-pyruvic transaminase more than 2 times normal
   (f) Hematologic (fewer than 100,000 platelets)
6. Negative results from the following studies (if obtained):
   (a) Blood, throat or cerebral spinal fluid cultures
   (b) Serologic tests for Rocky Mountain spotted fever, leptospirosis, measles

Treatment consists of surgical debridement for necrosis, antibiotics, circulatory and respiratory care, anticoagulant therapy for disseminated intravascular coagulation, and immunoglobulin [47]. Experimental approaches have included use of antitumor necrosis factor monoclonal antibodies and plasmapheresis.

Acute median nerve compression has been reported [48] in three patients from the administration of large amounts of intravenous fluids during liposuction. The edematous compression of the nerve resolved with elevation of the extremities and use of diuretics.

The range of intravenous fluids was 4,000–6,000 ml. Obviously the anesthesiologist in each case did not understand that small amounts of intravenous fluids should be administered in liposuction cases, limiting the amount to 250 ml/h or less.

50.4 Conclusions

Complications of liposuction are best avoided when possible. The surgeon should be aware of methods to prevent the various complications and the treatments available. Aggressive liposuction by removing very large amounts of fat and doing very superficial liposuction in order to get more skin retraction can be associated with an increase in complications. It may be preferable to remove less than 5,000 ml of fluid and fat at each sitting and repeat the procedure at a later date than perform large-volume liposuction or megaliposuction. The risk of complications may then be reduced.

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51 Disharmonious Obesity Following Liposuction

James E. Fulton Jr., Farzin Kerendian

51.1 Introduction

Liposuction is considered an excellent technique for body sculpting by removing unwanted fat [1–3]. The method has achieved much popularity in the past decades and is now one of the commoner elective cosmetic surgical procedures in the USA [4]. Liposuction is considered safe and effective [5, 6]. Although major complications associated with liposuction are rare, the potential for early and delayed complications exists. The early postoperative complications are extensively described in the literature and they include bleeding or unusual bruising, seroma formation, infections, lidocaine toxicity, skin necrosis, fat embolism, and perforation of major organs or vessels [7]. However, the long-term complications or sequelae are not so well established. One of the sequelae is the development of disharmonious obesity after liposuction. After removing one portion of the body's fat cells, the other fat cells may pick up the burden of fat storage. This may lead to an unusual area of fat bulging that becomes unattractive.

51.2 Authors' Experience

A retrospective study was completed on 125 patients who had undergone liposuction in the last 5 years. Histories, physicals, and photographs were reviewed and 15 patients were found that had developed unusual hypertrophic fat pockets (Table 51.1, Fig. 51.1). There were examples of hypertrophic fat pockets in the submental area, upper back, arms and legs, breasts, anterior and posterior flanks. No particular fat deposits were exempt. After obtaining an informed consent, the patients were placed on a low-carbohydrate diet, aerobic exercise and scheduled for repeat liposuction.

Table 51.1. Foci of disharmonious obesity after liposuction

Area	Number	Area	Number
Submental	2	Upper abdomen	3
Upper arms	3	Mesenteric fat	3
Breasts	6	Interthighs	2
Upper back	4	Knees	2
Lower flank	5	Ankles	1

There were 31 sites. The breasts, upper backs and flanks were the commonest areas of fatty hypertrophy; however, no fatty foci were exempt. There was an average of two sites per patient.

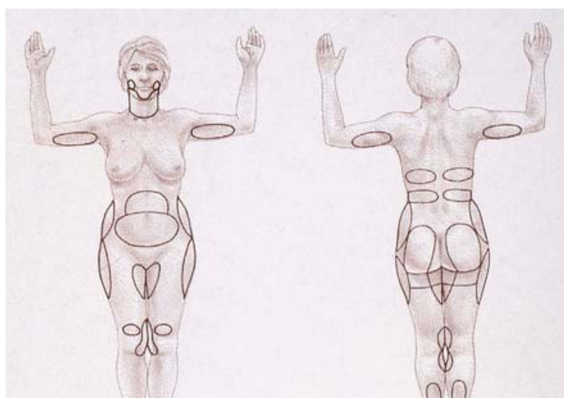

Fig. 51.1. Potential areas of hypertrophic fatty deposits. Any of these fatty foci can hypertrophy following body sculpting with liposuction. (Courtesy of Coleman et al. [8])

51.3 Case Histories

Case 1: This 44-year-old woman had undergone liposuction and abdominoplasty 5 years previously following three pregnancies. The abdominal wall was defatted with liposuction, the abdominal muscles were plicated and the skin was closed in three layers. Over the next few years the anterior abdomen remained flat. However, there was a gradual bulging of the flanks, which became disfiguring (Fig. 51.2).

After the patient developed an exercise program, reduced her carbohydrate intake and underwent liposuction of these hypertrophic flanks the condition improved.

Case 2: This 45-year-old woman had an abdominal pannus, which was removed with liposuction and abdominoplasty (Fig. 51.3). She noticed a reduction in waist size and a flat abdomen. However, over the next few years her breasts became hypertrophic and caused chronic back pain and depressions of the shoulders from the bra straps. After breast reduction with liposuction her figure became more harmonious.

Case 3: This 52-year-old woman underwent extensive liposuction 4 years previously. She came in for an evaluation of tumors that had developed on the upper flank (Fig. 51.4). After developing an aerobic exercise program, using a low-carbohydrate diet and undergoing liposuction of the residual fatty deposits the body became more harmonious.

Case 4: This 43-year-old woman had undergone two previous liposuction surgeries to contour the body. The areas of the liposuction improved; however, she developed fatty deposits of the arms (Fig. 51.5). After reducing carbohydrate intake and having liposuction of these fatty deposits the arms became more proportional.

Case 5: This 38-year-old woman had extensive liposuction 5 years previously. Over the intervening years she had developed a "buffalo hump," bilateral tumors on the upper abdomen and a tail on both breasts

Fig. 51.2. Disharmonious obesity after liposuction and abdominoplasty. **a** Before liposuction and abdominoplasty. **b** After liposuction and abdominoplasty. The flanks gradually became hypertrophic and displeasing to the patient

Fig. 51.3. Breast hypertrophy following liposuction. **a** Prior to liposuction. **b** Patient developed breast hypertrophy that was associated with chronic back pain following liposuction

(Fig. 51.6). These were improved with additional liposuction, aerobic exercise and a low-carbohydrate diet.

Case 6: This patient demonstrated hypertrophy of anterior and posterior flanks after liposuction (Fig. 51.7).

Fig. 51.4. Hypertrophic fat deposits of the upper flank. **a** Patient prior to liposuction. **b** Patient developed unusual fatty tumors of the upper flanks following liposculpture 4 years previously

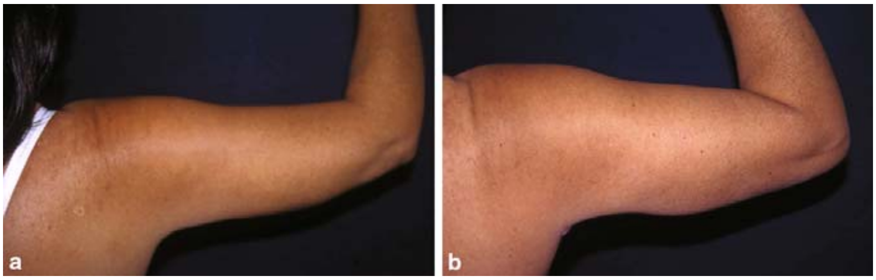

Fig. 51.5. **a** Patient prior to liposuction. **b** The arm fat pad became hypertrophic following liposculpture of other areas

Fig. 51.6. After liposuction 5 years previously this patient developed bilateral fatty deposits on the upper abdomen and a fatty tail on both breasts and a buffalo hump on the upper back. These were improved with additional liposuction, aerobic exercise and a low-carbohydrate diet

Fig. 51.7. Note the hypertrophy of the flanks after liposuction

Case 7: This patient developed mesenteric fat hypertrophy after liposuction (Fig. 51.8).

Case 8: This patient developed bulging of the lateral buttocks after liposuction (Fig. 51.9).

51.4 Discussion

These cases demonstrate one of the sequelae of liposuction, hypertrophy of residual fat pockets that have been untreated or inadequately treated with liposuction. Previous authors have also documented areas of fatty hypertrophy following liposuction. Matarasso et al. [9] studied fat distribution between subcutaneous and visceral adipose tissue after large-volume (more than 1,000 ml) liposuction. They found that liposuction of subcutaneous fat led to a 12% increase in the proportion of visceral adipose tissue. The authors also found this clinically.

There was often an increase in mesenteric fat after subcutaneous liposuction. Scarborough and Bisaccia [10] were the first to document breast hypertrophy following liposuction. Yun et al. [11] also documented that one third of their 73 subjects reported breast hypertrophy after liposuction. This phenomenon results from a decrease in the number of fat cells in the area treated by liposuction and a compulsory increase in fat deposition in residual fatty pockets. This preferential fatty hypertrophy results in the appearance of disharmonious obesity. Larson and Anderson [12] discovered that visceral depots were compensated by an increase in average fat cell size, whereas subcutaneous depots were compensated by an increase in fat cell numbers. Also, when fat deposits with hormone receptors such as the outer flanks are removed the same level of circulating estrogen has a more profound effect on the residual fat cell receptor sites, such as the breasts. There is relatively more estrogen available at the residual hormone-dependent fat cells after liposuction [13].

Obviously, the adipose tissues not only store fat but also participate in the general metabolic processes. The rate of fat deposition and its use is determined by diet intake and energy expenditure. In addition to corrective liposuction, the therapeutic program must include aerobic exercise and a low glycemic diet. The reduction in refined carbohydrate intake will reduce the insulin levels so sugars will not be directly converted to fat [14].

It is important to discuss the risk of this occurrence preoperatively with the liposuction candidate. The physician must stress the necessity of weight control and the benefits of exercise. It is much easier to develop inappropriate fat pockets when other areas of body fat have been eliminated and the patient maintains a high glycemic diet. With this patient awareness and education it may be possible to avoid these sequelae.

Fig. 51.8. After liposuction of the subcutaneous fat of the abdomen, this patient developed extensive mesenteric fat hypertrophy

Fig. 51.9. Note the lateral bulging of the buttocks after liposuction. This was corrected with weight loss following aerobic exercise and a low-carbohydrate diet

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Blood Loss in Liposuction Surgery 52

E. Antonio Mangubat, Colin Harbke

52.1 Introduction

The safety of liposuction surgery continues to be a major concern in contemporary cosmetic surgery. Initial measurements of blood loss in liposuction were performed by measuring the volume of blood present in the infranatant fluid [1–3] and ranged from 5 to 12 ml of blood per liter of total aspirate. Unfortunately, this analysis does not consider third-spacing blood loss into the extravascular tissue known to occur postoperatively which can be substantially more than that observed in the aspirate. This would lead the clinician into a false sense of safety.

The potential complications are usually avoidable by limiting the total amount of surgery performed empirically; however, no systematic attempt has been described to define the actual volume limitations of liposuction. As long as total aspirated volumes during liposuction remain small, the risk of blood loss is almost negligible. The tendency toward greater liposuction aspirate volumes in larger patients makes the definition of precise volume limitations important. Empirical determinations of volume limitations have been one-dimensional simply by stating a maximum volume limit [4–6]. In this chapter we will explore the factors involved in determining blood loss and to apply these variables to create a statistical model to predict blood loss preoperatively.

52.2 Studying Blood Loss

Blood loss in liposuction surgery has been evaluated superficially. Blood losses among different methods of liposuction including suction-assisted liposuction, pneumatic-power-assisted liposuction and ultrasound-assisted liposuction were found to be similar [2, 7]. The common factor among these methods was use of the tumescent technique and it is well accepted as the factor responsible for vastly diminishing blood loss in liposuction surgery.

Some striking blood losses and severe complications of large-volume liposuction have been reported [8, 9] but these appear to be attributable to errors in technique. Others have reported success with minimal blood loss after large-volume liposuction [10, 11].

Attempts to mitigate blood loss of aesthetic procedures with anticipated blood loss have also been described [12]. The novel method involves collecting autologous blood immediately preoperatively, replacing the volume 4:1 with crystalloid, and reinfusing the autologous blood immediately postoperatively, the thought being that bleeding intraoperatively would be hemodiluted blood leading to less blood loss.

With obesity becoming a significant problem in the USA, the trend towards large-volume liposuction has grown. Even potential health benefits have been described. Large-volume liposuction has been reported to significantly improve insulin sensitivity and decrease glucose postoperatively [13 14], decrease body weight, systolic blood pressure, and resting insulin levels [15]. If these results are found to be long-term benefits, large-volume liposuction could possibly be used as therapeutic as well as cosmetic treatment.

The forces driving more surgeons towards larger-volume liposuction require a better characterization of exactly what defines a large-volume liposuction. Clearly patients are of different sizes and shapes. Intuitively, the impact of a 4-l aspirate on a patient weighing 50 kg is clearly different from that on a patient weighing 100 kg. Yet the published guidelines do not address patient variability.

Human biodiversity creates significant challenges in characterizing physiologic reactions to various stresses. These challenges include reliable data collection, identifying relevant variables to measure, small sample sizes, and limitations in statistical power to derive significant and tangible conclusions. The authors rely on experience with trauma research and statistics to identify certain significant variables [16]. Liposuction is a controlled surgical injury. The severity of the injury should be intuitively proportional to the severity of blood loss. Furthermore, the severity of injury for any given patient is a function of patient size, how much volume is aspirated, and speed of surgery. These factors taken with presurgical conditions were used to determine if the prediction of blood loss could be made preoperatively.

52.3 Methods and Materials

Data were collected from 187 women who underwent liposuction surgery between September 1998 and September 2002. Anesthesia was achieved predominantly with epidural block. A small number of patients had pure local or general anesthesia but their sample size was not significant to segment them from the study. Tumescent solution consisting of 0.45% lidocaine and 1:1,000,000 epinephrine in lactated Ringer's solution was infused up to a total lidocaine dose of 35–40 mg/kg for all patients. Additional wetting solution consisting of only 1:1,000,000 epinephrine was infused after the safe lidocaine load had been reached, preventing drug toxicity yet providing for the intense hemostasis required to prevent blood loss. Discussion of this rationale will follow.

Some patients underwent additional procedures in addition to liposuction during the same session. As displayed in Table 52.1, the values for "surgery time" and "percent mass extracted per minute" are based on the amount of time for all surgical procedures the patient may have received and do not reflect the time course of the liposuction procedure alone. Despite the introduction of measurement error that may have occurred by using the duration of all surgical procedures the patient received, it should be noted that because of the common practice of performing multiple procedures during the same surgical session these values represent the "real-world" effect of cosmetic surgery on the patients' blood loss. "Percent of mass extracted" values represent the volume of fat extracted during liposuction divided by the patient's presurgery weight in kilograms. "Percent of mass extracted per minute" is the average amount of percentage mass extracted per minute of the total surgical session and can be considered as a measure of the surgeon's speed during the procedure. In keeping with the author's intention to measure the real-world effect of cosmetic surgery on the patient's blood loss, it should be noted that hemoglobin (Hgb) values incorporate error that may have been introduced by the patients' lifestyles or other relevant extraneous variables (e.g., smoking and menstruation).

52.4 Data Analysis

To identify variables that affect the patient's change in Hgb levels, a hierarchical linear model (HLM) [17] was computed using the statistical software HLM [18]. Unlike traditional multiple regression techniques that do not address inaccuracies that arise by taking multiple measurements from the same patient, HLMs are appropriate for modeling change over time. Put simply and in terms of the present study, hierarchical linear modeling is a two-stage process in which (1) slope coefficients describing each patient's change between presurgery and postsurgery Hgb levels are estimated, and (2) these slope coefficients are predicted by a linear combination of independent variables (i.e., predictors). Descriptive statistics for the slope coefficients from the first stage of the HLM are provided in Table 52.1 and can be interpreted as the change in Hgb values between the presurgery and postsurgery measurements.

Table 52.2 summarizes the factors that affect a patient's change in presurgery and postsurgery Hgb levels. The amount of mass extracted during liposuction had the greatest effect on Hgb levels (indicated by the magnitude of standardized coefficients, β). Both the

Table 52.1. Sample descriptive statistics for relevant variables

Variable	*N*	Mean	SD	Minimum	Maximum
Presurgery Hgb	186[a]	13.13	1.00	9.30	15.00
Postsurgery-Hgb	169[1]	11.22	1.36	6.30	14.20
Change coefficient in Hgb units[b]	168[1]	–1.87	1.37	–6.83	1.07
Age (years)	187	41.28	10.54	21.00	72.00
Weight (kg)	187	79.80	17.76	47.63	127.01
Surgery time (min)	187	153.97	68.59	35.00	475.00
Mass extracted (kg)	187	5.02	2.73	0.35	12.85
Percent mass extracted	187	6.09	2.71	0.58	12.41
Percent mass extracted per surgery minute	187	0.04	0.02	0.01	0.09

Hgb hemoglobin, *SD* standard deviation
[a] Missing data reduced *n*
[b] The hierarchical linear model estimates these change coefficients (i.e., dependent variable) using a linear combination of independent variables (i.e., predictors in Table 52.2)

surgeon's speed (i.e., percent mass extracted per minute) and the patient's presurgery weight also had an effect on Hgb levels. In addition to the change described by the predictor variables, the patients' Hgb levels decreased, on average, by 1.16 Hgb units, as indicated by the intercept coefficient in Table 52.2. The model displayed in Table 52.2 fits the data significantly better than a model that included no predictor variables (i.e., unrestricted model), $X^2(3)=61.81$, $p<0.001$.

52.5 Interpretation of the Model

Figure 52.1 displays the effect of each predictor on the patient's Hgb levels assuming that the values for the remaining two predictors and presurgery Hgb levels were equal to the sample mean. The greater a patient's presurgery weight and the faster that surgeon performs the procedure, the less loss of Hgb. However, patients who have a greater percentage of their total mass aspirated during liposuction will suffer the greatest loss of Hgb. Put in other terms, liposuction patients with low presurgery weights who request large percentages of body mass be removed are at the greatest risk of complications due to blood loss. The surgeon can theoretically minimize the patient's blood loss by performing the procedure quickly but this goes against the aesthetic goals of smooth results.

Although the current statistical model clearly demonstrates the statistically significant relationship between individual patient characteristics and blood loss it does fall short of the authors' ultimate goal of reliably predicting blood loss preoperatively in all patients. The potential utility of this model, however, is to identify those patients with greater risks wishing to undergo liposuction.

Table 52.2. Regression estimates and confidence limits (*CLs*) predicting Hgb change

Predictor	*B*	*b*	SE *b*	95% CLs of *b*
Weight (kg)	0.13	0.01	0.01	0.00–0.02
Percent mass extracted	−0.62	−0.34	0.04	−0.43 to 0.26
Percent mass extracted per minute	0.16	11.82	5.70	0.65–22.98
Intercept	–	-1.16	0.43	−0.21 to −0.31

All predictors significant at $\alpha=0.05$. Overall model provides a greater fit than a model with no predictors (i.e., unrestricted model), $X^2(3)=61.81$, $p<0.001$.
SE standard error

52.6 Discussion

As of this writing, blood loss in liposuction is not analytically well understood. We have learned through experience that the profound vasoconstriction of epinephrine provides for intense hemostasis and allows significantly larger volume aspiration during liposuction with greater safety. Gilliand et al. [19] reported that hypovolemia and anemia were virtually eliminated in their retrospective review; however, they did not report preoperative and postoperative measurements of Hgb and hematocrit (HCT). Numerous other authors have stated that blood loss in liposuction surgery is minimal [11, 13, 20] yet no rigorous analysis has been reported.

Many authors report total volume aspirated not supernatant fat aspirated [19]. The actual tissue removed

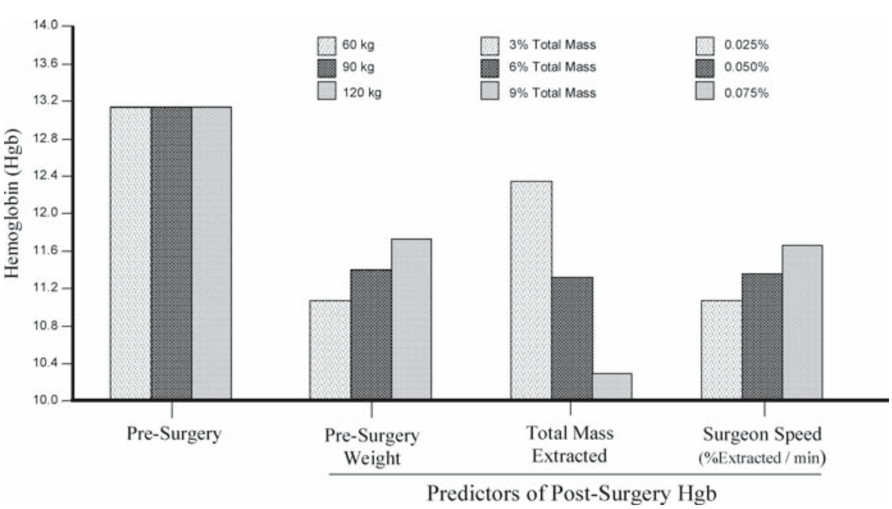

Fig. 52.1. Predictors of postsurgery hemoglobin (*Hgb*)

is related to the supernatant fat and thus it is logically the more accurate variable to report. In our study, the total liposuction volume aspirated was not statistically significant, supporting our premise that supernatant volume should be the reporting standard.

Furthermore, the concept of injury severity has not been defined in liposuction surgery. The commonest factor associated with injury severity is total volume aspirated during liposuction surgery [4–6] as noted by the respective practices guidelines published by the American Academy of Cosmetic Surgery, American Society of Dermatologic Surgery, and the American Society of Plastic Surgery. These guidelines pose limits of approximately 5000 ml of total aspirate as their recommended safety limits.

From the study of trauma, we know that injury severity is related to multiple factors [16, 21]. In many ways, liposuction can be related to the combination of burn and blunt injuries. The volume of aspirate may be indicative of the amount of blunt trauma inflicted during the procedure and the total areas of liposuction address the total body surface area (BSA) of injury. Although BSA was not statistically significant in our study, the concept provided the initial framework for examining liposuction injury.

The new concept of percent mass extracted (ratio of supernatant volume to body mass in kilograms) is the theoretical corollary to injury severity. It can be thought of as the relative amount of injury suffered (mass removed) in relation to the size of the patient (weight). This newly derived variable was statistically significant and explains what we intuitively already know; that larger patients can tolerate larger volumes of liposuction that smaller patients.

Only three variables were found to be statistically significant in predicting blood loss in our study: patient weight, surgery time (which represents the speed of surgery), and supernatant volume (expressed as percent mass). Surprisingly BSA was not statistically significant; however, a larger dataset may improve detection and reveal other significant variables in the future.

Klein's introduction of tumescent anesthesia in 1987 is a major milestone in liposuction history. Not only did the technique provide local anesthesia for large areas of liposuction, the profound vasoconstriction caused by the dilute epinephrine in the mixture virtually eliminated significant blood loss. The elegantly simple technique set the stage for monumental gains in the evolution of the liposuction procedure.

Large-volume liposuction was a predictable outgrowth of the tumescent technique but it required infusion of larger volumes of tumescent infusion that delivered concomitantly larger loads of lidocaine almost an order of magnitude greater that the maximum load recommended in the *Physicians desk reference* (PDR) [22].

Fortunately, lidocaine toxicity, pulmonary edema, and volume overload were rare events. Reported tolerable loads of lidocaine were found to be much higher than the traditionally accepted PDR limits [23, 24]. The tumescent technique created a new level of safety where larger volumes of fat could be safely aspirated in a single session; however, it also left us with a new frontier to define: exactly how much fat can we take out safely? Given human biological diversity, this a complex question; however, new statistical techniques allow the researcher to identify relationships among multiple variables measured serially in a group of subjects [17, 18].

Anesthesia for liposuction surgery in its early history was limited to general anesthesia. As liposuction evolved, surgeons began using other forms of anesthesia, many of which were aimed at reducing blood loss. Fournier [25, 26] strongly advocated cryoanesthesia in which patients were infused with normal saline chilled to 2°C, believing that the cold temperature would not only have a numbing effect reducing the lidocaine load, but it would also have a vasoconstricting effect reducing blood loss.

The tumescent technique achieves both of these goals simply and reliably. The two components of the tumescent technique are the local anesthetic effect produced by infusion of a large volume of dilute lidocaine and the vasoconstriction caused by the dilute epinephrine in the solution. In large-volume liposuction, vasoconstriction is the most important contribution minimizing blood loss, maximizing fat evacuation. Logically, larger aspirated volumes on larger and more obese patients demanded larger volumes of infused tumescent solution. The reported safe lidocaine loads have been reported to range from 35 to 60 mg/kg [22–24, 27]; however, the tumescent volume required in large-volume liposuction may far exceed even these large doses. With large-volume liposuction the concern over lidocaine toxicity emerged and toxic complications have been reported [27].

This signaled a need to change the original tumescent concept in order to accommodate large-volume liposuction. The concept of separating the two functions of the tumescent technique has been described [28]. Anesthesia can be provided by other methods such as regional blocks (epidural and spinal) or general anesthesia. Regardless of anesthesia, it is the epinephrine effect that decreases blood loss, increases safe operating time, and increases the volume of fat that can be aspirated. Limiting or eliminating lidocaine from the tumescent formula eliminates the potential for toxicity yet retains what is most import in liposuction, the safe elimination of fat by minimizing blood loss [28]. Furthermore, limiting or removing lidocaine virtually eliminates the volume limit of tumescent fluid that can be infused for fear of toxicity.

Of the numerous potential complications in liposuction surgery (Table 52.3), only blood loss and pulmonary edema would directly limit aspiration of larger volumes of fat. Although, fluid overload is a concern, fluid absorption from subcutaneous infusion (also known as hypodermoclysis [29]) is slow and unlikely to overload normal renal function causing fluid overload and pulmonary edema. As expected, these complications are rarely reported.

Separating the two critical functions in the tumescent technique is critical for large-volume liposuction to be effective and safe. The complex interactions of the physical response of human systems make this a daunting task. In addition to identifying factors that affect blood loss, preoperative conditions are equally important in determining the extent of blood loss that can be safely tolerated, e.g., a patient with a preoperative HCT of 35% will tolerate significantly less blood loss than a patient who starts with a CVT of 45%. How these complex interactions relate is the major obstacle of this effort.

Many clinicians believe that a patient who is awake, alert, and comfortable during the procedure can give early warning of excessive blood loss [3]. Unfortunately this end point of safety is fraught with inaccuracy and danger. Blood pressure does not begin to drop until 15–30% of the patient's blood volume has been lost (Table 52.3). This corresponds to 2–4 units of blood loss, which is significant and potentially dangerous if not recognized early before clinical signs are apparent (Table 52.4).

In large-volume liposuction, the authors believe that blood loss is the most likely end point that limits how much can be aspirated. With sufficient forethought and care, all other potential complications of liposuction surgery can be predicted and prevented. Only blood loss has not been well defined since the development of tumescent liposuction. Clearly the guidelines presented by leading organizations have done much to aid liposuction surgeons in staying within safe grounds; however, they have also discouraged the exploration of the true limits of large-volume liposuction for fear of violating a somewhat arbitrary standard of care not derived from evidence-based conclusions.

The ultimate predictive model would be to be able to predict, with statistical confidence, postoperative Hgb and HCT given preoperative conditions. Possessing such a tool would be extraordinarily valuable to the liposuction surgeon and patient. Being able to customize the surgery for every patient regardless of size and anticipated volume reduction would allow us to maximize results and minimize complications. Knowing the safe end point preoperatively would be a tremendous advantage for risk management and optimizing results, especially in large patients.

Of course, factors that contribute to increase bleeding such as aspirin, non-steroidal anti-inflammatory drugs, alcohol, and blood thinners must be avoided. Any of these factors can confound the predictive value of any model and alter the calculated safe aspirate volume limits significantly.

Table 52.3. Complications of liposuction surgery

Pulmonary edema
Drug toxicity
Skin necrosis
Necrotizing fasciitis
Fat embolus
Deep venous thrombosis, pulmonary embolus
Blood loss, shock, anemia
Visceral perforations

52.7 Conclusions

In large-volume liposuction, blood loss appears to be the most likely end point that limits how much can be aspirated. With sufficient forethought and care, all other potential complications of liposuction surgery can be predicted and prevented. The three variables

Table 52.4. Classification of shock (Adapted from the *Advance Trauma Life Support Instructor's Manual* [30])

	Class I	Class II	Class III	Class IV
Blood loss (ml)	≤750	750–1,500	1,500–2,000	≥2,000
Blood loss (% blood)	≤15	15–30	30–40	≥40
Volume	<100	>100	>120	>140
Pulse rate	Normal	Normal	Decreased	Decreased
Blood pressure	Normal or increased	Decreased	Decreased	Decreased
Capillary blanch test	Normal	Positive	Positive	Positive
Respiratory rate	14–20	20–30	30–40	>35
Urine output (ml/h)	≥30	20–30	5–15	Negligible
CNS (mental status)	Slight anxiety	Mildly anxious	Anxious and confused	Confused, lethargic
Fluid replacement	Crystalloid	Crystalloid	Crystalloid + blood	Crystalloid + blood

that were found to be statistically significant in predicting blood loss were patient weight, surgery time (which represents the speed of surgery), and supernatant volume (expressed as percent mass).

Clinical experience is mandatory in order to carry out large-volume liposuction safely and reliance on a single statistical predictor is ill-advised. The authors emphasize that although the modeling in this chapter is statistically significant, it is a product of ongoing research and should utilized only a clinical estimator. The responsibility of the patient's well-being and results must exclusively be the responsibility of the treating surgeon. Given the increasing patient demands of the promising health benefits from large-volume liposuction [13–15], precisely defining the true volume limits of liposuction becomes increasingly important.

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Fat Shifting for the Treatment of Skin Indentations

Melvin A. Shiffman, Guillermo Blugerman

53.1 Introduction

Saylan [1] was the first to describe a technique called "liposhifting" as a safe and simple method to treat liposuction irregularities. This method moves fat from around the indentation into the depressed area by injecting tumescent solution consisting of 1 l of normal saline containing 1 mg epinephrine and 12.5 mEq sodium bicarbonate. A 3–4-mm Becker cannula is moved in a crisscross fashion through multiple incisions to loosen the fat globules. The fat is then pushed into the defect by rolling a 6–10-mm cannula toward the indentation. A tape dressing is then applied to keep the fat in position. It takes about 4–7 days for the fat globules to become vascularized [2].

53.2 Technique

The area that is depressed and the surrounding elevated regions are marked prior to surgery.

The injection of Klein's solution containing 1 l of saline (or lactated Ringer's solution) with epinephrine, lidocaine, and sodium bicarbonate is not necessary if general anesthesia is use. In that instance a solution of 1,000 ml saline with 1 mg epinephrine is used. Local tumescent anesthesia can be utilized with or without sedation. The solution that is least painful for a patient under local tumescent anesthesia is 1 l of lactated Ringer's solution with 1 mg epinephrine, 300 mg lidocaine, and 12.5 mEq sodium bicarbonate.

The fat is loosened around and under the defect with a cannula by not applying suction and obstructing the open end with the finger or plug. Some cannulas may be more aggressive than the blunter tipped cannula but crisscross and fan-shaped patterns with multiple layers should be utilized. The subdermal tissues in the area of the defect are treated in the same manner as the surrounding fat utilizing tunnels and no sweeping motion. Subcision may be required if there is scar attachment of the skin to the underlying tissues.

Special instruments devised by Blugerman can obtain predictable fat grafts and comprise a spatula (Fig. 53.1) and a tubular "scalpel" with a solid handle (Micro Graft Fat Cutter; Laser Point, Nordkirchen, Germany) (Fig. 53.2). These are produced as reusable or disposable instruments. The spatula is utilized to create tunnels in multiple layers (Fig. 53.3), which can reduce the incidence of hematoma. If more fat mobilization is necessary, the instruments can be utilized again to produce more fat grafts.

Fig. 53.1. Blugerman spatula

Fig. 53.2. Tubular "scalpel" with solid handle (Micro Graft Fat Cutter)

The fat in the surrounding tissues is moved or "shifted" into the defect by rolling a 6–10-mm cannula over the tissues with moderate pressure until the defect is at least flat (Fig. 53.4). Fat can be mobilized by massage maneuvers as well. Blugerman has devised a roller pin that is more efficient in shifting the fat. Absorption of the tumescent solution will result in a loss of any excess fullness within a few days.

The incisions are not sutured. The area is sprayed with tincture of benzoin and then stretch tape is applied around the repaired depressed area to hold the fat in its intended position (Fig. 53.5). A foam pad may be used under the stretch tape to reduce bleeding. Compression is maintained for 24 h. If blisters occur on the skin, the tape should be removed and any open blisters covered with antibiotic ointment daily until the skin has healed. Tincture of benzoin helps to prevent blisters but is not 100% effective.

The patient is placed on antibiotics, administered either orally starting the day before surgery or intravenously at least 30 min before the start of surgery. The oral administration of the antibiotic is continued for at least 5 days postoperatively.

Fig. 53.3. The spatula is used to create tunnels in multiple layers

53.3 Complications

There may be bruising as with any liposuction procedure. Bruising will reduce the amount of fat survival. If the surgeon is too aggressive with the undermining, hematoma can occur.

Blisters from the tape can be irritating to the patient but if treated timely by removal of the tape, there will be no residual scarring or pigment loss. Blisters that are unbroken can be treated with protective dressings and observation. Open blisters are treated with antibiotic ointment.

Infection would be devastating to fat survival and is treated by increasing the dose or changing the antibiotics. Culture and sensitivity may be required if the infection does not respond readily to the antibiotics. This may require needle aspiration to obtain a specimen if there is no drainage. Incision and drainage is rarely necessary.

Undercorrected defects may require repeat lipo-shifting procedures. This can be performed after 3 months, when there is no longer fat reabsorption.

53.4 Discussion

The fat globules or "pearls" receive their new blood supply in 4 days with new blood vessel formation in

Fig. 53.4. **a** Fat shifted with a large cannula. **b** Fat shifted with manual massage. **c** Fat shifted with a large roller

the periphery of the globule [2]. The center of the globule will be reabsorbed. The amount of fat that survives will be permanent after 4 months.

The technique is easy to learn and has not been associated with any major complications. The procedure can be used for any depression, whether or not it is associated with prior liposuction. The depression may need subcision if a scar or fibrosis is involved. The face is not a good area to use liposhifting since there is not enough fat to move into a defect and the underlying bony structure makes shifting more difficult. However, a technique with a small diameter, short tube to roll the fat into place into a small depression may very well be developed.

Reduction of surrounding elevated areas and elevation of depressed areas can be obtained in a single procedure (Figs. 53.6–53.8).

Fig. 53.5. Stretch tape with foam applied around the fat-grafted area of the depression

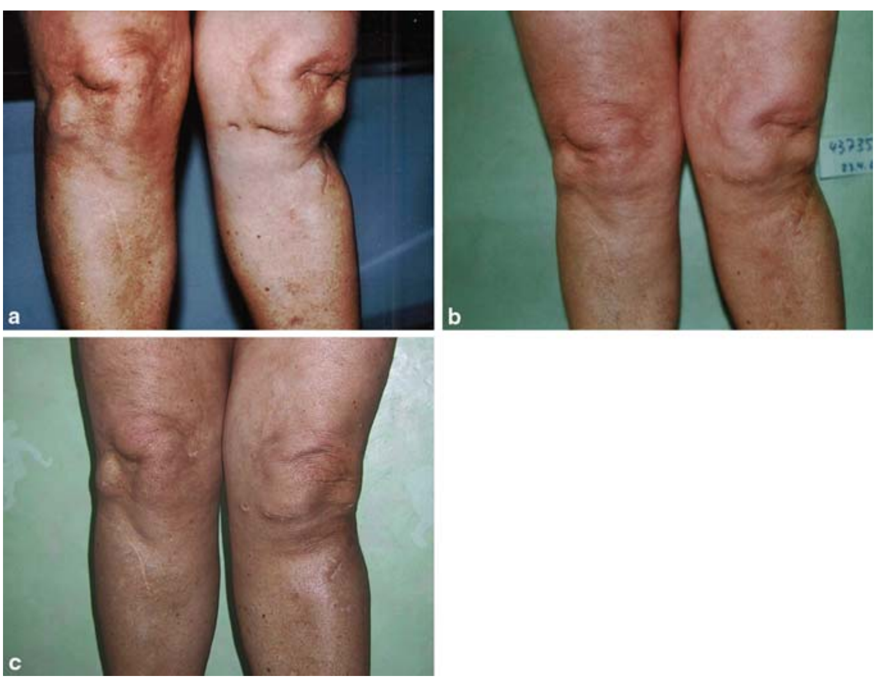

Fig. 53.6. a Traumatic depression of the left knee area. **b, c** Progressive filling of defect with liposhifting

Fig. 53.7. **a** Preoperative depressions of medial thighs. **b** Postoperative improvement in the medial thighs following liposhifting

Fig. 53.8. **a** Preoperative defect of the right lateral buttock. **b** Postoperative improvement in the defect following liposhifting

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Liposuction Mortality

Melvin A. Shiffman

54.1 Introduction

Any surgery, minor or major, has risks of mortality associated with the procedure from complicating medical disorders, allergies, anesthesia, and physician error. There are few true statistics that distinguish adequately between all the possible causes of mortality in a variety of cosmetic surgical procedures, especially liposuction.

There have been statements that large-volume liposuction and megaliposuction are associated with a higher risk of mortality than with liposuction under 5,000 ml. It has been pointed out that local tumescent anesthesia for liposuction does not have a risk of mortality, which is untrue, although the risk of mortality is definitely less than with general anesthesia or deep sedation.

Statements have been made that general anesthesia is more of a risk for thromboembolic disorders than local tumescent anesthesia and that concomitant additional surgical procedures at the time of liposuction increase the risk of mortality, which may very well be true. Surgeons have claimed that thromboembolism does not occur with facelift, which is not true. Careful research into the risks of mortality with cosmetic surgery has not been done; mainly retrospective surveys have been utilized.

54.2 Risks of Mortality with General Anesthesia

Forrest et al. [1], in 1990, reported an incidence of 1.11:1,000 procedures resulted in deaths from anesthesia. Actually, out of 17,201 cases there were 19 deaths, in only seven of which anesthesia may have been a contributing factor. All the patients were American Society of Anesthesiologists (ASA) physical status 1 or 2 and deaths from sepsis, bleeding, and pulmonary embolus were included.

Other authors [2, 3] have reported a 1:10,000 risk of purely anesthesia-associated mortality.

Coldiron [4] reported on 43 procedure-related complications and eight deaths in a prospective study by the state of Florida through reporting requirements. Nineteen months of data were collected but the number of patients who had surgical procedures was not stated. Liposuction in eight patients of the 43 had complications with general anesthesia and with one patient under deep sedation. There were three deaths from liposuction under general anesthesia and none were reported following local tumescent anesthesia. There was one case of acute anaphylaxis from lidocaine.

Eichhorn [5], in 1989, showed that there were no complications or deaths in 319,000 patients having general anesthesia and monitored in accordance with the standards of the ASA.

Cardenas-Camarena [6] reported no mortalities in 1,047 patients having liposuction with the tumescent technique and general anesthesia. The volume of aspiration ranged from 500 to 22,200 ml with a median of 6,230 ml. Major complications included one patient with two prior liposuction procedures who had skin necrosis, one patient who had abdominoplasty also developed infection, one patient with abdominoplasty as well as liposuction developed fat pulmonary embolism, and one patient who had breast implants as well as liposuction developed fat pulmonary embolism.

54.3 Medical Risks of Mortality

Obesity and body mass index (greater than 35) pose a significant risk to life [7], while severe untreated hypertension (over 120 mmHg) is likely to increase anesthetic morbidity [8]. Medical conditions such as diabetes mellitus, heart disease, and pulmonary disease pose significant risks with the use of general anesthesia.

Allergies to medications can result in anaphylaxis with death. Oral contraceptives pose a 1:28,000 mortality risk [9] and it has been advised to avoid preoperative oral contraceptives [10].

54.4 Surgical Risks of Mortality

There has been reported a 1:1,000 patient mortality with hysterectomy and a 1:333 patient mortality with mastectomy [11].

Luft et. al. [12] stated that high volumes of surgical activity were linked to lower mortality probabilities.

54.5 Cosmetic Surgical Procedures and Mortality

For cosmetic procedures performed under general anesthesia the risks of mortality are:

1. Facelift: 1:922 [13] to 1:5,000 [14]
2. Abdominoplasty: 1:600 [15]

Fatalities may occur when liposuction is combined with other adjunctive operations [16–18]. Bernstein and Hanke [19] reported no fatalities in 9,478 cases of liposuction with 71% of patients receiving local anesthesia and 29% given general anesthesia.

Teimourian and Rogers [20] stated that there were 1:29,000 fatalities with liposuction from fat embolism and pulmonary thromboembolism. The causes of the fatal outcomes from liposuction were reported by Grazer and de Jong [21] (Table 54.1).

There was a death reported from necrotizing fasciitis following liposuction [22] and several other deaths have been reported [23] but the causes of the deaths were not adequately described.

54.6 Discussion

Many of the statistics quoted are over 15 years old. Anesthetic agents and techniques have, since that time, advanced and helped to reduce mortality. Combining liposuction with abdominoplasty is a known risk for thromboembolism and mortality. Adding lengthy procedures to a significant volume of liposuction aspiration has been associated with deaths. Lidocaine, even in small doses, has caused acute anaphylaxis and death sometimes attributed to the presence of methylparaben as a preservative (G.A. Farber, personal communication, January 18, 1999) [24–26]. No surgical procedure with any type of anesthesia is without significant risk.

Table 54.1. Fatal outcomes from liposuction: 496,245 cases from 1994 to 1998; 130 fatalities [1:3817 cases or 26:100,000 (0.026%)]. (Reprinted with permission from Ref. [21])

Disorder	Number of deaths
Thromboembolism	30
Abdomen/viscus perforation	19
Anesthesia/sedation/medication	13
Fat embolism	11
Cardiorespiratory failure	7
Massive infection	7
Hemorrhage	6
Unknown	37

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Part X
Principles and Standards

Psychology and Quality of Life of Patients Undergoing Liposuction Surgery

Gerhard Sattler, Dorothee Bergfeld, Boris Sommer, Matthias Augustin

55.1 Introduction

Skin, skin care and cosmetics were already in ancient times important aspects of individual well-being as well as interindividual interaction. Such cosmetic changes of appearance are well appreciated in all cultures. The desire for alteration and improvement of the individual appearance has been part of human evolution for thousands of years.

Nonetheless there is a constant discussion about the role and legitimacy of cosmetic medicine. Are medical cosmetic corrections necessary or only tolerable? Are they useless or even contraindicated?

Cosmetic surgery interventions are in most cases elective procedures. What is the motivation for people to undergo cosmetic surgery? How does it affect their life?

55.2 Psychological Aspects

Until today nearly no studies have been made on psychological signs of "the typical patient" undergoing cosmetic surgery, the preset for cosmetic surgery procedures, the satisfaction with therapeutic outcome or changes in quality of life after treatment [1].

Clinical experience demonstrates a wide range of patients' motivations for cosmetic surgery. There is a wide variety in the self-concern and perception of the individual outer appearance, ranging from a reduced, self-neglecting approach to an exaggerated, overconcerned one. The person with a reduced cosmetic or aesthetic self-concern does not care for his or her outer appearance or does not take this aspect serious, whereas the person with an exaggerated cosmetic self evaluation is more or less constantly concerned about it and will, for example, frequently look in the mirror.

Another aspect that plays an important role in the decision to undergo cosmetic surgery is the subjective self-perception, which can vary from a negative to a beautified perception. The personal perception does not need to correlate with the objective perception of the environment (Fig. 55.1).

Between the two extremes of self-neglect versus overconcern and negative versus beautified self-image there are a wide range of people with a so-called normal concern and perception of their appearance. These are people who care for themselves without exaggeration and have a realistic view of their outer appearance. They are the peer group for cosmetic medicine.

55.3 Sociodemographic and Quality of Life Aspects

To obtain data on sociodemographic aspects and quality of life before and after liposuction (Fig. 55.2), the profile of 300 patients undergoing liposuction surgery at the Rosenparkklinik, Darmstadt, Germany for cosmetic reasons were investigated in a clinical retrospective study [1]. The study investigated satisfaction with the outcome, sociodemographic parameters and effects on the quality of life.

The patients were asked to complete a standardized questionnaire, which was especially designed by a group of experienced dermatologists and psychologists from the University of Freiburg, Germany [1–4].

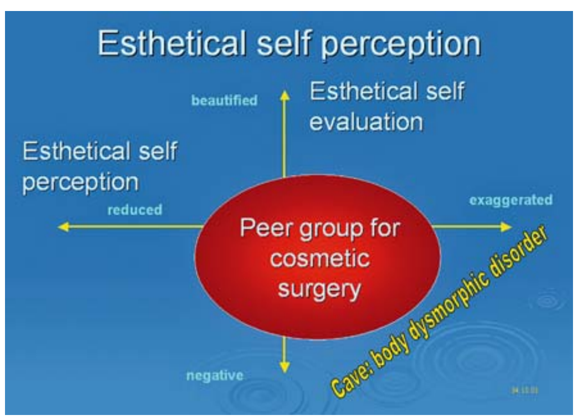

Fig 55.1. Aesthetic self-perception

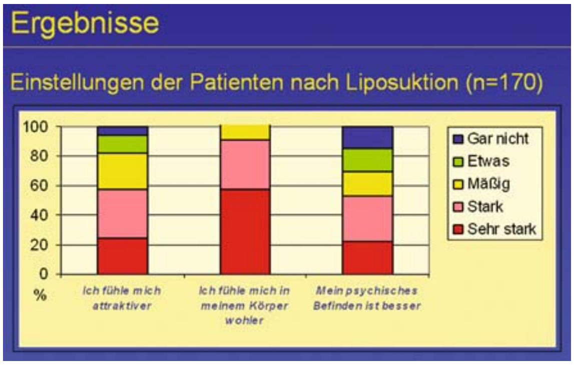

Fig 55.2. Profile of 300 patients undergoing liposuction surgery at the Rosenparkklinik, Darmstadt, Germany, for cosmetic reasons

The patients were asked to describe their motivation for undergoing liposuction surgery, their body feeling and the major problems with their appearance.

The sociodemographic data obtained in this study confirm that liposuction is most frequently sought by women. Most patients had white-collar jobs or were self-employed. The patients' education resembled that of the German population. These data together with the almost equal age distribution between 30 and 60 years and the mostly normal body mass indexes indicate that a broad spectrum of "normal" women of different social groups undergo liposuction surgery. Patients' expectations with regard to operation technique and satisfying results were high. The results of the study correlate with the daily experience of surgeons.

About 90% of the patients were completely or mostly satisfied with the treatment and would recommend the treatment to others. Almost the same proportion of patients regarded the treatment as beneficial to themselves. About 80% of the patients were not at all or just a little stressed by the operation.

About 60% of the patients reported feeling more attractive and about 90% felt more comfortable with their body after liposuction. Fifty-five percent responded that their emotional feeling was better after liposuction.

When investigating the social effects about 50% confirmed feeling better in company; 20% confirmed profiting from the treatment in their jobs.

The data obtained on quality of life with this scientific approach might help to argue against prejudices concerning cosmetic surgery in the public and media discussion. It will be necessary to obtain more data in the future to allow a broad discussion on these aspects.

To achieve patient satisfaction and improvements in quality of life it is essential to take the following aspects into account before recommending an invasive cosmetic treatment: careful patient information, creation of realistic expectations only, no treatment of "problem" patients and realistic judgement of own abilities [5–12].

55.4 Body Dysmorphia

People with an exaggerated concern about their looks combined with an unrealistic negative self-evaluation might suffer from a pathologic body perception called dysmorphophobia (body dysmorphic disorder). This disorder is defined as an exaggerated concern about a suspected deficiency (which is not objectionable) in the person's appearance or an unjustified fear about an imagined disorder.

This disorder is not rare. Approximately 3–5% of patients consulting a dermatologist have a body dysmorphic disorder. Anamnestic hints are an excessive use of make-up, a long history of cosmetic treatments or the wish for unjustified invasive measures, e.g., operation.

It is important to recognize dysmorphophobia before starting a massive treatment as this might lead to serious psychological disorders and lots of trouble for the surgeon.

55.5 Discussion

Invasive operative cosmetic treatment should therefore only be performed when objective clinical deficiencies exist and the patients' expectations are realistic.

In a study from the dermatologic department of the University of Freiburg, Germany, patients undergoing different cosmetic treatments were compared with a control group in regard to whether any specific psychological abnormalities existed. Of the 405 patients investigated, the majority (179) were undergoing liposuction surgery. There was no hint for more psychological abnormalities in the study group.

In a similar group of patients undergoing cosmetic treatment the attitude towards body, aesthetic perception and aesthetic treatments was investigated and again compared with the attitudes of a control group. Compared with the control group the patients that were treated showed a higher perception and awareness of body care and aesthetic aspects. They watched their environment more carefully and felt more watched by others. Compared with the control group there was a higher degree of dissatisfaction with the outer appearance.

The data from the studies confirm the clinical experience that patients undergoing liposuction are in most cases happy with the treatment and experience positive effects for body, mind and social interactions.

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56 Liposuction Practitioner Profile and Current Practice Standards and Patient Safety

Robert F. Jackson

56.1 Introduction

Our current practice of liposuction, which is the removal of unwanted or excess fat from the body through suction techniques, evolved from physicians' efforts to extract fat in the most effective manner and with the least number of complications for their patients. This procedure has developed through the expertise of multiple disciplines. Recent reports by the American Academy of Cosmetic Surgery, the American Society of Plastic Surgery, and the American Society of Dermatologic Surgery have indicated minimal complications when using tumescent techniques for liposuction.

In 1998, The American Academy of Cosmetic Surgery undertook a survey to determine a practitioner profile in order to learn who is practicing liposuction, their qualifications and where procedures were being performed. Some of these findings will be included in this profile.

56.2 Evolution of the Procedure

In the 1920s physicians attempted fat removal with a curette, resulting in complications such as seroma formation and amputation [1]. The multidisciplinary advancement of today's techniques can be illustrated by the fact that the early practitioners came from a variety of specialties. In the 1970s liposuction was advanced by the Italian otolaryngologist Georgio Fischer, who developed suction cannulas. Fischer operated on a group of patients using 5-mm incisions and published his results in 1976. Pierre Fournier, a French cosmetic surgeon, further refined the technique. As the procedure progressed simplification of the cannulas as well as a reduction in diameter of the cannulas yielded fewer complications.

In the early 1980s members of the American Academy of Cosmetics Surgery traveled to Europe and studied under Ives Illouz, a French obstetrician/gynecologist, and Fournier. The same group brought Illouz and Fournier to America to teach the technique the following year. Once a core group of qualified surgeons had been established the technique was taught through didactic and live workshops. The attendees of the workshops were then proctored by members of the faculty at their own facility. This remains the hallmark of learning any new technique not learned during a physician's training program. One must complete all three phases (didactic training, live surgical training and individual one-on-one proctorships until the proctor feels the trainee is qualified) prior to embarking on attempting any new procedure.

In 1986, dermatologist and cosmetic surgeon Jeffrey Klein created the tumescent technique, using a formula of fluid and local anesthesia lidocaine injected into the area of proposed liposuction. Today this is the gold standard of liposuction. Liposuction continues to be improved through ongoing refinements in technique and as the experience of the physicians performing the procedure continues to grow.

In 1998 a survey was conducted by the American Academy of Cosmetic Surgery to determine the qualifications and the current specialty practice of physicians performing liposuction. The survey was sent to 1,053 members of the Academy, 28.2% responded, which is considered to be a high response rate. The industry standard is 10% for this type of study. The accuracy rating was listed as 95–97% [2].

Some of the interesting demographics show that members who responded and perform liposuction represented 40 of the 50 states and 93% were board-certified in their specialty (Fig. 56.1). The majority of the members of specialties who responded had their original certification in the following five specialties: dermatology, general surgery, oral and maxillofacial surgery, otolaryngology, and plastic surgery (Fig. 56.2). Another specialty that has an increasing number of liposuction surgeons is obstetrics and gynecology.

The number of liposuction procedures accomplished increased steadily through the 1990s and at the turn of the century was one of the most popular cosmetic surgery procedures performed [3]. A survey of members of the American Academy of Cosmetic

Surgery revealed there were 814,080 liposuction procedures performed on women and 138,394 procedures performed on men in 2001 alone [3].

The majority of the current practitioners of liposuction have obtained their training in didactic seminars and live workshops (Fig. 56.3). A few residencies now incorporate liposuction in their core training. However in many of these programs the amount and training of liposuction is inadequate. Prior to 1990 it was rare for liposuction to be offered as a part of a residency or fellowship training. Today plastic surgery programs, cosmetic surgery fellowships, dermatologic surgery programs and others are beginning to offer core training in the field of liposuction. Most practicing liposuction surgeons, however, obtained the techniques that they now use through postgraduate, postfellowship and postresidency didactic courses, live workshops and proctorship.

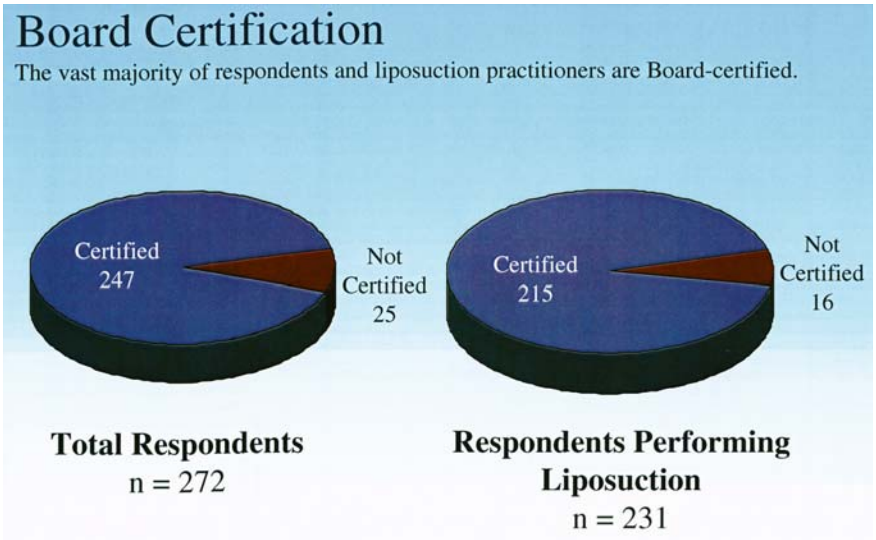

Fig. 56.1. Board certification

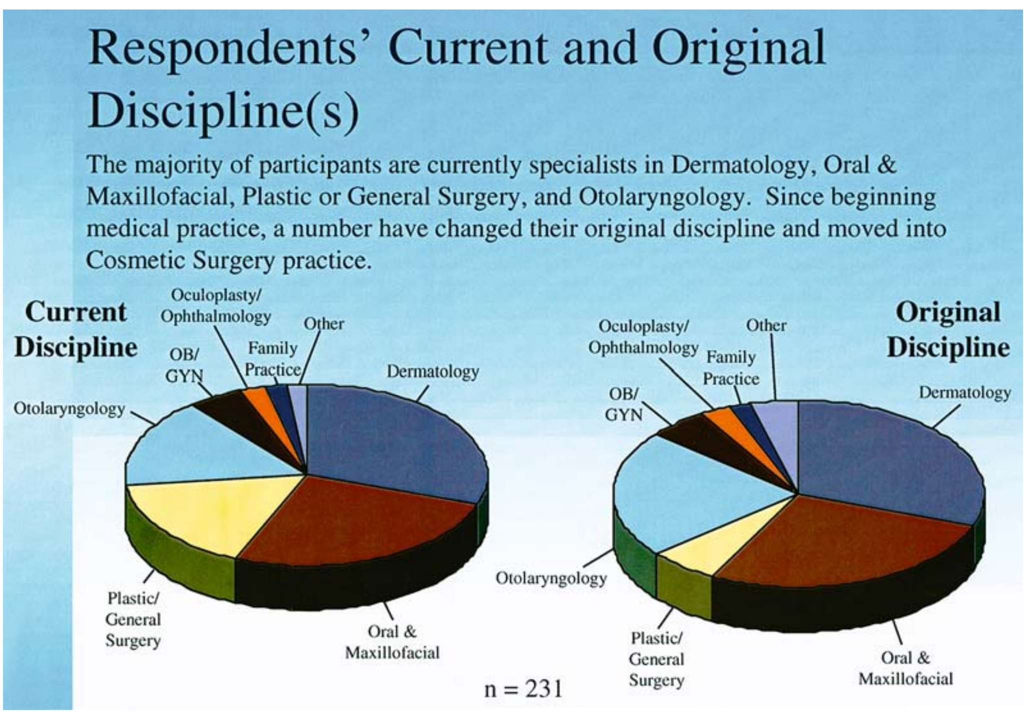

Fig. 56.2. Respondents' current and original discipline(s)

According to surveys conducted by the American Academy of Cosmetic Surgery and the American Society of Plastic Surgery as well as others the majority of liposuction practitioners perform procedures in clinic-based surgical facilities or freestanding surgical centers (Fig. 56.4). A minority of the procedures are accomplished in a hospital setting. Many but not all liposuction surgeons have specific hospital privileges

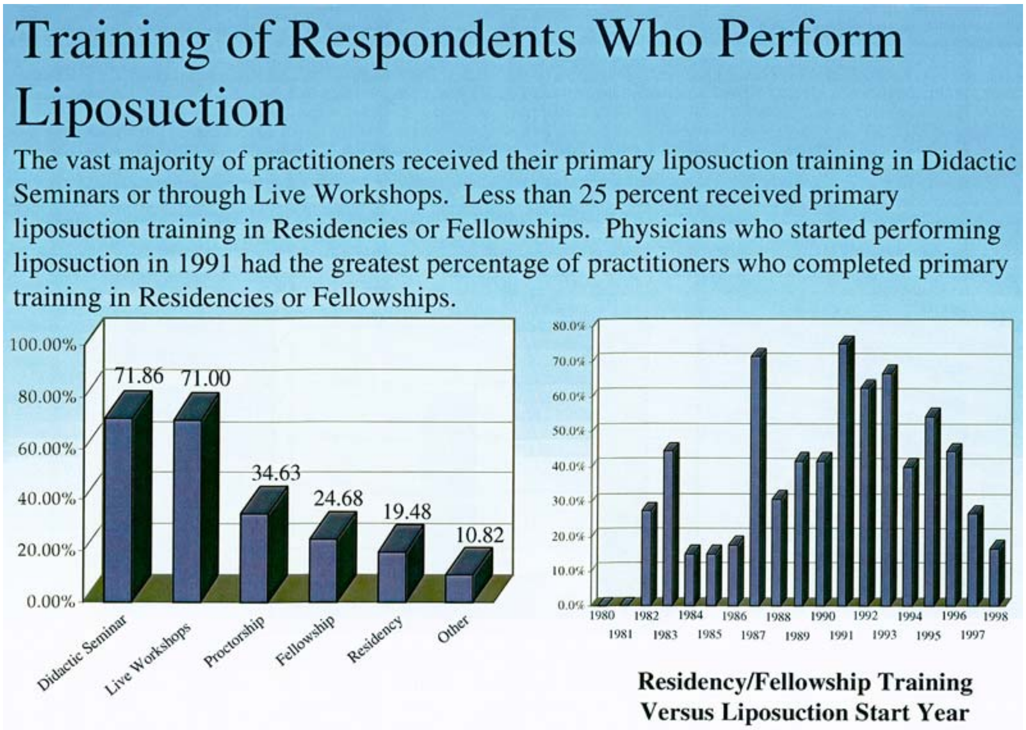

Fig. 56.3. Training of respondents who perform liposuction

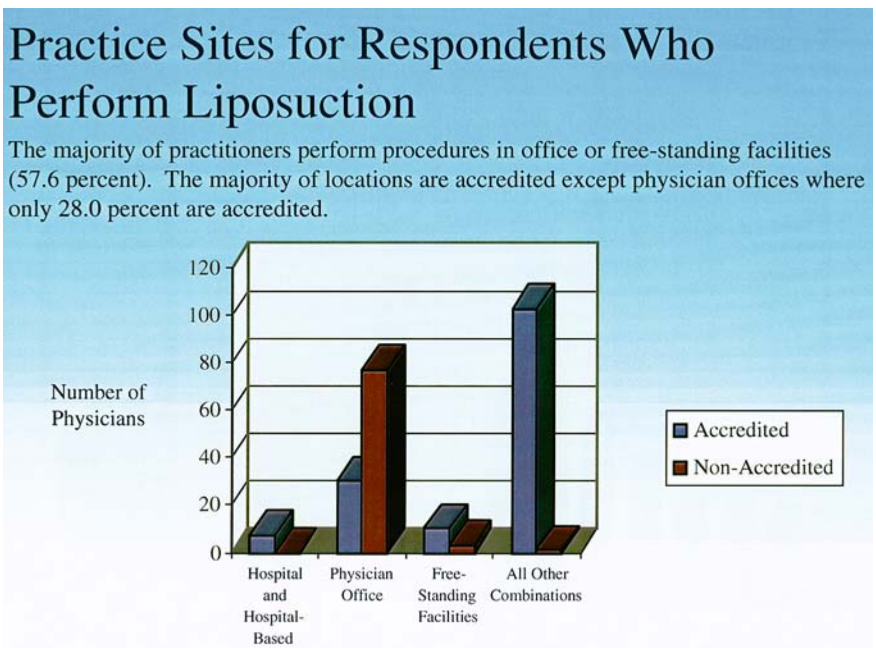

Fig. 56.4. Practice sites for respondents who perform liposuction

to perform liposuction (Fig. 56.5). Unfortunately, a significant turf war exists for the right to accomplish certain cosmetic surgery procedures. Liposuction is one of them.

The American Medical Association indicates that privileging should be by those who are your peers. In some situations procedure privileges are held within the domain of certain specialties. The addition of surgical privileges should be based on training, experience and qualifications. Hospital staff and the public in general must avoid being influenced by any group who claims domain over liposuction. Physicians practicing liposuction should seek educational experiences that include a multiple disciplinary approach to the procedure.

There is an increasing demand by patients for a higher level of expertise in cosmetic surgery as a specialty and in liposuction as a procedure; for that reason increasingly surgeons will need to have familiarity with new developments from more than one discipline. Richard Webster, the father of modern-day cosmetic surgery, felt very strongly that surgical skill, intellectual curiosity and a desire to learn were of greater importance than a particular medical specialty. There is no other procedure in cosmetic surgery that emphasizes those principles more than liposuction surgery.

The profile of physicians doing liposuction surgery in the study of the American Academy of Cosmetic Surgery revealed the overwhelming majority of those doing liposuction were board-certified in their original discipline and had received their training as mentioned before in didactic seminars, live workshops and proctorships (Fig. 56.6). The guidelines of liposuction indicate that the training and experience should be adequate to diagnose and manage cardiovascular, surgical and/or pharmacologic complications that might arise. A practitioner who is operating in any capacity as a liposuction surgeon should have training that is equivalent to the American Heart Association's certification in advanced cardiac life support (ACLS). It is highly recommended that at least one other member of the operating team also be ACLS-certified (Table 56.1).

Table 56.1. 2003 Guidelines for liposuction surgery of the American Academy of Cosmetic Surgery

A joint Ad Hoc Committee of the American Society of Lipo-suction Surgery (ASLSS) and the American Academy of Cosmetic Surgery (AACS) was formed to create the following guidelines for liposuction surgery.[1]

1. Training and education

Physicians practicing liposuction surgery should have adequate training and experience in the field. This training and experience may be obtained in residency training, cosmetic surgery fellowship training, observational training programs, CME accredited post-graduate didactic and live surgical programs, or via proctorship with trained

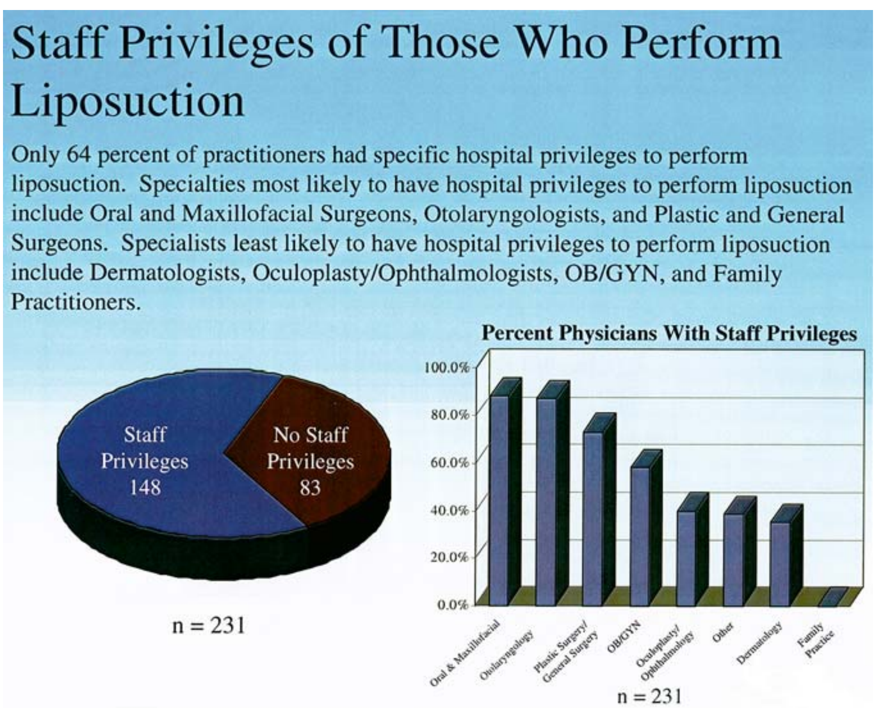

Fig. 56.5. Staff privileges of those who perform liposuction

credentialed surgeons experienced in liposuction techniques. Post-graduate training should include completion of CME accredited didactic and live surgical training courses approved by the American Academy of Cosmetic Surgery. In addition, training and education should include one-on-one or observational training experiences, in a proctorship or preceptorship setting with qualified practitioners of liposuction techniques.
Surgeons of multiple specialties perform liposuction surgery. Qualified surgeons who practice liposuction surgery should have the necessary skills to perform the procedures and the knowledge to diagnose and manage cardiovascular, surgical, or pharmacological complications that may arise. Surgeons, who have received adequate training and surgical experience as either a primary surgeon or co-surgeon as part of their residency, do not require attendance at didactic courses, live surgical workshop, or preceptorship. If residency experience is not adequate, the surgeon should complete the three levels of education.

2. Preoperative evaluation
An appropriate documented medical history, physical examination, and appropriate laboratory work based upon the patient's general health and age must be performed on all patient candidates. It is recommended that the guidelines of the American Society of Anesthesiology should be followed for liposuction candidates. Special attention should be given to bleeding disorders, potential drug interactions, history of thrombophlebitis, and other common risks of surgery. Informed consent must be obtained prior to surgery.
Thorough clinical examination should include a detailed evaluation of the regions to be lipocontoured including a notation of hernias, scars, asymmetries, cellulite and stretch marks. The quality of the skin and, particularly, its elasticity, and the presence of stria and dimpling should be evaluated. The underlying abdominal musculofascial system should be evaluated for the presence of flaccidity, integrity and diastasis recti. The deposits of body fat should be recorded. Standardized photodocumentation is strongly recommended.

3. Indications
Indications for liposuction or use of liposuction techniques include removal of localized deposits of adipose tissues. These would include:

1. Body contouring, including the face, neck, trunk and extremities
2. Treatment of diseases, such as lipomas, gynecomastia, pseudogynecomastia, lipodystrophy and axillary hyperhydrosis

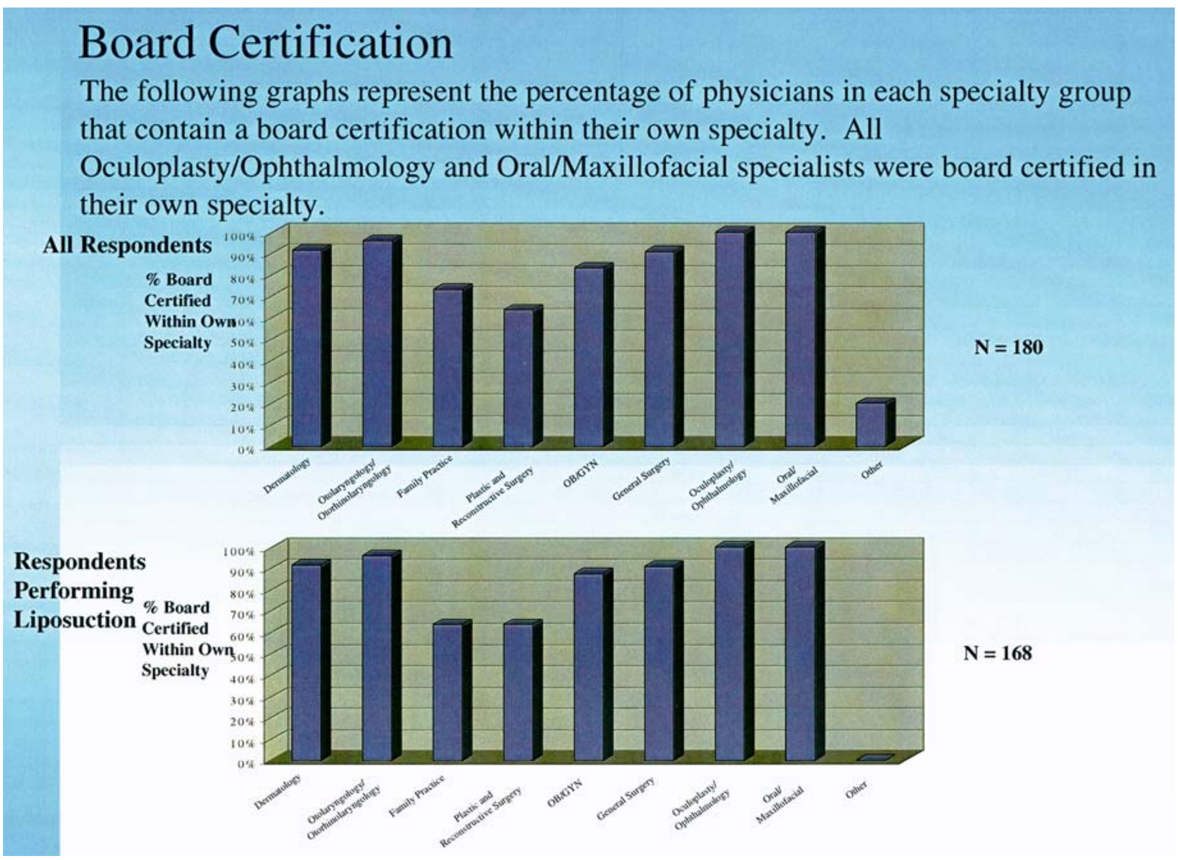

Fig.56.6. Board certification

3. Reconstruction of the skin and subtissues in flap elevations, subcutaneous debulking, and help in mobilization of flaps or other conditions
4. To harvest fat cells for transfer (grafting) to provide tissue augmentation, correction of scar defects, etc.

Note: Weight loss is not considered an indication for liposuction surgery.

4. Techniques of liposuction
Tumescent: Tumescent infiltration has been shown over the last fifteen years to be an important adjunctive technique for liposuction and lipocontouring, with the improved safety, fastest recovery time, and the least number of complications in the liposuction patients. Not only has infiltration of large volumes of dilute local anesthetic (lidocaine 500 mg/l) with epinephrine (0.5 mg/l) has been clinically shown to significantly decrease blood and intravascular fluid loss, it is believed to facilitate lipocontouring. (The dosages and amount of the above agents may vary within recognized safe limits). Most recognized authorities define tumescent infiltration as placement of a 1:1 or higher ratio of subcutaneous infiltration to total aspirated volumes.
When using the tumescent technique and other forms of infiltration of lidocaine with epinephrine, studies recommend a maximum range of 45–55 mg/kg. The limit of 55 mg/kg should rarely be exceeded. The safe dosage is dependent on the total volume of body fat and size of patient. Small patients with minimal body fat should receive doses at the lower range level. Larger volume patients may receive doses approaching the 55-mg/kg level.
Ultrasonic: Ultrasonic-assisted liposuction (UAL) is a recognized technique that appears to be safe, based on current reported clinical experiences. It is common to use ultrasonic-assisted liposuction in conjunction with conventional liposuction techniques (machine or syringe). Use of ultrasonic liposuction technique is recommended for use by surgeons who have extensive previous experience with use of conventional techniques, and who have received additional post-graduate education dedicated to ultrasonic-assisted liposuction.

5. Megaliposuction
Megaliposuction is single stage removal of more than 6,000 ml supranatant fat. The American Academy of Cosmetic Surgery recommends serial liposuction for the removal of large volumes of fat, rather than utilizing megaliposuction. Until sufficient data is collected on megaliposuction, its use should be restricted to experienced surgeons performing clinical research in a hospital setting and under the supervision of an IRB (Institutional Review Board).

6. Recommended volumes for removal
Liposuction surgery, using the tumescent technique, has been demonstrated to be safe for the routine removal of volumes up to 5,000 ml (supranatant fat). Volumes exceeding 5,000 ml should be removed in select patient without co-morbidities in an approved operating facility. Recommended maximum volumes should be modified based on the number of body areas operated on, the percentage of body weight removed, and the percentage of body surface area covered by the surgery.
Liposuction may be safely performed utilizing tumescent local anesthesia only, local plus IV sedation, epidural blocks, or general anesthesia on an outpatient basis. Liposuctions within the recommended volume range typically do not require use of autologous blood transfusion.

7. Surgical setting
Liposuction surgery may be commonly performed on an ambulatory, outpatient basis in clinic-based surgical facilities, free-standing surgical facilities, or hospital settings. The procedures must be performed using sterile technique. Elimination of microorganisms is vitally important in preventing the spread of infection. It may be achieved by various physical or chemical means, such as boiling, steam autoclaving, ultraviolet irradiation, or x-radiation. Cold sterilization may not be adequate for liposuction instrumentation. Additionally, the procedures must be performed with routine monitoring of vital signs, oxygen saturation, EKG monitoring, end-tidal CO_2 monitoring (if under general anesthesia). IV access is recommended for removal of volumes greater than 100 ml of fat.
The surgeon or other health care provider administering tumescent local anesthesia should be properly trained and qualified to provide the required level of anesthesia. At least one health care provider in the operating room should have adequate training in cardiopulmonary resuscitation techniques (ACLS). In the immediate post-operative period, as long as the patient remains in the facility, there should be an individual immediately available to provide appropriate level of cardiopulmonary resuscitation.
It is recommended that operating facilities have AAAHC certification (or equivalent) or function under equal guidelines as those required for such certification. Appropriate and safe management of waste products must be in compliance with current OSHA regulations.

8. Expected sequellae

(a) Common side effects: Edema, ecchymosis, dysesthesia, fatigue, soreness, scar, asymmetry, and minor contour imperfections are expected sequellae.
(b) Occasional side effects: Persistent edema, long-term dysesthesia, hyperpigmentation, prurits, hematoma, seroma, and drug or tape adhesive reactions.
(c) Uncommon complications: Skin necrosis, severe hematomas, recurrent seromas, nerve damage, systemic infection, hypovolemic shock, intraperitoneal or intrathoracic perforation, deep vein thrombosis, pulmonary edema, pulmonary embolism (ARDS) and loss of life have been reported.[2]

9. Postoperative care and medications
Post-surgical compression garments including binders, girdles, foam tape, closed-cell foam, and other specialized equipment have been effectively utilized. The use of compression is considered optional, but appears to be most helpful in the first seven days following surgery. Some surgeons also prefer to facilitate drainage of tumescent fluids after surgery.

Prophylactic antibiotic therapy may be indicated in cases of liposuction surgery. Reasonable early ambulation of liposuction patients is advisable to avoid venous stasis and shorten the post-operative recuperation period.

10. Documentation of care
Patients should have standardized pre-operative and post-operative photographs to document patient condition. Patient's weight should be documented prior to the procedure. The operative record should include, at a minimum, the following information:

1. Quantity of tumescent fluid infused
2. Total dosages and drugs utilized
3. Total volume of fat and fluid extracted
4. Volume of supranatant fat
5. Technique utilized
6. Type of anesthesia
7. Anatomical sites treated
8. Use of ultra-assisted technique (internal of external)
9. Drains (if placed)
10. Complications should be noted
11. Post-operative garments utilized

Surgeons should review and compare before and after photographs to objectively evaluate the quality and extent of final outcomes. Critical outcome analysis is valuable for surgeon and patient perspectives.

11. Privileging for liposuction surgeons
Privileging in hospital, ambulatory surgery center, or clinic-based surgical facilities should follow appropriate guidelines required to grant privileges for adding any surgical procedure. The granting of privileges and the determination of competency should be based on a surgeon's education, training and experience. Surgeons seeking privileges in liposuction should be prepared to submit evidence of completed accredited CME didactic coursework, live surgical conferences, and clinical case experience. Clinical experience may be derived from proctoring or preceptorship training with a qualified, experienced liposuction surgeon for a reasonable number of procedures to adequately determine satisfactory technique and patient management. The proctor or preceptor should have current privileges at an accredited facility (peer review/quality assurance reviewed) to perform such procedures, and be willing, without bias, to observe and evaluate the applicant surgeon. The number of procedures required may be determined at the local facility according to published guidelines, and should be adequate to evaluate pre-operative, intra-operative, and post-operative case management. Confidential case evaluations should be provided, in writing, to the appropriate committee or board granting surgical privileges. Any conflict that may arise between proctor and applicant surgeon should be resolved according to regulations and bylaws of the facility and/or hospital.
Annually, liposuction surgeons are encouraged to obtain continuing medical education (CME) credits specifically in the field of liposuction and related surgery. This may be in the form of current scientific publication review, video tapes, scientific conferences, courses or workshops.

12. Recording adverse events
It is the surgeon's duty and responsibility to report any adverse event, including, without limitation, significant morbidity and mortality as required by local or state requirements. Report should also be provided to the surgeon's respective professional organizations, such as the American Academy of Cosmetic Surgery and/or American Society of Liposuction Surgery in order to provide statistical tracking of such events.[3]

13. Disclaimer
The recommendations contained in this document are not intended to establish a standard of care, but serve only as a guideline. The ultimate responsibility for the patient's well being rests on the clinical judgment of the attending physician and surgeon.

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[1] The members of this committee include: Jim E. Gilmore, MD; Robert W. Alexander MD, DMD; Ronald A. Fragen, MD; Dee Anna Glaser, MD; Kevin Pinski, MD; and Jacob Varon, MD. The ASLSS Advisory Council reviewed the Guidelines in May 2002. These revised Guidelines were presented to and passed by the AACS Board of Trustees on October 3, 2002.

[2] Fatalities are rare; 1 in 40,000 according to a recent AACS survey.

[3] Legislatures and state medical boards are urged to support legislation that will permit the medical profession and the insurance industry to cooperate in formulating a non-punitive policy toward reporting surgical complications. An ideal solution to the problem of identifying unrecognized causes of death as a result of surgery or anesthesia would be for each specialty to take full responsibility for reporting and analyzing each and every unanticipated death. This would require compulsory reporting, absolute confidentiality and significant penalties for non-compliance. The AACS and ASLSS may serve as a clearinghouse for the collection of data concerning the safety of liposuction and the occurrence of adverse events.

The current standard of liposuction practice indicates that the majority of liposuction practitioners perform their procedures in clinic-based surgical facilities or freestanding surgery centers. There did not appear to be any statistically significant difference in the rate or severity of complications based on the location of the performance (Fig. 56.7). The profile shows that most practitioners use anesthesiologists or certified nurse anesthetists (Fig. 56.8). It is strongly recommended that in cases involving use of general anesthesia or intravenous sedation that this service be provided by an anesthesiologist or a certified nurse anesthetist [4]. In the case of pure tumescent anesthesia it is still recommended that another registered or licensed health official have the responsibility of monitoring the patient while the surgeon is completing the liposuction.

The practitioner profile of those liposuction surgeons indicates definitely that there is a learning curve. According to the American Academy of Cosmetic Surgery survey those performing a higher than average number of cases per year and those who began performing liposuction more than 10 years prior to the survey had lower complication rates (Fig. 56.9).

The guidelines of liposuction surgery are renewed and reevaluated each year by the American Academy of Cosmetic Surgery. Those guidelines are then submitted to American Medical Association as a standard of care. The profile of the liposuction surgeon would not only include the aforementioned descriptions but in the essence of patient safety would be one who subscribed to and followed those guidelines. The 2003 guidelines are given in Table 56.1. The surgical setting in which the liposuction procedures are performed must be adequately equipped to allow for meticulous sterile technique with routine monitoring of vital signs, oxygen saturation, EKG monitoring and entitle CO_2 monitoring if the patient is under general anesthesia.

As long as the patient remains in the facility individuals who are trained in cardiopulmonary resuscitation should be immediately available. The author highly recommends that its practitioners attain AAAHC (or equivalent) certification of his operating facility.

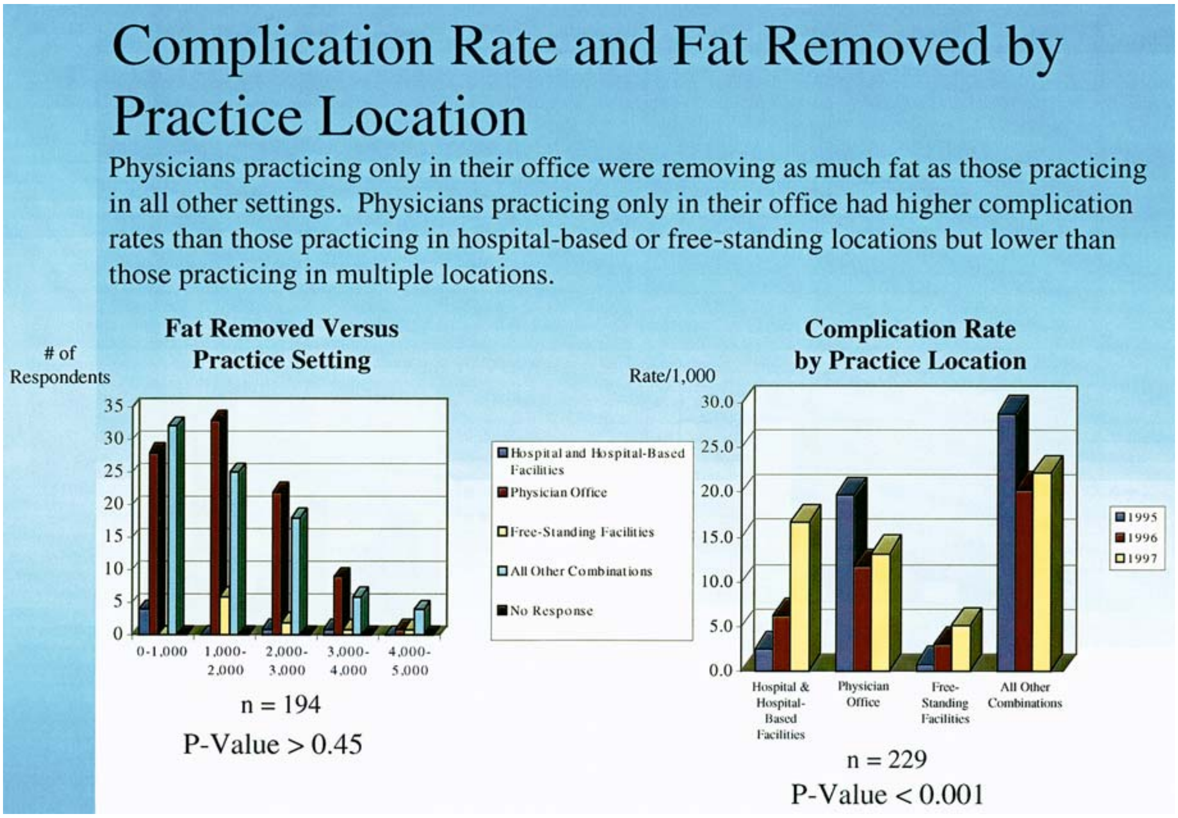

Fig. 56.7. Complication rate and fat removal by practice location

56.3 Summary

A profile of today's liposuction surgeon is as broad as the background of the original discipline; however, the training, expertise and pathway of learning are similar. These practitioners are specialists in dermatology, oral-maxillofacial surgery, plastic and general surgery, otolaryngology and other surgical specialties and they are board-certified in their original discipline. They have followed the three-track pathway to learn and hone their skills, including didactic training, live surgical workshop experience and proctorship. The practitioner documents preoperative status and postoperative results of the patient. Outcome studies are documented and complications recorded.

This practitioner continually updates his or her skills through postgraduate medical education. He or she uses the tumescent technique of liposuction, which is the gold standard today. In an effort to maintain the best techniques and safest environment for his or her patients the practitioner follows guidelines similar to those of the American Academy of Cosmetic Surgery. The practitioner carefully evaluates his or her patient and documents a thorough medical history.

56.4 Conclusions

The practitioner profile shows that cosmetic surgeons who perform liposuction are highly qualified to perform this procedure. This is evident by the very low complication rate, the number of procedures performed and the percentage of board-certified physicians who have incorporated this procedure into their practice (Figs. 56.10, 56.11).

Acknowledgement I appreciate the American Academy of Cosmetic Surgery for the use of the survey of grafts, etc.

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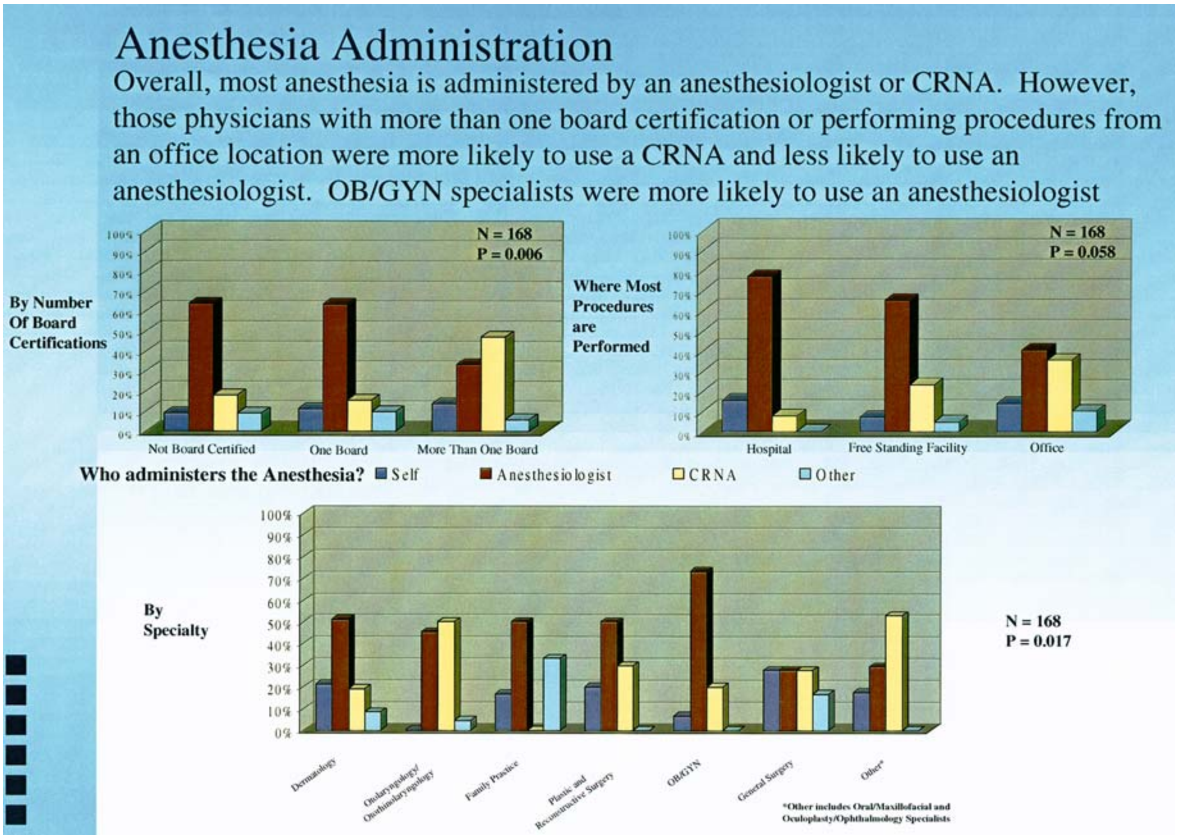

Fig. 56.8. Anesthesia administration

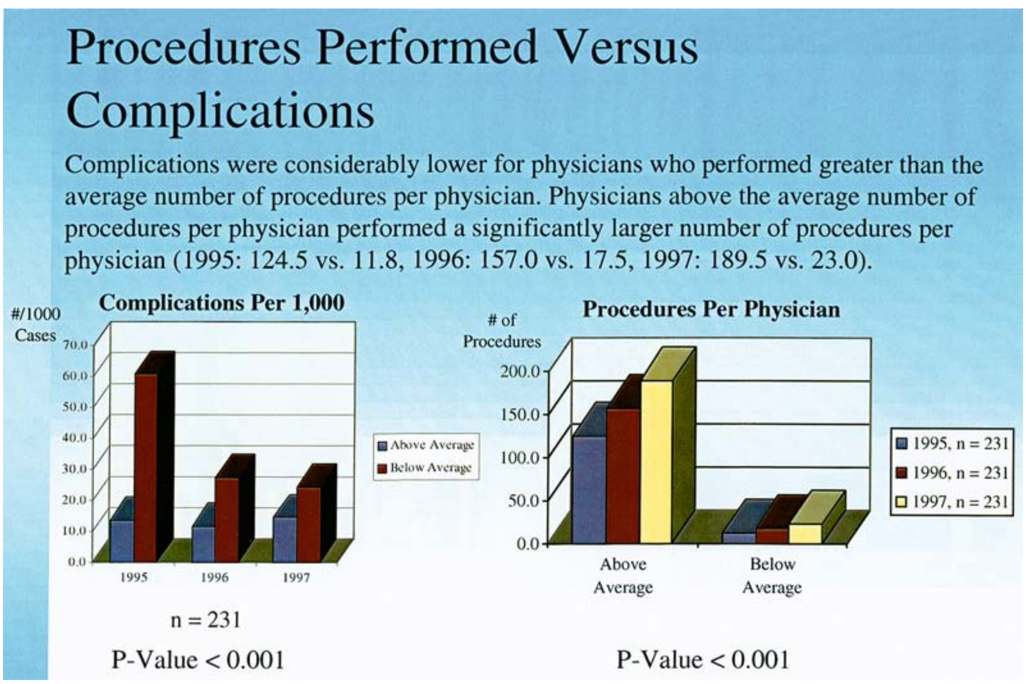

Fig. 56.9. Procedures performed versus complications

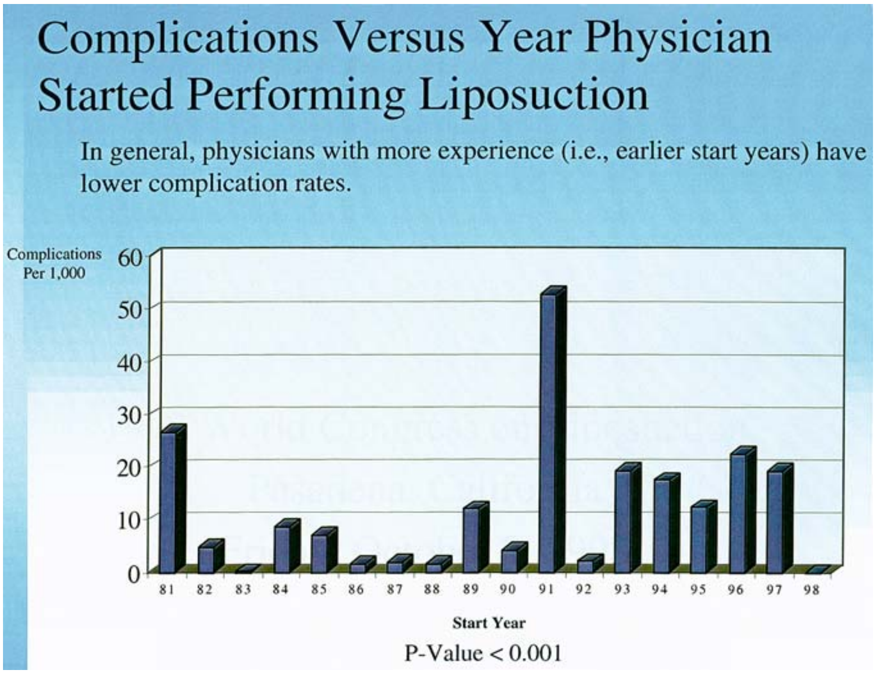

Fig. 56.10. Complications versus year physician started performing liposuction

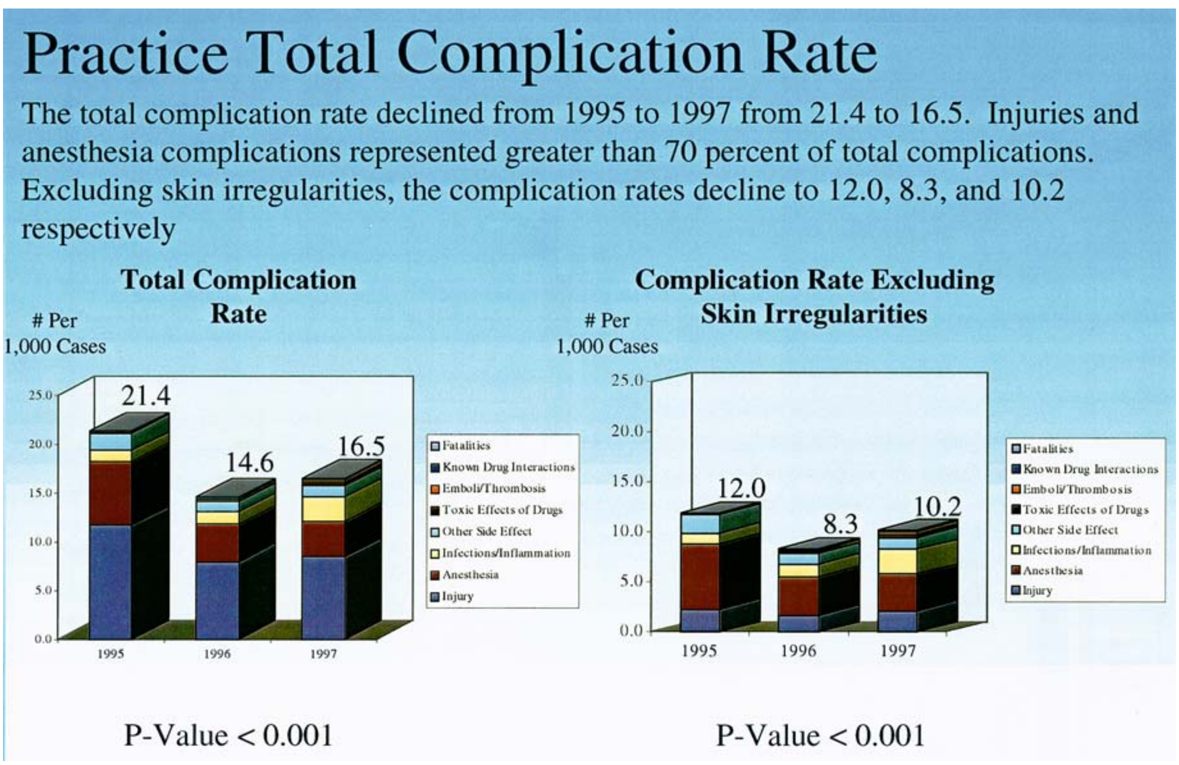

Fig. 56.11. Practice total complication rate

Principles of Liposuction

Melvin A. Shiffman

Since the advent of liposuction by Fischer [1, 2], there has been development of a variety of techniques, anesthesia, and instruments. Principles of liposuction were established (Table 57.1) [3] and then improved.(Tables 57.2–57.4) [4–6]. But liposuction is a continuously changing procedure with modification of and introduction of new principles to improve the surgical results and patient safety.

The suggested new Principles of Liposuction are:

1. *Proper selection of patients*. Liposuction can be performed for body contouring and may be utilized for improvement of obesity, and to improve the treatment for diabetes and heart disorders in the morbidly obese.
2. *Patients have the right to make an informed knowledgeable decision*. Every patient must receive enough information as to the procedure, alternatives to the procedure, and risks and complications in order to make an informed decision. These are essential to obtain an informed consent.

Table 57.1 Illouz's technical principles of liposuction (1985) [3]

1. Use blunt instruments
2. Create many tunnels
3. Dissecting hydrotomy is useful
4. Operate deeply
5. Conceal the scar
6. Use the retraction of the skin

Table 57.2. Illouz's ten commandments of adipoaspiration (1989) [4]

1. Create only tunnels:
(a) Never create a cavity
(b) Never undercut
2. Be as gentle as possible:
(a) Only use small, blunt instruments
(b) Use the least possible number of passages
3. Respect the superficial layer of fat
4. It is not so much what is removed that is important, but what is left behind
5. Use, anticipate, and estimate skin retraction instead of fighting against it
6. Do not undertake and "important" resection that is locally and generally dangerous
7. Indications should be restrictive. Adipoaspiration is not a panacea
8. All fat is final
9. Results in the operating room approximate the final result
10. This technique demands blind surgery

Table 57.3. Fournier (1991) [5]

1. Use small-caliber cannulas
2. Blunt orifices must point downward
3. Distend tissues with normal saline containing adrenaline (1 mg/l) at 2°C
4. Use a syringe for the extraction
5. Use the least trauma possible and never move laterally with the cannula
6. Use fan-shaped dissection
7. Stay deep
8. Use only tunnels
9. The left hand dominates the operation
10. Do peripheral mesh undermining, remodel the tissues, and immobilize

Table 57.4. Shiffman's principles of liposuction (1997) [6]

1. Proper selection of patient
2. Plan and mark areas prior to surgery
3. Use the tumescent technique
4. Use small cannulas
5. Use only blunt-end cannulas
6. Make only tunnels
7. Avoid damage to dermal vessels
8. Orient cannula openings downward (deep)
9. Never use a curette
10. Use the non-dominant hand for guidance
11. Do not pinch fat into the cannula
12. Undercorrect rather than overcorrect
13. Compression dressings
14. Use a strict sterile technique

3. *Preoperative marking*. The patient should have the areas to be liposuctioned marked while standing prior to surgery so that the patient understands what areas are going to be treated and the surgeon can visualize the areas to be liposuctioned.
4. *Use the tumescent technique*. The tumescent technique means the use of adequately diluted solutions (usually containing lidocaine and epinephrine) to swell the tissues to the extent necessary for local tumescent anesthesia or the tumescent technique. Lidocaine should be limited to 55 mg/kg when using deep sedation, general anesthesia, or local tumescent anesthesia. The smaller the patient, the lower the maximum level of lidocaine. Normal saline (0.9%) or lactated Ringer's solution may be used for the diluent but when used for local tumescent anesthesia, lactated Ringer's solution causes less discomfort with infiltration than normal saline. Sodium bicarbonate should be added when using local tumescent anesthesia. Little or no lidocaine is necessary if general anesthesia is used.
5. *Use small cannulas*. Use cannulas under 6 mm for deep liposuction, preferably under 4 mm if possible, and under 3 mm for superficial liposuction. Microcannulas, less than 2.2-mm internal diameter, are helpful when using local tumescent anesthesia but require many more incisions and a longer period of time for surgery.
6. *Use blunt-tipped cannulas*. Avoid sharp-tipped cannulas that can increase bleeding and the risk for perforation.
7. *Use a lower vacuum* [7]. Decrease the machine vacuum to at least 400 mmHg, preferably to 250–300 mmHg, which reduces bleeding. Syringe liposuction should be performed with a vented syringe (add a few milliliters of air or saline) to reduce the vacuum pressure.
8. *Use tunnels*. It is helpful to pretunnel before starting liposuction. By making crisscrossing tunnels during liposuction, there will be a more even removal of fat.
9. *Never move the cannula from side to side*. Moving the cannula from side to side when liposuctioning will result in open spaces and an increased risk of seroma formation.
10. *Avoid damaging the subdermal vessels*. Subdermal liposuction is a precarious method for obtaining skin retraction. Avoid turning the openings of the cannula toward the skin, except for liposuction of the face and neck, to prevent subdermal damage. The only exception may be Gasparotti's [8] technique of limited removal.
11. *Orient cannula openings downward*. Except under special circumstances (see principle 10).
12. *Use the non-dominant hand for guidance*. This will allow the surgeon to limit the extent of the liposuction at the premarked areas and prevent or limit problems of perforation of vessels or viscus.
13. *Feather the edges of each of the areas of liposuction*. Feathering allows a smooth transition between the liposuctioned area and the non-liposuctioned area
14. *Do not pinch fat into the cannula*. Pinching the fat while liposuctioning may cause irregularities. The fat may be pinched to detect residual fat and to compare the evenness of both sides.
15. *Undercorrect rather than overcorrect*. Undercorrection can be improved by repeat liposuction. Overcorrection may require autologous fat transfer or "liposhifting."
16. *Closure of wounds*. Small incisions do not need to be sutured closed. Any incision over 5 mm in length should be sutured (either with subcuticular or small cuticular sutures) in order to obtain a satisfactory scar.
17. *Compression dressings*:
    (a) Compression maintains contour, forces fluid from the tissues, and reduces swelling.
    (b) Enough padded dressings should be used to collect fluid drainage.
18. *Use a strict sterile technique*. A full sterile gown and gloves are necessary for large liposuctions but sterile gloves alone may suffice for small procedures. The liposuction areas should be cleansed with sterilizing solutions, draped with sterile drapes, and all equipment must be sterilized prior to use.

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Part XI
Medical Legal

Medical Liability Claims for Liposuction – Improving the Odds

Rudolph H. de Jong

58.1 Introduction

Because elective cosmetic surgery holds out the promise of making a well patient look better, the legal expectations of performance standard and warranty, along with the patient's anticipation of a more attractive look, combine to place a heavier burden of care on the cosmetic surgeon than on the physician trying to make a sick patient well again. That burden of care is made all the heavier the more unrealistic outcome expectations outstrip nature's endowments – exhaustive and tactful explanation notwithstanding. At the very least, the public expects elective surgery patients to walk out of the physician's office no worse off then when they walked in – if they do not, litigation is bound to follow [1].

This chapter first focuses on closed liposuction claims (litigation completed), continues with statistics on adverse outcomes (litigation yet to come), and ends with recommendations for improving the odds of performing claimless liposuction (litigation deflected). Up-to-date information about liability claims by ambulatory patients is virtually inaccessible because malpractice carriers have become averse to open their databases to the public, malpractice court records commonly are sealed, and out-of-court settlements are shielded by non-disclosure clauses. Ambulatory surgery has come under increasing scrutiny by state regulatory agencies following several highly publicized deaths after liposuction in medical offices [2 ,3]. The State Medical Boards of Florida, Texas, California, and New Jersey have been at the forefront, mandating prompt reporting of serious adverse events. Moreover, the Federation of State Medical Boards recently issued minimum recommendations for uniform regulation of office-based surgery throughout the USA [4]. Adding fuel to the public fallout regarding office-based surgery – and consequent spiraling costs of insurance, let alone insurability [5] – is a recent analysis of Florida Medical Board data; the authors' conclusions bear sober consideration (see "Adverse Outcomes") [6].

Assessment of the magnitude of the present national claims experience is not helped at all by liability carriers who – stung by staggering loss ratios and crushing contract terminations – warily have shrouded their databases in a protective cocoon of non-disclosure (personal contacts with senior industry management by both the chapter author and the book editor notwithstanding), making self-policing efforts by the medical profession all the more difficult, and skyrocketing policy premiums a near-given. Just in the first half of 2003 alone, yet another four carriers (Frontier, St. Paul, PHICO, and Reliance) withdrew from the medical liability insurance market.

58.2 Liposuction

Prior to the 1980s lipoplasty, the curettage of ungainly body fat under direct vision, was rarely elective – and then in the hospital setting only – because of unsightly scars and prohibitive blood loss. The bikini swimwear fashion of the 1960s fueled the search for a less formidable body contouring procedure, culminating in the percutaneous cannula aspiration of subcutaneous fat deposits (suction-assisted lipoplasty). In 1987 dermatologist Jeffrey Klein popularized office-based tumescent anesthesia (field block analgesia) by subdermal infiltration of highly dilute (0.1% or less) lidocaine with epinephrine prior to suction aspiration [7]. Spiraling costs of hospitalization, combined with the evolution of virtually bloodless fat aspiration through small-diameter cannulas, propelled a quantum practice shift towards ambulatory surgery. By 1997 liposuction had become the most frequent cosmetic surgical procedure in North America, and by 2002 more than half of all cosmetic procedures were performed outside the hospital [8].

With the exponential annual growth of liposuction surgery came increasing reports of adverse outcomes, including dozens of fatalities [2, 3, 6, 9]. The subsequent media uproar was such that, in 1997, the American Society of Dermatologic Surgeons published *Guiding Principles for Liposuction* [10], soon (1998) followed by the American Society of Plastic and Reconstructive Surgeons, the American Society of Aesthetic Plastic Surgeons, and the Lipoplasty Society of North America, who jointly established a Task Force on Lipoplasty to report on complications associated with lipoplasty so as to draft evidence-based recommendations for practice guidelines or advisories [11]. Representing a procedure, rather than specialty specific membership, the American Society of Lipo-Suction and the American Academy of Cosmetic Surgery jointly published annual liposuction guidelines [12].

58.3 Liposuction Claims Experience

Although accounts of the "safety" (euphemism for 'absence of deaths') of liposuction by individuals or dedicated clinics abound, all are by resolute physicians practicing in fully staffed accredited facilities. The ugly reality is that no surgical procedure is complication-free, not all medical offices are as up-to-date as they could or should be, and fatalities occasionally occur. Liposuction certainly is no exception, as so forcefully documented in recent years [2, 3, 6]. Professional society practice guidelines and advisories have gone far in tightening the unbridled practice of liposuction by unqualified individuals under less-than-optimal conditions – as evident from a heartening decline in mortality rates [9]. Nonetheless, unrealistic patient expectations, and the inescapable burden of perfection placed on the cosmetic surgeon, remain – with adversarial action an all-too-common outcome.

In 1999, 73% of US insurance companies still wrapped lipoplasty/liposuction indemnity into the basic coverage package for surgical specialties. Even then, close to half (43%) of the insurers insisted on documented proof of competence (residency, preceptorship, Board certification, peer review, etc.) before issuing policies covering full-body contouring. Some 40% of the companies had already placed constraints on office-based liposuction: restricting body sites, optimizing patient selection, limiting volume of aspirate, and narrowing choice of anesthesia [13].

So as to identify common threads that led patients to sue their doctors, the Physician Insurers Association of America (PIAA; an umbrella insurance trade organization whose members collectively insured some 60% of America's private practice physicians at the time) summarized the industry's closed liposuction claims experience from 1985 to mid-1998 (Table 58.1) [14].

Territorial interpretations derived from these data by, respectively, dermatologists and plastic surgeons, led to an unfortunate flurry of specialty turf wars [13, 15, 16]. (Being positioned, unwittingly, squarely in the midst of an unseemly professional finger-pointing squabble dissuaded PIAA from further cooperation.) Even so – putting aside for the moment whether one specialty has more adverse outcomes than another, or whether relatively fewer deaths occur in the ambulatory than in the hospital setting (Table 58.2) – unarguable trends emerged [13]. Not the least of these trends is that 66.1% of the 292 liposuction claims were based on medico-legal issues related to informed consent, battery, or breach of contract (see "Severity Rating"), a 2.5 times higher frequency than PIAA's consolidated surgical claims experience (26.5%) during the comparable time period. In Table 58.2 is the higher incidence of adverse events in office-based liposuction, accounting for two thirds of the ambulatory patient claims.

58.3.1 Severity Rating

The insurance industry uses the National Association of Insurance Companies severity code to grade

Table 58.1. Liposuction claims sorted by physician specialty. Claims filed with US Physician Insurers Association of America (*PIAA*) member companies from January 1985 to July 1998 [13]

Physician specialty	No. of claims
Plastic surgery	252
General surgery	19
Obstetrics/gynecologic surgery	7
Dermatology	5
ENT surgery	5
Other surgery	2
Family practice	2
Total	**292**[a]

[a] Of the 292 total claims, 263 had been closed; 29 still were active at report compilation time.

Table 58.2. Liposuction claims stratified by practice location

Practice location	No. of claims (% of claims)
Hospital operating room	191 (65.4)
Physician office	61 (20.9)
Ambulatory surgery facility	31 (10.6)
Other	9 (3.1)
Total	**292 (100)**

The high ratio (65.4%) of claims arising from liposuction performed in hospital operating rooms probably reflects on greater complexity, multiple procedures, longer duration, larger tissue volume removed, and the use of general anesthesia or prolonged deep sedation [13]. Of the 92 claims by ambulatory patients, two thirds (66.3%) originated from physician offices.

numerically the magnitude of patient injury or disability, scoring on an ascending scale from 1 (emotional trauma) to 9 (fatal outcome); see Table 58.3 for particulars. Rating codes 1–3, ranging from trivial to minor temporary injuries, accounted for nearly two thirds (66.1%) of the total claims. The more serious temporary and permanent injuries, designated codes 4–8, accounted for less than one third (31.5%) of the claims. There were seven fatalities (code 9) in the 13.5-year time frame (see "Gender Distribution" for additional details). The mean severity code for all 292 claims was less than 3.3 – a misadventure slightly beyond minor temporary injury (code 3), but substantially less serious than major temporary injury (code 4). The 3.3 severity code for liposuction contrasted quite favorably with PIAA's aggregate mean claims experience index of 4.6, hovering closer to minor permanent injury (code 5).

58.3.2 Claims Payment

Of the 292 liposuction claims collected by 1998, 263 had been closed – permitting analysis of industry risk ratios [14]. Mirroring the relatively benign nature of injuries sustained overall was an average payout of less than $100,000 ($94,534) per liposuction claim resolved. Board-certified physicians (Table 58.4) fared notably better in this regard, with an average indemnity payment of $83,350 per claim – 30% less than that of uncertified physicians ($118,025). All the same, PIAA cautioned its member indemnity insurers that "... liposuction claims have the potential for dramatic increase in this decade [1990s] …" and advised that "… insurers may want to revisit their policies with respect to certification, training, and facility requirements ..." [14].

Although the average indemnity payment ($94,534) for liposuction claims was 40% less (in 1998) than the aggregate national medical liability claims payment ($157,126), a liposuction claim had a higher likelihood of being indemnified (41.0%) than the average claim (31.8%). While nearly 60% (58.6%) of claims were lodged against American Board of Medical Specialties certified specialists (Table 58.4), fewer than half (43.7%) of these allegations were resolved in favor of the claimant with an average payment of $83,350. Physicians without Board certification (Table 58.4), conversely, experienced a claim payout ratio of 52.5%, and an average of $118,028 per paid claim.

A Medical Insurance Exchange of California (MIEC) policyholder "letter" quoted the aforementioned PIAA data adding that, while 116 of the 263 closed claims (44.1%) received an average indemnity payment of $94,534, payment to the estates of the seven decedents averaged $150,000 [17]. MIEC, at that time (1999) had processed 20 liposuction-related claims, with 16 of the 20 claims already closed. Four of the 16 closed claims received an average of $25,960 each, the other 12 were closed without payment [17]. Worth emphasizing is that 12 of the 20 MIEC claims (60%) were based on dissatisfaction with the results of the procedure (comparable to the 66% incidence in the aforementioned PIAA analysis) – surely a red flag warning to spend sufficient time with the patient before proceeding with surgery [1, 18].

The Doctor's Company (the single largest national carrier of plastic surgery policyholders) had experienced 45 "severe or fatal" incidents by 1997 [19]. Of

Table 58.3. Liposuction claims stratified by National Association of Insurance Companies (*NAIC*) severity code

Code	Description of injury	No. of claims (% of claims)
1	Emotional injury only	19 (6.5)
2	Insignificant injury	68 (23.3)
3	Minor temporary injury	106 (36.3)
4	Major temporary injury	46 (15.8)
5	Minor permanent injury	40 (13.7)
6	Significant permanent injury	5 (1.7)
7	Major permanent injury	1 (0.3)
8	Permanent injury requiring lifelong care	0 (0.0)
9	Fatal outcome	7 (2.4)
Total		**292 (100)**

NAIC severity codes score the alleged injury or mishap on an industry-standard progressive scale from a trivial 1 (emotional trauma) to a catastrophic 9 (fatal outcome). Nearly two thirds (66.1%) of the lipoplasty claims were for minimal to minor temporary injuries only (codes 1–3). The mean rating for all 292 claims was 3.26, corresponding to an average injury little worse in severity than the benchmark description "minor temporary injury" [13].

Table 58.4. Board certification reduces claims and payout (Consolidated from Bruner and de Jong [13] and from PIAA [14])

Board certification	No. of claims	Payout (%)[b] (% of claims)[a]	Payout ($)[c]
American Board of Medical Specialties certified/eligible	171 (58.6)	43.7	83,350
Not certified or unknown	121 (41.4)	52.5	118,025
Total	**292 (100)**	**50.0**	**94,534**

[a] Total liposuction claims, whether closed or still open at the time
[b] Percentage of closed claims in which damages were paid
[c] Average dollar amount paid per claim resolved

these 45 incidents, nearly 70% (n=31; 68.9%) occurred when liposuction was combined with other surgeries – one more bit of evidence that liposuction is far from the innocuous procedure so often portrayed to the public.

58.3.3 Gender Distribution

Gender distribution in PIAA's liposuction claims database was 87% female and 13% male (Table 58.5), matching national cosmetic surgery demographics of 88% female and 12% male at that time [13]. Inexplicably, more than half (four) of the seven death claims were men, versus three fatalities in women. Table 58.5 highlights this disparity in the rightmost column (incidence) where the number of deaths per 100 claims is stratified by gender. Note that the probability of a claim for death from lipoplasty was 8.5 times greater in men than in women. Because details other than gender (e.g., death causation, pre-existing medical condition, or age) of the seven fatalities were not released or not available, statistical significance testing was inconclusive.

From the limited number of fatalities (seven in total) reported, and lacking a ready explanation, the comparatively high liposuction mortality rate of male, as against female, patients may be no more than a statistical fluke. Nevertheless, even the remote possibility of gender-related complications may need to be added to the informed consent discussion with male patients until the gender issue is settled by outcome studies of the total exposure base (see "Informed Consent").

Table 58.5. Gender distribution of liposuction claims

Gender	No. of claims (% of claims)	Deaths[a]	Incidence[b]
Female	236 (87)	3 (43)	1.3/100
Male	36 (13)	4 (57)	11.1/100
Gender-identified claims	272 (100)	7 (100)	2.6/100

Because 20 of the 292 PIAA liposuction claims lacked gender identification, gender distribution analysis is confined to the remaining 272 claims [13].

[a] The gender of each of the seven fatal outcomes, however, was specified.

[b] Deaths per 100 claims for medical misadventure. In this small sample, the lipoplasty fatality rate was 8.5 times greater in men than in women.

58.3.4 Anesthesia and Sedation

Lacking relevant information about anesthetic technique, sedative drugs, or both, the PIAA claims database fell short in either corroborating or refuting assertions in the dermatology literature that the administration of intravenous sedation or general anesthesia elevates the risk of surgical lipoplasty – as opposed to tumescent liposuction anesthesia with diluted local anesthetic field block analgesia [15, 20].

58.4 Adverse Outcomes

As competition for lucrative liposuction intensified – and glossy advertisements and seductive infomercials whetted the public's appetite for effortless quick-fix rejuvenation – ever more unqualified physicians (and non-physician charlatans) flocked to this last remaining bastion of free enterprise in medicine. With growing numbers of patients, rising expectations, falling qualifications, and lax supervision, unwelcome incidents were bound to happen. By the mid-1990s the national news media had gotten wind that all was not well with liposuction; numerous articles and television exposés alerted the public to real, and at times imagined, hazards and misdeeds. The public outcry inevitably stirred politicians to press for tighter controls over, and regulation of, cosmetic surgery – liposuction in particular. While the breadth of state regulation is by no means certain, and delays with legal challenges a near-certainty, office-based liposuction will be regulated in the not too distant future. In the meantime, economic credentialing by malpractice carriers – through steep premium surcharges for non-accredited office facilities – will strike swiftly, once their claims analysts have fully digested these data.

The expectation of "making a well patient look better" places a substantial burden of care on the cosmetic surgeon. All the more so when that burden is not just a disappointing appearance but rather an adverse incident that may harm (perhaps even kill) the patient. That nearly two thirds of the cosmetic surgery complaints are filed by disappointed patients is all too evident from the preceding closed claims experience. But, because the time lag between initial complaint and eventual claims closure may span several years, an estimate of the other one third of claims – the serious, high-dollar malpractice suits – can be derived only from up-to-date adverse incident data. And those hard data are virtually impossible to acquire (if they exist at all), for lack of a national reporting system outside of the hospital and ambulatory surgery setting. Although ambulatory surgery incident reporting has been mandatory in California for several years, the data are considered confidential. Only the Florida Medical Board incident report database is accessible;

hence, many of the inferences in the following are not necessarily representative of, although probably not too far removed from, national statistics.

58.4.1 Morbidity and Mortality

Fatalities from liposuction itself, fortunately, are not all that common. But the fatality rate appears to rise steeply when liposuction is combined with other cosmetic or surgical procedures in an effort to hold down costs and save time; abdominoplasty ("tummy tuck") has proven particularly troublesome in that regard [9]. General anesthesia, and anesthetic induction agents or intravenous sedatives, likewise are claimed [15, 21] (but by no means proven) to contribute to morbidity and mortality in ambulatory settings; in one large series (more than 23,000 patients) general anesthesia for office-based cosmetic surgery proved non-fatal and, in fact, caused fewer complications than previously used intravenous office sedation [22].

Perhaps the most revealing perspective on the magnitude of cosmetic surgery incidents is provided by the Florida Medical Board's ambulatory surgery incidents database, started when office incident reporting became mandatory in March 2000. (Although other states, notably California and New Jersey, likewise mandate office incident reporting, their data are closely held – short of exhaustive "freedom of information" litigation, we were unable to secure information release for this chapter.)

Coldiron [23] summarized the first 1.5 years of the Florida incident-reporting experience by singling out liposuction under general anesthesia as causing the most grievous office-practice injuries. Analysis of the official cause of death by de Jong [24] confirmed that office liposuction indeed was cursed by a disproportionately high adverse incident rate which, however, proved to be procedure-related (i.e., liposuction) rather than anesthetic-related [16]. Of the total 76 adverse incidents (including seven fatalities) initially reported by Florida medical offices, 31 were perioperative incidents (including six of the seven fatalities); 17 of these 31 surgical mishaps struck cosmetic surgery offices (accounting for five of the six surgical deaths). Nine of the 17 cosmetic office incidents (including three of the five cosmetic surgery deaths) resulted from liposuction/lipoplasty. Said differently, half (three out of six) of the surgical fatalities were attributable to liposuction in the office setting. Still, for lack of a proper procedure count, one is left to wonder whether liposuction's substantial contribution to cosmetic procedure incidents relates to its great popularity or – far more troubling – whether liposuction is inherently riskier than other office-based surgical operation.

Closing the information gap, Vila et al. [6] made a statistically conservative estimate of the numbers of ambulatory patients, physician offices, and office procedures (direct counts unavailable) so as to determine the case count numerator, and thus to calculate relative risks. Tables 58.6 and 58.7 summarize their findings which come to the crushing conclusion that – at least for the aggregate of ambulatory surgery patients – office-based surgery, in general, had a more than tenfold higher complication rate than comparable surgeries performed in ambulatory surgery centers (ASCs) [6]. That sobering finding is sharply at odds with prevailing wisdom that proclaims office-based surgery to be as safe as, if not safer than, surgery at hospitals or surgicenters [15, 22, 23, 25]. Although lacking specifics about the number of liposuction procedures in either ASCs or medical offices, comparison of Tables 58.6 and 58.7 illustrates that cosmetic surgery in physician offices retained its uncomfortably high mortality rate (one of six surgical fatalities in ASCs, versus five of nine surgical fatalities in offices) – even though more than 16 times more surgical procedures were performed in ASCs than in medical offices.

Table 58.6. Ambulatory surgery incidents—surgical centers (Florida Agency for Health Care Administration data; January 2000–2001) (Modified from Vila et al. [6]; 2,316,249 surgical procedures performed (direct count))

Surgery type	Incidents[a]	Rate[b]	Deaths	Rate[c]
Cosmetic	N/A	–	1	–
General surgery	N/A	–	1	–
Endoscopy	N/A	–	8	–
Gynecology	N/A	–	1	–
Eye & ENT	N/A	–	3	–
Other	N/A	–	4	–
Total incidents	**123**	**5.3/100,000**	**18**	**0.8/100,000**

[a] Categorical breakdown of non-fatal incidents not available
[b] Incidents per 100,000 procedures
[c] Deaths per 100,000 procedures

Table 58.7. Ambulatory surgery incidents-medical offices (Florida Medical Board data; April 2000–2002) (Modified from Vila et al. [6]; based on an estimated 141,404 surgical office procedures)

Surgery type	Incidents[a]	Rate[b]	Deaths	Rate[c]
Cosmetic	N/A	–	5	–
General surgery	N/A	–	2	–
Endoscopy	N/A	–	2	–
Gynecology	N/A	–	1	–
Eye & ENT	N/A	–	1	–
Other	N/A	–	2	–
Total incidents	**93**	**66/100,000**	**13**	**9.2/100,000**

[a] Categorical breakdown of non-fatal incidents not available
[b] Incidents per 100,000 procedures
[c] Deaths per 100,000 procedures

The outcome analysis of Vila et al. reaffirms the excellent safety record of ASCs (0.8 fatalities and 5.5 incidents per 100,000 procedures, Table 58.6, a two-fold improvement over an earlier outcome analysis by Morello et al. [25], who reported 1.7 deaths per 100,000 outpatient procedures in ASCs.

As shown in Table 58.7, by contrast, the incident record of surgery in Florida medical offices had a nearly 12-fold higher fatality rate (9.2/100,000), and a more than 12-fold higher adverse events rate (65.8/100,000) than ASCs [6]. Yet office-based surgery, at least under optimal conditions, need not be any less safe than ASC surgery, as witnessed by a prospective study of nearly 18,000 office surgery follow-ups without fatalities [26]. The latter encouraging outcome certainly suggests that office accreditation, staffing in depth, and cost-sharing all contribute to enhanced patient safety [27]. Whatever, there can be little doubt that liability insurance premiums for office-based surgery will climb to stratospheric heights, unless the unit is fully accredited, and staffed in sufficient depth.

58.4.2 Fatalities

As evident from Tables 58.6 and 58.7, four deaths attributed to liposuction in ambulatory patients were reported to Florida agencies between 2000 and 2002 (Florida newspapers cited evidence that not all office deaths had been reported [6]). That the rather substantial fatality rate of liposuction is not unique to just one state is borne out by a New York City Medical Examiner's report of five liposuction deaths [2].

Such regional reports represent just the tip of the national iceberg, of course. A survey of North American plastic surgeons, covering nearly one-half-million (496,245) lipoplasties between 1994 and mid-1998, counted 95 fatalities – a national fatality rate approaching 1/5,000 (1/5,224) procedures [3]. Fortunately, with intensive education and explicit guidelines, that grim mortality rate has come down in the years since. Surveying the same group of American Society of Aesthetic Plastic Surgeons members from mid-1998 to mid-2000, Hughes [9] counted just six deaths in nearly 72,000 lipoplasties, a more than two-fold decline (to 1/11,953) in the overall liposuction fatality rate [28]. Specifically, the fatality rate rose a heartening ninefold (1/47,415) when lipoplasty was the sole surgical procedure – but fell to a distressingly low 1/3,281 when lipoplasty was combined with abdominoplasty (and sometimes additional surgery as well). As the author pointed out, combining lipoplasty with other surgery, abdominoplasty (tummy tuck) in particular, substantially raises the complication rate, an observation that certainly will not have escaped malpractice carriers, and an exclusion that predictably will be attached to forthcoming indemnity policies.

58.5 Risk Management

In the preceding PIAA study, the 292 liposuction-related claims accumulated by mid-1998 calculate to fewer than two (1.8) claims per month – an estimate that may seem conservative at this reading. Heeding the red flags waving over office-based cosmetic surgery – warnings that surely have not gone unnoticed by the insurance industry – what are the options for closing litigation loopholes and for lowering insurance premiums? [29, 30]. This may be the opportune moment to reflect on Klein's steadfast caution that the tumescent technique of liposuction relies solely on the analgesia provided by infiltrating diluted local anesthetic solution (with epinephrine), and should not require further supplementation with intravenous sedatives or analgesics [21]. This chapter's author, likewise, considers that so-called conscious sedation (see "Sedation") teeters in the center of an ill-defined continuum between anxiolysis and general anesthesia; the longer the surgery lasts, the riskier to the patient will be laxly monitored conscious sedation. Because liposuction easily takes 2 h or more, it might be imprudent to administer intravenous sedation in offices inadequately equipped and/or staffed for dedicated patient monitoring and instant cardio-respiratory support [31]. Should sedation be anticipated for a lengthy liposuction procedure, an anesthesia caregiver might be contracted to deliver dedicated monitored anesthesia care.

58.5.1 Facility Credentialing

In the most up-to-date study yet of ambulatory surgery outcomes, eight of 13 (61.5%) deaths occurred in non-accredited Florida office facilities [6]. Regardless of how well staffed and equipped your medical office may be, accreditation by one of the three national agencies (AAAASF, JCAHO, or AAAHC) or, at the very least, conformance with state regulations modeled after the 2002 Federation of State Medical Boards recommendations [4, 27], demonstrates that patient safety and well-being are highest-priority considerations, and thus qualify the office for a substantial insurance premium discount. Even should a State Board resist regulation of office-based surgery, the insurance industry will suffer no such qualms – enforcing de facto nationwide regulation of office-based liposuction through economic credentialing.

58.5.2 Office Administration

The aforementioned insurance industry report's key findings pertinent to liposuction – comparatively trivial injury relative to the total claims experience, average plaintiff payment of less than $100,000, and preponderance of claims arising from procedures performed in hospital operating rooms – are neither surprising nor profound. Regrettably, the raw PIAA data have been misconstrued recently in a partisan manner when the authors, rather naively, equated liability claims and indemnity losses to unsafe surgical practice [15]. Although they claimed that liposuction in the dermatologist's office was "safer" than hospital-based lipoplasty by plastic surgeons, reanalysis of the data eventually laid that claim to rest [13]. Quite to the contrary, any office-based liposuction is at risk of astronomical premium increases – regardless of provider specialty. Rather than a house divided, it would seem appropriate for a united specialties task force to issue uniform practice guidelines so as to raise the safety of liposuction and lower premiums.

58.5.2.1 Patient Records

Trial attorneys, insurance claims analysts, and specialty organizations are agreed on one point at least: timely, precise, detailed, and readable patient records are the physician's greatest friend in a malpractice action. The old courtroom saw "if it isn't written down, it didn't happen" all too often comes true; it is a formidable plaintiff's weapon. A complete medical record, conversely, even if it details objectively an error or omission, is a physician's best, and at times only, defense against groundless claims or disgruntled patients [8, 18, 32]. Both author and editor speak from long court experience that incomplete – let alone absent, missing, or altered – records leave the hapless physician essentially defenseless.

58.5.2.2 Informed Consent

Sobering is the finding that two thirds of the liposuction claims (Table 58.3) were based on legal issues of informed consent or breach of contract, or both [13]. Clearly, liposuction surgeons must try more than ever to ensure that the unsedated patient is fully informed about realistic cosmetic outcomes and potential surgical complications before proceeding. Because the popular concept of liposuction, ironically, is one of "quick-fix" weight loss, the physician should be explicit that liposuction is a body sculpting procedure rather than superfluous fat removal, and perhaps even formalize that understanding in a separate informed consent clause. Also to be considered during the informed consent discussion are the potentially adverse effects of pre-existing illness (e.g., obesity or diabetes), medications (e.g., hormone therapy or nonsteroidal anti-inflammatory drugs), and lifestyle (e.g., sedentary or smoking). As so amply demonstrated here, liposuction is by no means minor surgery – serious complications will, and do, happen [30, 33, 34].

Although the overall female-to-male claims distribution ratio in the PIAA insurance industry report (Table 58.5) matched national cosmetic patient demographics, the fatality experience surprisingly proved to be the opposite: the probability of a claim for death from lipoplasty was 8.5 times greater in men (11.1/100) than it was in women (1.3/100) [3]. Absent specifics such as cause of death or pre-existing medical condition, and lacking a ready explanation, the higher male mortality rate may be no more than a statistical fluke. Nonetheless, male patients may well need to be advised of their potentially greater perioperative liposuction risk, until the gender issue is settled by large-scale outcome studies.

58.5.3
Professional Staff

58.5.3.1
Physicians

Specialty Board certification proved a potent litigation deterrent, in that fewer claims were resolved with lower payouts for each claim. That lucrative liposuction by unqualified physicians, conversely, gives rise to a disproportionate number of claims has not escaped notice by insurers either [18, 19]. Specialty Board certification (or eligibility) clearly is a vital component in reducing the odds of being sued, but only if bolstered by evidence of appropriate training, technical skill, and continued medical education. Territorial disputes aside, physicians and nurses joining the practice should become thoroughly familiar with the liposuction practice guidelines and advisories issued by the various specialty groups [12, 35–38].

Most patients (unlike liability carriers and trial lawyers) take sound training and surgical competency for granted and instead look for that indefinable aura of professionalism – a blend of integrity, expertise, accountability, respect, and sincere concern for the patient's well-being. To be sure, charisma and smooth bedside manner may go over well at the first visit but, if not backed up by solid professionalism, that initial charm soon fades to a shallow veneer. A patient–physician relationship founded only on slick salesmanship could end inauspiciously in litigious discontent with unfulfilled expectations.

58.5.3.2
Nurses

In a thinly staffed surgery office, the facility's registered nurse often has to assume multiple duties: surgical assistant, instrument nurse, and recorder of the patient's vital signs. Add to that the additional duties of tumescent local anesthetic infiltration and administering intravenous sedation, and one ends up with a "Jane of many trades, master of none" situation that could impact adversely on patient well-being in case of a mishap. Yet a nurse's oversight or medication error legally is considered the responsibility of the physician under the "captain of the ship" doctrine. Accrediting agencies are alert to this potential pitfall, and have become adamant that staffing be sufficient not only in numbers, but also in depth and training. Saving a few personnel dollars for the moment may prove to be short-sighted administrative policy in the long term.

58.5.4
Office Liposuction Candidates

A foremost safeguard in preventing liposuction liability claims is to accept only those patients who are physically and emotionally suitable for the procedure. Although patient selection has been explored in great detail in this book's preceding chapters, certain points relevant to minimizing liability claims bear repeating here. All the more so in that the ever-fewer medical liability carriers will add ever-more restrictive clauses to their liposuction policies in an effort to cut risks and raise profitability.

As shown by the Florida Ambulatory Surgery Incidents Report (Tables 58.6, 58.7), office-based surgery carries a substantial risk to the patient [6]. A keystone to minimizing that risk – and that of subsequent malpractice litigation – is the proper selection of candidates for office surgery. The American Society of Anesthesiologists (ASA) operative risk scoring system (see next) is universally recognized for such screening purposes. A contributory risk factor unique to liposuction is obesity, and it too can now be quantitated (see later). (Naturally, in considering a patient's suitability for liposuction, it must be considered whether her/his outcome expectations are at all realistic; if not, a dissatisfied patient may well seek consolation through litigation.)

58.5.4.1
Risk Classification (ASA Scores)

Many state regulatory agencies (e.g., Florida) have adopted the ASA numeric classification of operative risk because it is simple yet predictive. A healthy fit patient is given an ASA score of 1, whereas a moribund patient is scored as a category 5 grave risk. A patient in reasonably good health, with just one systemic disorder (e.g., diabetes, hypertension) is assigned a score of 2. Additional systemic illnesses raise the score to a 3 or 4. Class 1 or 2 patients have proven to be suitable candidates for ambulatory surgery; category 3 patients, on the other hand, might call for closer scrutiny, essential laboratory studies, and perhaps a consultation clearance [38]. Obvious shortcomings (age, smoking, obesity, lifestyle, etc. are not factored) notwithstanding, the ASA scores seem destined for incorporation in government regulation of office-based surgery [4].

58.5.4.2
Obesity (Body Mass Index Scores)

Because the public (erroneously to be sure) views liposuction as yet another means of weight reduction, it attracts a fair share of overweight and obese patients. Yet obesity, of itself, presents a substantial risk of perioperative complication(s), particularly when intravenous sedation or analgesia are used. The body mass index (BMI), readily calculated from just height and weight, should prove particularly useful in swiftly eliminating morbidly obese subjects [39]. A body weight 20% or less above normal (i.e., BMI<30) is considered acceptable for office surgery by one group of academic plastic surgeons [30].

58.5.5 Sedation and Analgesia

Results from the PIAA claims database failed to either corroborate or refute implications that the administration of intravenous sedation or of general anesthesia raises the risk, and reduces the safety, of suction-assisted lipoplasty, as compared with tumescent liposuction using only local anesthesia [20]. Because the PIAA database did not offer specifics about anesthetic technique, assertions that general anesthesia "… causes increased risk for liposuction …," or is associated with "… a number of cases of pulmonary edema …" reflect personal opinion rather than scientific fact [15, 23]. To the best of this author's knowledge, there is no compelling evidence that one anesthetic technique is inherently safer for liposuction than another. The study of Hoefflin et al. [22], for instance, found office-based cosmetic surgery under general anesthesia to be safe, preferred by patients, and less complication-prone than their earlier-used technique of local anesthetic infiltration supplemented by intravenous sedation.

Still, few medical offices are equipped for, or can accommodate in their limited space, more than an occasional general anesthetic. Most offices will rely instead on local or regional anesthesia techniques for liposuction – supplemented by intravenous sedation and/or analgesia if needed [33, 36]. As noted, this author considers "conscious sedation" appropriate only for brief procedures such as endoscopies or biopsies. The hazards of oversedating the patient simply are too great (Table 58.8), and the personnel requirements for judicious monitoring too demanding [40]. Short of a dedicated advanced cardiac life support trained nurse or anesthesia provider, the fine line between sedation and light general anesthesia is all to easily crossed, and extremely difficult to substantiate in court. Here too is fertile ground for economic credentialing by increasingly cautious liability insurance carriers.

58.6 Recommendations

The future (if not already the present) will see increasing regulation of office-based liposuction surgery by government agencies, and de facto economic credentialing by the insurance industry. The golden rules to avoid claims and thus, not so incidentally, minimize annual malpractice premiums are to maximize patient safety and to document thoroughly and legibly what you did, how and when you did it, and why you did (or did not) do it. One common-sense approach might be to adopt specialty association guidelines for liposuction, and those for sedation in the medical office, then adapt these guidelines to your particular practice in a "Policies and Procedures" document for the medical staff [10, 12, 35–38, 40].

Table 58.8. Ramsay sedation scale Adapted for medical office use from Abbott Laboratories, Abbott Park, IL, USA, 2003, and American Society of Anesthesiologists (*ASA*) *Practice guidelines for sedation by non-anesthesiologists* [40]

Score	Patient sedation status assessment
6	Profoundly sedated; unresponsive to painful stimulation ("light anesthesia")
5	Heavily sedated; sluggish response to glabellar tap or loud sound
4	Deeply sedated; arousable with glabellar tap or loud sound, awakens disoriented
3	Comfortably sedated; responds to verbal commands; slow orientation
2	Lightly sedated; cooperative, oriented to place and time
1	Minimally sedated; remains anxious, agitated and/or restless
0	Unsedated; anxious, agitated and/or restless

Level 2 ("lightly sedated") is comparable to ASA category anxiolysis. Level 3 represents optimal office sedation: patient is calm, yet retains protective reflexes; comparable to ASA category conscious sedation, with stable respiration and circulation scores greater than 3 draw ever closer to the treacherous "sedation-versus-anaesthesia" trap. Level 4 is the upper limit of manageable office sedation—a red flag to cut back sedation; comparable to ASA category deep sedation/analgesia: ventilation may be compromised. Level 5 demands dedicated patient monitoring by a designated ACLU-trained caregiver comparable to ASA category deep sedation/analgesia: airway and ventilation may need support, circulation usually maintained. Level 6 demands dedicated patient monitoring and support by an anesthesia care provider; comparable to ASA category general anesthesia; airway and ventilation will require active support, cardiovascular function may become labile and require support with little warning.

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Medical Legal Problems in Liposuction

Melvin A. Shiffman

59.1 Introduction

Liposuction has been considered to be a safe procedure [1–4]; however, complications and deaths are occurring that are unnecessary and giving liposuction a poor reputation. In California, the Medical Board is evaluating the liposuction complications and seeking means to prevent them by legislation. Legal methods in controlling the problem are detrimental to cosmetic surgery. It is up to the cosmetic surgeons to reevaluate the procedure and find means to prevent further deaths. There should be a consensus of knowledgeable liposuction surgeons utilizing the peer-reviewed literature and outcome statistics. Megaliposuction is one culprit that is being performed without adequate safeguards to protect the patient.

Fournier [5] has shown that megaliposuction can be performed safely in a hospital setting with continuous central venous and/or pulmonary artery pressure measurements as an aid in fluid management. Anesthesiologists generally are not prepared for the large subcutaneous fluid infiltration and resultant fluid shifts outside a hospital setting. There is no literature indicating that anyone has calculated the fluid balance problems in megaliposuction.

Should subcutaneous fluids be cold, at room temperature, or warm? With large amounts of cold solutions, hypothermia is apt to occur and the problem of cryoglobulinemia or of disseminated intravascular coagulation may become a factor. Are the physiologic solutions (saline) absorbed rapidly or in 8–12 h as with lidocaine? Is the use of larger amounts of lidocaine (more than 35 mg/kg) necessary even with tumescent anesthesia? Certainly the use of over 35 mg/kg lidocaine is unnecessary in a patient having general anesthesia or intravenous sedation.

As dedicated cosmetic surgeons, we should endeavor to answer these questions and many more before we push the envelope of the extent of liposuction any further. It is necessary to sit back right now and produce the statistics and problems being encountered in order to evaluate where liposuction is and where the dangers lie.

59.2 Anesthesia

Klein [6–9] has given liposuction a safer means of performing the procedure with less blood loss, and better results with smoother appearance and increased fat removal [10]. There is also a reduced incidence of pulmonary embolism (fat or clot). The combination of lidocaine and epinephrine in a normal saline solution allows the use of local tumescent anesthetic to perform liposuction in situations where general anesthesia or intravenous sedation may be undesirable either by the patient or surgeon.

Lidocaine up to 55 mg/kg has been shown to be safe [11–15] but there are certain perioperative medications (cytochrome P450 inhibitors) which can reduce lidocaine metabolism and cause lidocaine toxicity [16]. In those situations where these medications have been taken inadvertently or are essential for the patient, general anesthesia or intravenous sedation can be utilized with reduced amounts of or without lidocaine in the subcutaneous infusion. Infusion solutions can be modified from 500 mg lidocaine and 1 mg epinephrine in 1,000 ml normal saline to 250 mg/l lidocaine and 0.5 mg/l epinephrine with adequate hemostatic response and reasonable comfort with intravenous sedation.

59.3 Liposuction Limits

With the advent of the tumescent technique, the reduction of blood loss has allowed an increase in the amount of liposuction aspirate. The limit imposed by the “dry” (with local anesthesia only) or the “wet” (limited amount of local anesthesia, epinephrine, and fluid into subcutaneous tissues) techniques was 3,000 ml total aspirate. This was because blood loss (30% of the aspirate) would result in 1,000 ml of blood being aspirated with 3,000 ml aspirate plus blood in the tissues [17]. Blood replacement was recommended if 3,000 ml aspirate was exceeded.

The tumescent technique of utilizing large amounts of subcutaneous fluid with epinephrine and lidocaine has decreased blood loss to almost 1% of the aspirate, thus allowing aspirates of 4,000–6,000 ml of supernatant fat without danger to the patient [18, 19].

Some physicians are attempting megaliposuction (exceeding 8,000–10,000 ml supernatant fat) although there is insufficient data to establish fluid requirements, blood loss, and need for hospitalization [18]. Only experienced surgeons with adequate monitoring and prolonged patient observation should be attempting this type of procedure. Caution would tell us to do the liposuction in two or three phases.

59.4 Other Dangers

Recent reports have shown that antiobesity medications may be a danger to any patient undergoing general anesthesia [20]. Sudden hypotension can occur with induction that responds only to neosynephrine and not ephedrine.

Perforation of the abdominal wall with an infusion cannula or a thicker liposuction cannula has been known to occur. Bowel perforation may be the result. The onset of peritonitis is heralded by increasing abdominal pain and should be recognized by the surgeon.

No matter how careful the surgeon is in performing such a relatively low risk procedure as liposuction, there are always dangers of mishaps. The cosmetic surgeon should be aware of the risks and complications, know how to avoid them if possible, and certainly know how to treat them.

The following cases will illustrate some of the disasters in liposuction with comments.

59.5 Sousaris vs Anonymous, Case No. 78-193-0105-96, Hawaii (1997)

This 48-year-old plaintiff's decedent had liposuction of the abdomen, flanks, pelvis, chin, and neck on January 5, 1996. There was 2,500 ml tumescent solution used and there was 3,450 ml total aspirate using a 6-mm cannula. On the seventh postoperative day, the incisions in the pubic area began draining fecal material. She was admitted to the hospital and had resection of a necrotic perforated segment of small bowel protruding through and incarcerated in a 1-cm opening in the abdominal wall 5 cm lateral to the midline and inferior to the level of the umbilicus. Multiple abdominal wall debridements were carried out for necrotizing soft-tissue infection. She developed disseminated intravascular coagulation and adult respiratory distress syndrome and died on January 30, 1996. The plaintiff claimed that the defendant negligently perforated the abdominal wall and small bowel and pulled the small bowel loop through the abdominal wall opening with the suction cannula. The defendant claimed that an asymptomatic undiagnosed Spigelian hernia was present and the bowel loop was injured during the liposuction.

Comment: Although this case was lost at arbitration, there was no way that the Spigelian hernia could have been recognized preoperatively and, therefore, bowel perforation under these circumstances was unforeseeable. The Spigelian hernia is the only logical explanation of the events:

1. Seven days until intestinal content leakage occurred is usually seen when there is interruption of the blood supply of the bowel loop with delayed perforation.
2. The 1-cm abdominal wall opening was in the precise position for a Spigelian hernia.
3. The 6-mm cannula would not have made a 1-cm abdominal wall perforation.
4. It is virtually impossible to pull a loop of bowel through a 6-mm opening in the abdominal wall with the liposuction cannula even with –760-mmHg vacuum.
5. Protrusion of a loop of bowel in an incarcerated hernia with scarring (as in this case) only occurs from longstanding herniation.

The case is presently being appealed.

59.6 Medical Board of California vs Matory, Tustin District, CA; Medical Board of California vs Hoo, Tustin District, CA

The 46-year-old plaintiff's decedent had surgery on March 17, 1997. The surgeon performed liposuction of the arms, abdomen, flanks, thighs, calves, and buttocks over a 6.5-h period. A total of 14,500 ml tumescent solution was used consisting of Ringer's lactate, with lidocaine and epinephrine (concentrations not recorded). There was 10,900 ml total aspirate. An endoscopic brow lift was performed over 1 h and this was followed by a face lift for 3 h. The anesthesiologist gave over 18,000 ml of intravenous fluids over the 10.5 h of surgery, despite only an 860 ml total urine output. At the completion of the procedure, the patient was cold, edematous, and non-responsive. The paramedics were called and cardiopulmonary resuscitation started. In the emergency room the hemoglobin (Hgb) value was 2.1 and the hematocrit (HCT) was 6.85. Attempts at resuscitation were unsuccessful. Autopsy showed cerebral edema with compression of the medulla oblongata into the foramen magnum. Both surgeon and anesthesiologist had their licenses revoked.

Comment: The events that transpired are a combination of breaches in the standard of care by both surgeon and anesthesiologist. The surgeon should not have planned to do megaliposuction (more than 10,000 ml aspirate) outside a hospital setting and without central venous or Swan–Ganz monitoring. The liposuction could have been performed in at least two to three sessions on an outpatient basis. To perform other cosmetic procedures for four additional hours was unnecessary and risky. The surgeon should have forewarned the anesthesiologist to limit intravenous fluids since the 14,500 ml tumescent solution would be reabsorbed into the vascular system over a period of time. If 500 mg lidocaine was in each liter of solution (Klein's formula), then 100 mg/kg was administered, which probably would have resulted in lidocaine toxicity after 8–10 h. The anesthesiologist never notified the surgeon that the blood pressure was low throughout the procedure and that there was a very low urine output. He should have understood and kept track of the fluid balance and not administered large amounts of intravenous solution. Even at the end of the procedure, when the patient was cold, edematous, and non-responsive, the anesthesiologist did not notify the surgeon of all the problems except to say that the patient should probably be admitted to the hospital because of the prolonged procedure. There was failure to promptly notify the paramedics of the blood pressure instability and patient unresponsiveness after the surgery was completed. There was no effort to check the Hgb and HCT after such a large liposuction procedure and there was no attempt to warm the patient following the liposuction part of the procedure.

59.7 Teillary vs Pottle, New Hanover County (NC), Superior Court. In *Medical Malpractice Verdicts, Settlements & Experts* 1996;12(8):47 and 1996;12(11):46

The plaintiff, a former nurse, had liposuction of the abdomen. She was seen postoperatively for abdominal pain, hospitalized, and then released. She went to an emergency room shortly thereafter and was readmitted for surgery. The small bowel had 32 perforations that had to be repaired. There was a $490,000 settlement.

Comment: Persistent severe abdominal pain (not simply soreness) after abdominal liposuction is from a perforated vessel or viscus until proven otherwise. Bowel perforation during abdominal liposuction is a known complication of the procedure, especially if there are abdominal wall scars that can misdirect the cannula. However, sixteen different through-and-through intestinal perforations could only occur if the non-dominant hand was not palpating the cannula tip (one of the principles of liposuction). Delayed diagnosis of the perforations probably contributed to the decision to settle.

59.8 Herron vs Stewart, Forsyth County (NC), Superior Court. In *Medical Malpractice Verdicts, Settlements & Experts* 1995;11(10)47

The 37-year-old plaintiff's decedent had liposuction of the face planned for December 1990. On induction of general anesthesia, cardiovascular collapse occurred. The patient was revived after 40–50 min but suffered severe brain damage. She lived in a vegetative state for 2 years and died in January 1993. The plaintiff claimed that there was failure to timely diagnose and respond quickly to the cardiovascular collapse and that there was failure to follow proper medical procedures. There was a confidential settlement after the jury was deadlocked in June 1995.

Comment: Failure to timely diagnose and respond quickly to cardiovascular collapse is inexcusable. Every office performing surgery, even with local anesthesia, must be prepared for any emergency event, especially cardiac arrest. Brain damage or death are known sequelae of cardiac arrest even in the best of circumstances, but especially in an outpatient setting and not in a hospital.

59.9 Medical Board of California vs Su, San Diego District, CA; Mondeck vs Su, California

The plaintiff's decedent had lower abdominal liposuction scheduled for June 21, 1994. Preoperatively, she was given 100 mg Atarax, 60 mg prednisone, 50 mg Valium, 750 mg Cipro, and 500 mg Augmentin. The tumescent solution consisted of 500 ml Ringer's lactate with 1,500 mg lincomycin, 1,000 mg Keflin, 100 mg Cipro, 240 mg Marcaine, 2.5 or 5 mg epinephrine, and lidocaine (amount unrecorded). Approximately 200 ml of this solution was injected over 8 min despite a blood pressure of 74/57 just prior to the infusion. One minute later the patient complained of a headache and then lost consciousness. The defendant claimed that 1 mg epinephrine was given intramuscularly and oxygen was started. When the paramedics arrived 4 min later the patient was pulseless and cyanotic, no cardiopulmonary resuscitation was being given, there was no oral airway, and no oxygen was being administered. The defendant voluntarily surrendered her license to the Medical Board.

Comment: There is absolutely no need for multiple antibiotics for prophylaxis. Adding antibiotics to the tumescent solution increases the risk of drug reaction and the absorption rate and length of action is unknown. There is no indication for the use of Marcaine (bupivicaine) in tumescent solution especially if lidocaine is in the solution. Marcaine bonds to the cardiac nerves and the possible effects include heart block, decreased cardiac output, hypotension, bradycardia, ventricular arrhythmias, ventricular tachycardia, ventricular fibrillation, and cardiac arrest. Epinephrine is not absorbed when given intramuscularly in a patient in cardiac arrest. It should have been given intravenously. There was failure to timely perform essential lifesaving procedures such as cardiopulmonary resuscitation, to maintain an adequate airway, and to administer oxygen.

59.10 Medical Board of California vs Greenberg, Tustin District, CA

In California 31 cases of postoperative infection following liposuction were documented from one physician's office. Subcutaneous nodules appeared 1–6 weeks postoperatively in these patients. The nodules showed inflammation and then drained serous fluid and pus. *Mycobacterium chelonae* was cultured from ten patients and *M. fortuitum* from one patient. The Heath Department investigated the physician's office and noted that the liposuction tubing and towel drapes were washed, not sterilized, and reused. No definite source for the infections was found.

Comment: It was ultimately learned that the liposuction cannulas, which were supposed to be heat-sterilized, actually were not being sterilized properly. The individual picked in the office to sterilize and do the back-office work was untrained except for being told how to do things by her predecessor. In fact, the 20-min heat-sterilization cycle was being started when the autoclave was turned on and not when the proper temperature and pressure had been attained. It is the physician's responsibility to hire adequately trained personnel or otherwise do adequate training in office.

59.11 Medical Board of California vs O'Neill

The 36-year-old female patient was 5' 6" in height and weighed 249 lb. On September 3, 1996 liposuction of the abdomen, neck, and inner thighs was performed under intravenous sedation. Blisters on the lower abdomen were noted on 6 September 6and bacitracin ointment was applied. On September 7 there was a huge red "bruise" on the lower abdomen and pustules in the pubic area. The patient's temperature was 101.4°F. Treatment with Duricef was changed to Augmentin. A diagnosis of cellulitis was made on September 8 at which time debridement of the abdominal wall and neck were carried out. The accusation was that there was failure to diagnose and adequately treat the infection.

Comment: On the fourth postoperative day, the diagnosis of cellulitis probably should probably have been made and consideration given for intravenous antibiotics. Infectious disease consultation would have been appropriate. Cellulitis is a superficial infection and would ordinarily not require debridement unless there is underlying necrosis. Late treatment of necrotizing fasciitis results in increased tissue loss.

59.12 Taylor vs Graves, San Diego County (CA) Superior Court, Case No. 694348; Medical Board of California vs Graves

The 50-year-old, 5' 4", 220-lb plaintiff had liposuction by the defendant. The hips, legs, and abdomen were liposuctioned on December 15, 1994 removing 11,000 ml aspirate and this was repeated in a second procedure removing 4,000 ml aspirate. The defendant had a medically untrained individual in his office who cleaned instruments and acted as a surgical assistant but was known to have performed liposuction on other patients. The plaintiff developed postoperative urinary incontinence which her expert witness stated was caused by the liposuction trauma. The plaintiff claimed that the liposuction resulted in indentations and irregularities of the hips and abdomen which were from use of a negligent surgical technique by an untrained healthcare employee of the defendant. The plaintiff also alleged that there was lack of informed consent and that liposuction should not have been performed on a morbidly obese patient. There was a confidential settlement and the Medical Board of California revoked the defendant's license.

Comment: The performance of liposuction is a medical procedure that can only be performed by a licensed physician. To allow anyone else to perform liposuction is considered as aiding and abetting the unlicensed practice of medicine and the physician is subject to revocation of his/her state license. Liposuction in a morbidly obese patient may have poor cosmetic results and this must be explained to the patient and recorded in the medical record. Surgical removal of redundant skin by some form of abdominoplasty may be necessary after liposuction and this must also be discussed with the patient and recorded.

59.13 Medical Board of California vs Chavis, Los Angeles District, CA

The 43-year-old, 4' 11", 197-lb female patient had liposuction of the medial and lateral thighs, hips, and abdomen, Five liters of tumescent fluid was injected (50 ml of 1% lidocaine, epinephrine, and 12.5 mEq sodium bicarbonate in each 1,000 ml normal saline). The aspirate volume was 3,500 ml with an estimated blood loss of 300 ml and intravenous fluid volumes of 3,000–4,000 ml. Versed, 17.5 mg, and Stadol, 3.5 mg, were used over the 1 h 50 min of surgery. Four hours postoperatively the patient wanted to get out of bed to sit in a chair. While in the chair, in the presence of her husband and the registered nurse, the patient became unresponsive. No breath sounds were noted but the pulse was present. Mouth-to-mouth resuscitation was started and the husband performed compressions when the pulse became no longer palpable. The paramedics took the patient to the hospital emergency room, where the HCT was recorded as 8.1 and the Hgb as 2.8. She expired after unsuccessful resuscitation in the emergency room. Disseminated intravascular coagulopathy, hypothermia, anemia, and pulmonary edema were diagnosed at autopsy. The physician's license was revoked.

Comment: Marked blood loss is unusual when the tumescent technique is used but it may occur. In this case, the surgeon gave the patient Aleve orally just prior to surgery. The physician should have known that non-steroidal anti-inflammatory drugs can cause bleeding problems. When this patient had pulmonary arrest, there were not enough medical personnel in the office to perform cardiopulmonary resuscitation. In actuality, the husband had to do cardiac compression during the arrest, which is totally unacceptable in a physician's office. The patient had been given 5,000 ml subcutaneous fluid and 3,000–4,000 ml intravenously over a 2-h period of time, which may have contributed to the pulmonary edema.

59.14 Anonymous vs Anonymous

In March 1999, three female patients had liposuction for minor lipodystrophies in a dermatologist's non-accredited office in Florence, Italy. Tumescent anesthesia was utilized, but there were no data on the contents of the solution. The cannulas used were sterilized by autoclaving at another clinic and they were transported to the office where the surgeries were performed. Within a few hours postoperatively, each patient developed high fever, nausea, vomiting, and feelings of anxiety. Hospitalization in an intensive care unit was immediate. Blood tests showed infection to all three patients with blood cultures positive for *Staphylococcus aureus* and *Pseudomonas aeroginosa*. Despite antibiotics being administered intravenously and resuscitative measures, one patient developed renal failure followed by coma and pneumonia. She died after 1 week. The two other patients recovered following dialysis and 2 weeks in the hospital. Investigation by local authorities showed the cannulae to be free of contamination, but the saline solution used for tumescent anesthesia was contaminated from being left open for 1 week (not discarded). The physician was suspended by the College of Surgeons for operating in an office not authorized for surgical procedures. All three cases are presently being litigated.

Comment: All surgeries should be performed under sterile conditions. Liposuction is no exception. Caps and masks, with sterile gowns and gloves, and sterilization of the skin will help to prevent contamination. Proper sterilization of instruments is essential and excess intravenous and tumescent fluids should be discarded, not reused. There tends to be a cavalier attitude by many physicians performing liposuction surgery that infections are so rare that indiscriminate contamination of the field by unsterile scrub suits and suction tubing will cause no harm. This, however, is a danger to the patient and is below the standard of care for a reasonably prudent (careful) physician. The postoperative nausea and vomiting might possibly be from lidocaine toxicity, but without the patient's weight and total lidocaine dose, this cannot be properly evaluated. It would be unusual for the peak lidocaine level to occur a few hours after surgery. The total surgery time would have to be taken into consideration, since, with proper tumescent anesthesia of 2:1 or 3:1, the lidocaine serum level should peak from 8 10 h after "administration."

59.15 Estate of Caswell vs Daniel, Commonwealth of Kentucky Fayette Circuit Court (Eighth Division), Case No. 99-CI-1947

The 30-year-old plaintiff's decedent had liposuction of the abdomen and panniculectomy on July 2, 1998. Four liters of tumescent solution was injected, and 4 475 ml aspirated. There was no written consent for liposuction. Two hours postoperatively there was a significant drop in blood pressure to 80/47. He was given increased intravenous fluids. For the next 3.5 h, the blood pressure varied from a high of 105/68 to a low of 66/40. This was followed for the next 1 h and 10 min by systolic blood pressures in the 70s. The patient was then transferred to the intensive care unit. HCT ordered at 1945 hours was reported at 2100 hours as 30.9. Repeat HCT at 2245 hours was 20.8. Packed cells were ordered at 0005 hours on July 3, 1998, and transfusions were begun at 0015 hours. The patient had cardiac arrest at 0030 hours and was pronounced dead at 0135 hours. Autopsy showed the cause of death to be from exsanguination with 1,600 ml of blood in the liposuction area of the abdominal wall, 400 ml in the scrotal sac, and extensive hemorrhage in the subcutaneous tissues extending to the back.

There was a settlement for an undisclosed amount.

Comment: Hypotension following a major surgical procedure is primarily caused by blood loss. HCT should have been ordered 2 h postoperatively when the first hypotensive episode occurred. The low blood pressure did not respond adequately to crystalloids. When the HCT was 30.9 at 2100 hours, blood should have been given. Packed cells are not indicated for hypotension following blood loss unless albumin or Hespan is used at the same time. Whole blood is the better means of expanding the vascular volume. By the time the patient had had severe hypotension for over 1 h, there was little likelihood of survival because of irreversible shock from extensive tissue damage. A timely diagnosis and treatment of blood loss would have saved this patient's life.

59.16 Estate of Marinelli vs Geffner, New Jersey Superior Court (1999). In *Medical Malpractice Verdicts, Settlements & Experts* 1999;15(8):37

The 23-year-old female plaintiff's decedent had liposuction by the defendant dermatologist in May 1994. One day following the surgery the patient died from a pulmonary embolus. The plaintiff claimed that the defendant was negligent in failing to tell the decedent not to take birth control pills and also applied the bandages in a manner which cut off the circulation and caused blood clots to form. There was also a question raised about the use of liposuction in a woman weighing only 115 lb. There was a $558,000 verdict.

Comment: It is essential that patients discontinue birth control pills prior to cosmetic surgery over 1 h. Cutting off the circulation with bandages would result in edema of the extremity but not deep vein thrombosis. Liposuction can be performed in a patient of any weight and is dependent upon the abnormal location of the fat deposits rather than the patient's weight.

59.17 Donnell-Behringer vs McCann, Los Angeles County (CA) Superior Court, Case No. VC26507. In *Medical Malpractice Verdicts, Settlements & Experts* 2000;16(8):50

The 45-year-old plaintiff had surgery on her shoulder and liposuction in the defendant's outpatient surgery clinic. She had follow-up visits with the defendant on the first and second postoperative days. On the third postoperative day, the plaintiff was admitted to the hospital by another doctor for infection of the liposuction site that required surgery. The plaintiff alleged that the defendant negligently performed liposuction, failed to utilize proper surgical techniques, and was negligent in postoperative care. The defendant claimed that he was not negligent, that the standard of care had been met, and that infection was a risk of the procedure. There was a $902,000 verdict that was reduced through MICRA to $660,000.

Comment: Infection is a known risk of any surgical procedure. The fact that infection occurred and was not timely recognized by the surgeon despite regular office visits was enough to convince the jury of a breach in the standard of care. Since the patient had to be admitted to the hospital and operated upon by another doctor, there is evidence that the infection was diagnosable by another physician within 1 day of having been seen by the defendant

59.18 Trebold vs Fowler, Dallas County (TX) District Court, Case No. 00-6073-D. In *Medical Malpractice Verdicts, Settlements & Experts* 2002;18(8):55

The 44-year-old plaintiff had liposuction of the abdomen and thighs. Postoperatively discoloration and necrosis of the skin of the abdomen and thighs developed that required debridement and packing. The result was disfiguring scars of the abdomen and thighs. The plaintiff alleged breach in the standard of care. The defendant claimed that the plaintiff failed to follow postoperative instructions. There was a $291,000 verdict with the plaintiff 20% negligent.

Comment: Infection, necrosis, and scarring are known complications of liposuction. Despite a lack in the breach of the standard of care, the jury found for the plaintiff possibly because of the severity of the necrosis and scarring and prolonged recovery.

59.19 Medical Board of Texas vs Ramirez, 1987

In 1987, a young 5' 1", 117-lb female patient had liposuction of the abdomen. No preoperative or postoperative antibiotics were administered. Two days postoperatively the patient developed an overwhelming infection and sepsis. She was admitted to the hospital and treated with intravenous antibiotics, but she died.

Comment: Sterility is a sine qua non of any surgical procedure. Instruments and wounds should be handled with strict sterile precautions. The cavalier attitude of some surgeons not to use masks, gowns, sterile drapes, and a sterile surgical suite to perform liposuction risks patient lives. Liposuction causes extensive internal tissue damage and the standard of care requires perioperative antibiotics.

59.20 Informed Consent

59.20.1 Definition

The patient has the absolute right to receive enough information about his/her diagnosis, proposed treatment, prognosis, and possible risks of proposed therapy and alternatives to enable the patient to make a knowledgeable decision. The patient is the one who makes all the decisions in opposition to the old paternalistic theory that gave the physician complete control over all decisions. A physician would now have to prove that the decision he/she made was because of the patient's inability to make the decision or because there was an extreme emergency.

Other requirements of the "informed consent" doctrine in law require that a complication which was not explained to the patient did in fact occur and that the patient would not have agreed to have the surgery if informed of that particular risk or complication.

59.20.2 Legal Definition

In terms of surgical procedures, the patient must have explained to him/her the nature and purpose of any proposed operation or treatment, any viable alternatives, and the material risks and benefits of both. All questions must be answered.

In order for the plaintiff to succeed in a complaint for lack of informed consent, he/she must show both of the following:

1. That the risk or complication, which was not explained to him, indeed did occur
2. That if he had been informed of that particular risk, he would not have consented to the surgical procedure

There are different means of proof at trial depending upon the jurisdiction (state). The expert opinion as to what risks are "material" to the patient in order to make his/her decision, under the same or similar circumstances, can be that of:

1. A reasonably prudent physician. This allows a physician to testify as to what is material.
2. A reasonably prudent patient. This allows the jury to decide what a reasonably prudent patient would consider material risks.
3. The plaintiff patient. This places the onus on the plaintiff to decide what would be material risks for him/her.

The Illinois Appeals Court, in Zalazar vs Vercimak (1994) [21], decided that the subjective (patient) standard is less of an "insurmountable" barrier than the objective standard (reasonably prudent physician or reasonably prudent patient) would be. The court believed that the decision whether to elect cosmetic surgery is personal and third-party testimony as to the decision a reasonably prudent person would make under similar circumstances would be of limited value.

In Parikh vs Cunningham (1986) [22] the plaintiff had signed a release prior to surgery, which authorized the treatment, recited the procedures to be performed, and recited that the risks and consequences had been explained and that no guarantees or assurances had been made as to the results. The court reversed a jury verdict for the defendant physician where the jury instruction stated that a written consent, executed by a person mentally and physically competent to give consent, gave rise to a conclusive presumption of informed consent. The court held that there must be more than just a writing introduced as evidence and that the elements of informed consent must be established.

In Largey vs Rothman (1988) [23], the New Jersey Supreme Court adopted the "prudent patient" standard for informed consent. The court held that the disclosure of "material risks" is determined by what a reasonable patient, in what the physician knows or should know to be in the patient's position, would be likely to attach significance to the risk or cluster of risks in deciding whether to forego the proposed therapy or to submit to it.

59.20.3 Suggestions For Office

Methods for preventing litigation concerning informed consent are misunderstood by most physicians who are convinced that a patient's signature or initials on a list of risks and complications will forego the problem. You can be assured that every time there is litigation, the patient will testify to the "fact" that the defendant physician did not explain the risks to him/her and that he/she did not read the consent form with all the risks listed despite his/her signature.

The following recommendations are made:

1. The physician should explain all material risks and viable alternatives and their risks and complications and answer all the patients' questions. In the alternative, if the surgical procedure, alternatives, and risks and complications are explained by audiovisual methods or by other health care personnel, the physician has the responsibility to meet with the patient to answer all questions and verify the patient's understanding of the surgery and risks.
2. The medical record should contain the following: "The surgical procedure was explained to the patient and risks and complications were discussed as well as viable alternatives and their risks and complications. All questions were answered."
3. Any witness to the patient's signature or initials concerning information for informed consent should have the following statement above the witness signature: "I requested that the patient read the complete form. I personally observed the patient read the form. The patient stated to me that all the material was read and, after all questions were answered, understood the complete form before signing."
4. Except under special circumstances, the physician should meet with the patient prior to the day of surgery to establish some personal rapport. Sometimes it is not possible to consult with the patient directly before the day of surgery if the patient is from out of town and arrives shortly before the day of surgery. It is usually possible to meet with this type of patient the evening before surgery if the physician is insistent. Remember that it is the physician's ultimate responsibility to establish the relationship and make sure the information necessary for the patient to make a knowledgeable decision has been received and understood. The day of surgery is a relatively poor time to try to explain all that is necessary when the patient is nervous, fearful, and is finding it hard to concentrate on what the physician is trying to explain.

59.20.4 Medications

The patient has the right to know what medications are being given, the purpose of the medication, and the possible risks and complications of the medication. This can usually be done by means of a written explanation describing all the information about the drug or by discussion with the patient by the physician or by other adequately trained health care personnel.

The following recommendations are made:

1. The medical record should contain the fact that a discussion about the medication was held or that the patient received written information.
2. Check allergies to drugs.
3. Evaluate need for laboratory studies as per the *Physician's Desk Reference* (PDR).
4. Prescribe for the purposes as set forth in the PDR. If off-label use is decided upon, all the reasons should be set down in the medical record.
5. Prescribe or dispense only in small quantities for the period of time needed.
6. Refills should be recorded in the chart and should be cautiously given especially if it is a controlled substance. Remember that the physician has the final determination as to how much and how often a medication should be taken. Do not let the patient control the medication prescription. If overuse is detected, then refuse all further refills and record this in the chart or refer to another physician for evaluation specifically for the drug use.

59.21 Discussion

Analysis of the cases of liposuction disasters reviewed by the author, a few of which are included in this chapter, shows that most of the problems occur from lack of knowledge of or errors by the physician. Basically, many of the events, although not always preventable, are foreseeable and should have been planned for.

Every office should be prepared for an acute allergic reaction or cardiopulmonary arrest. The proper equipment and medications must be available and the office staff trained for any type of emergency. At least one person in the office must have advanced cardiac life support (ACLS) certification as long as any postoperative patient is in the office.

The physician and staff must know and understand all possible postoperative complications. Any inflammation, excessive swelling and pain in the wound area, or fever has to be timely investigated for possible infection. High fever treated with antibiotics and followed by hypotension should be considered possible toxic shock syndrome (Table 59.1). When a patient complains about bleeding from the wound, this must be taken seriously rather than

Table 59.1. Centers for disease control: criteria for diagnosis of toxic shock syndrome (Adapted from Ref. [24])

1. Fever (>102°F)
2. Rash (diffuse, macular erythroderma)
3. Desquamation (1–2 weeks after onset, especially of palms and soles)
4. Hypotension
5. Involvement of three or more organ systems:
   – Gastrointestinal (vomiting, diarrhea at onset)
   – Muscular (myalgia, elevated CPK)
   – Mucous membrane (conjunctiva, oropharynx)
   – Renal (BUN or creatinine > 2 times normal)
   – Hepatic (bilirubin, SGOT, SGPT > 2 times normal)
   – Hematologic (platelets < 100,000)
   – CNS (disorientation)
6. Negative results on the following studies (if obtained):
   – Blood, throat, or CSF cultures
   – Serologic tests for Rocky Mountain spotted fever, leptospirosis, measles

passed off as the usual wound drainage of tumescent solution. If a patient has persistent dizziness when standing up or even sitting up, blood loss with orthostatic hypotension should be the first consideration. Chest pain following surgery should be considered a possible life-threatening situation and a workup should be performed to rule out pulmonary embolus, pneumonitis, myocardial ischemia, and myocardial infarction.

Rao et al. [25] reported four deaths related to tumescent liposuction. The authors concluded that two of the deaths were related to lidocaine toxicity or lidocaine-related drug interactions although this is not confirmed in the article. Both patients had hypotension, bradycardia, and then cardiac arrest. Another patient had severe postoperative anemia and received blood transfusions, morphine and intravenous fluids. She was discharged after 2 days but developed worsening dyspnea and an episode of syncope. Ventricular fibrillation ensued and the patient was resuscitated. Pulmonary edema was diagnosed and apparently treated but she remained in anoxic coma. Death ensued 3 days later. The last patient died from a saddle pulmonary embolus 25 h after surgery. Lidocaine levels were 5.2and 2 mg/l in the first two patients and 2.9 mg/l in the last patient.

Plasma concentration of lidocaine is related to toxicity symptoms [26] (Table 59.2). The rapider the injection, the lower the plasma concentration necessary for toxicity. Respiratory acidosis, and to a lesser degree metabolic acidosis, with increased $PaCO_2$ and decreased arterial pH decreases the convulsant threshold of local anesthetics. Cardiovascular collapse has been described at concentrations of 10 mg/l [27]. In postmortem studies, concentrations of 4–6 mg/l

Table 59.2. Plasma concentration of lidocaine and toxicity symptoms

Plasma level (μg/ml)	Symptoms
3–4	Circumoral and tongue numbness
4–4.5	Lightheadedness, tinnitus
6–6.5	Visual disturbances
7.2–8.2	Muscular twitching
10–10.5	Convulsions
11.5–12	Unconsciousness
15–16	Coma
19–20	Respiratory arrest
23–25	Cardiovascular depression

have been reported in deaths attributed to lidocaine [28, 29].

Anesthetists and anesthesiologists should be warned to limit intravenous fluids when more than 3,000 ml tumescent fluid is infiltrated into the subcutaneous space. If there is a preoperative blood pressure problem, no anesthesia, even local, should be administered until the pressure has been controlled and the cause identified. Certainly, surgery should not be continued until the cause of hypotension is determined and treated.

Megaliposuction (over 10,000 ml total aspirate) should be done only with proper monitoring and in a hospital setting. The morbidly obese (more than 100 lb overweight) patient will usually have medical problems which increase the risk of anesthesia. Possible fluid balance problems and blood loss requires ready access to laboratory studies. Patient safety is more important than simply achieving a successful megaliposuction in the office.

59.22 Conclusions

Liposuction disasters are usually preventable or treatable with adequate preparation by the surgeon, including information to the patient, being cognizant of the causes of complications and avoiding them, timely diagnosis of complications, and understanding the various treatments available for each possible complication.

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Part XII
Commentary

Editor's Commentary

Melvin A. Shiffman

60.1 Introduction

I have taken the liberty to try to place into perspective some of the material in this book and some material that is not in the book. This allows a general overview of liposuction from a personal point of view.

60.2 Terminology

There is some confusion at times with the term "cellulitis," meaning excess fat as may be used outside the USA. Cellulitis in the dictionary is described as suppurative inflammation of the subcutaneous tissues [1]. The term "cellulite" (not found in the medical dictionary) is ordinarily used to mean indentations caused by excess fat (cheesy appearance). Outside the USA the term may be used to mean excess accumulation of fat, similar to the term lipodystrophy. "Lipodystrophy" is used by most cosmetic surgeons, at least in the USA, to mean an abnormal increase in fat accumulation especially in localized areas. In the dictionary, lipodystrophy is a term used to describe any disturbance of fat metabolism or defective fat metabolism with loss of subcutaneous fat [2]. Lipodysmorphic refers to fat that is "dysmorphic" or malformed, disrupted, or deformed [3]. "Lipohypertrophy" may be a more appropriate term to use since it means hypertrophy of subcutaneous fat [4].

There has not been consensus as to the meaning of the terms "large-volume liposuction" and "megaliposuction." Not only the total amounts taken out are at controversy but also the content, fat (supranatant) versus fat plus fluid (supranatant and infranatant). Some of this problem stems from the attempts to limit liposuction to 5,000 ml by government agencies where it is important to the cosmetic surgeon that the limitation concerns only the amount of fat removed. If fat (supranatant) alone is considered, then the total amount removed can be 20–40% more. The easiest method to define the terms is with total (fluid and fat) aspirant, 5,000–10,000 ml being large-volume liposuction and over 10,000 ml being megaliposuction. In this way fat is not the only determining factor.

60.3 Obesity

There is no doubt that liposuction is indicated for and can be used in the obese and morbidly obese (over 100 lb from the ideal weight) patient. There can be improvement in the cardiovascular status of the morbidly obese patient as well as a reduction in the need for cardiac or diabetic medication. Although the contours may be improved somewhat in the obese or morbidly obese patient, good cosmetic results should not be anticipated. Further procedures may be necessary to improve the appearance, i.e., abdominoplasty (usually less extensive after liposuction than a full abdominoplasty), repeat liposuction, brachioplasty, and other surgical contouring procedures. Liposuction may induce the obese patient to start losing weight. A weight-loss program may be started but most of these patients will not maintain a strict diet.

60.4 Power-Assisted Liposuction

The use of powered equipment makes removal of fat easier in liposuction; however, the vibration is possibly a problem for the surgeon. Surgeons have a potential to develop arthritis, ulnar palsy, carpal tunnel syndrome, elbow problems, as well as a hand, arm, and shoulder syndrome.

60.5 New Technologies

There are on the market many types of medications that can be injected into the tissues to cause loss of fat that is termed mesotherapy. Mesotherapy may contain aminophylline, plant extracts, phosphatidyl choline, vitamins, and other medications that supposedly cause a general dissolution of fat over parts of the body [5]. This is a common method of treatment outside the USA. Mesotherapy shows a reduction of fat in an area when phosphatidyl choline is injected into the mid dermis. There have not been substantial studies to show what percentage and amount of phosphatidyl choline should be used when injected, the amount of spread of the medication, and what the limitations are. I cannot comment on the procedure since I have not had experience with this method.

Endermologie has been found to reduce fat, essentially by "crushing" the cells with the machine, and may be useful for some improvement in body contour [6].

Similar to the reciprocating cannula, the rotating cannula for liposuction can reduce fat in certain lipodystrophies that are not easy to treat, i.e., epigastrium, knees, and upper back [7]. The vibrations, as with any of the powered cannulas, have the potential of causing problems for the surgeon in the form of shoulder, arm, and hand syndromes.

Injection of carbon dioxide has been utilized to treat localized adiposities [8]. This was found useful in accumulations located in the knees, thighs, and abdomen. This is not a permanent solution for the accumulated fat.

There is a report of a new device consisting of an external extension of the cannula with a guard wheel resulting in less uneven appearance, asymmetry, and inadequate removal of fat [9]. The device is very similar to Fischer's "swan-neck" cannula that helps the surgeon to maintain an even cannula depth [10].

Laser-assisted liposuction (Neira, Chap. 47) is a new technology with the potential of reducing the work required to remove the fat. The most interesting aspect of this work is that laser does not destroy the fat cell but actually causes loss of the fat from the cell through micropores. A less expensive and equally effective method is with percussion massage-assisted liposuction (Shiffman and Mirrafati, Chap. 46).

Lipostabil (phosphatidyl choline, Aventis, Strasbourg, France) given intravenously is an alleged burner of fat and, theoretically, can break down fat [5]. The clinical studies show hypolipidemic effects of lipostabil but not actual fat cell breakdown [11–13].

60.6 Anesthesia

The use of articaine (Fatemi, Chap. 13) instead of lidocaine is an interesting idea with some merit since the toxicity of articaine is less than that of lidocaine.

Local tumescent anesthesia is fine for those surgeons who do limited volumes of liposuction and are not concerned with a prolonged surgical procedure. Large-volume liposuction under local tumescent anesthesia would be limited because a ratio of tumescent fluid to total aspirate of 2:1 or 3:1 limits the amount used for tumescence to avoid lidocaine toxicity. There are many patients who do not wish to be awake during the procedure and hear what is going on around them. Others prefer one procedure to multiple procedures to remove the same amount of fat. The cost to the patient having local tumescent anesthesia is concomitantly increased because of the prolonged time to perform the surgery and the surgeon has to limit the number of procedures that can be performed in one day. Local tumescent anesthesia assisted with intravenous sedation is a safe method to perform liposuction. General anesthesia is safe if given and monitored properly (Shiffman, Chap. 54).

Marcaine should be contraindicated in liposuction tumescent fluid since it is totally unnecessary and highly dangerous since it can bind with the myocardium if excess is administered or if it is administered too rapidly. If cardiac arrest occurs, there is almost no chance to resuscitate the patient [14].

60.7 Reduced Negative Pressure

Elam (Chap. 44) has resolved one of the major causes of bleeding and bruising following liposuction with the reduction of the vacuum pressure (from 760 mmHg or 1 atm vacuum to 250–300 mmHg vacuum) when using the liposuction machine. This simple maneuver has not as yet been taken into account by most liposuction surgeons. The vacuum can also be reduced in syringe liposuction by venting the syringe with air or saline prior to use (place 2 ml of saline or air in a 20-ml syringe prior to use).

60.8 Ultrasound-Assisted Liposuction

Surgeons still use ultrasonics, externally and internally, to emulsify the fat prior to suctioning. The cost of the machines is excessive and perhaps unwarranted. The use of the external percussion massage machine (Shiffman and Mirrafati, Chap. 46) usually at a cost of less than US $100 results in the same emulsification and ease of removal. There may be indications for the use of ultrasound-assisted liposuction in the face but the amounts removed are so small that the cost of the machine would override the benefits to the surgeon. External ultrasound is more useful postoperatively, after 3 weeks (bleeding may occur in the tissues if used sooner), to reduce the fibrosis.

60.9 Combination Liposuction and Abdominoplasty

Despite Matarasso's [15, 16] caution about doing liposuction on certain areas of the abdomen at the same time as doing full abdominoplasty, there is still some lack of understanding of the dangers by some physicians. Combining extensive abdominal liposuction and full abdominoplasty at the same time increases the danger of fat embolism and thromboembolic complications as well as necrosis. When extensive liposuction is performed prior to and at a separate time from abdominoplasty it is important not to perform a full abdominoplasty because of the increased risk of flap necrosis. It may be more prudent to perform full abdominoplasty first and, after complete healing, liposuction can be performed without restriction to the extent and area of liposuction.

60.10 Aesthetic Medicine

Gasparotti (Chap. 29) describes the reduction of fat, reduced circumference of the extremity, and improvement in cellulite with the use of Cellasene (a herbal medication) and compares this with data for liposuction patients. The author has no experience with this medication.

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61 Non-Cosmetic Applications of Liposuction

Melvin A. Shiffman

61.1 Introduction

During the years that liposuction has been used for cosmetic purposes, there have been reports of non-cosmetic uses of the procedure. Liposuction has been quite successful in treatment of these disorders with minimal incisions and rapid recovery time.

The author utilized liposuction in a very difficult case involving chronic infection from Vicryl sutures that were contaminated at the manufacturer's facility and despite multiple resections of tissue, the chronic recurring cellulitis continued.

61.2 Case Report

A 32-year-old patient had breast reduction surgery in November 1996. One month later she developed bilateral cellulitis of the breasts that required hospitalization and intravenous antibiotics. Twice more, 2 months apart, she needed hospitalization for intravenous antibiotics. In May 1997, she had excision of a left breast mass that was an abscess that grew out *Staphylococcus*. In February 1998, a mass was excised from the left breast that showed foreign body giant cell reaction and 1 month later had drainage of an abscess in the left breast. She continued to get cellulitis every 1.5–4 months that required intravenous antibiotics intermittently for the next few years and she had surgical resection ten times to remove extensive amounts of subcutaneous tissues and skin where contaminated Vicryl sutures had been used for suturing. In April 2002, because there was very little subcutaneous tissue remaining in the inferior aspects of the breasts, liposuction, using the tumescent technique, was performed in the inferior aspects of both breasts where the cellulitis was present. Pathology of the various surgical specimens, including the liposuction specimen, showed remnants of Vicryl suture and suture granulomas. The liposuction procedure resulted in relief of the symptoms of cellulitis for a longer period of time (5 months) than the prior surgical procedures. A second liposuction procedure was necessary and following this procedure there was no further evidence of inflammation or infection (follow-up for 12 months).

A prior lawsuit against Ethicon had been filed alleging contamination of the sutures by defective sterilizing apparatus at the Irving, Texas, facility. The company failed to recall all the sutures and only warned some of the hospitals of the contamination. The lawsuit was dismissed because of failure to obtain an expert to prove that the contamination caused the infection. After the statute of limitations had run, the attorney for this case was sued for failure to obtain adequate expert opinions and for allowing the statute of limitations to expire. There was a confidential settlement.

The most recent lawsuit [1] against Ethicon alleged that the sutures were not only contaminated but that there was lack of adequate research as to the length of time for Vicryl suture to be absorbed, that defective manufacture resulted in the suture not absorbing over 6 years, and that the continued infections were made worse by the partial suture absorption causing breaking up of the suture into multitudinous fragments making complete removal virtually impossible. There was an arbitration judgment for the defendant.

61.3 Non-Cosmetic Disorders Treated By Liposuction

There are some non-cosmetic disorders that have been treated with liposuction that some may consider cosmetic. These include:

61.3.1 Breast Reduction

The problems of macromastia and gigantomastia actually have significant medical symptoms (neck and upper back pain, grooving of the shoulders from the bra straps, inframammary fold irritation and dermatitis) that are treatable with breast reduction [2–11]. The utilization of liposuction to reduce breast volume and, at times in conjunction with breast lift to relieve ptosis, can achieve resolution of the symptoms.

61.3.2 Gynecomastia

Gynecomastia [12–17] may appear in the adolescent male as part of the physiologic and hormonal changes taking place, in the elderly male because of hormonal changes, from of a variety of drug therapies in males that are associated with stimulation of the breast tissue, and in a male with a breast tumor that may very well be malignant. True gynecomastia consists of excessive breast tissue and fat, but pseudogynecomastia is the excessive accumulation of fat.

Breast enlargement in the male is often an embarrassment to the patient because of the large breasts. Surgical removal of the breast for gynecomastia is an accepted medical procedure for the abnormal enlargement of the breast in males. Liposuction is now the preferred method for removal of excess fat and breast parenchymal tissue.

61.3.3 Cellulite

Cellulite [18, 19] involves indentations caused by the increased accumulation of fat with restricted expansion by the fibrous attachments of the skin to the underlying fascia. Liposuction has been utilized to remove the excess fat and relieve the tension that causes the indentations because of the fascial attachments and also by transecting some of the fascial attachments.

There are a number of medical conditions that can be amenable to liposuction for improvement or cure. These are described in the following sections.

61.3.4 Lipoma

A lipoma [3, 15, 20–40] is a benign, soft, rubbery, encapsulated tumor of adipose tissue, usually composed of mature fat cells generally occurring in the subcutaneous tissues of the trunk, nuchae, or forearms but it may occur intramuscularly, intermuscularly, intraarticularly, intraspinally, intradurally, and epidurally. These can become an annoyance to the patient because of size and because of the cosmetic appearance.

1. Lipomatosis dolorosa: Lipomatosis in which lipomas are tender or painful.
2. Lipomatosis gigantea: Adipose deposits form large masses.
3. Nodular circumscribed lipomatosis: Formation of multiple circumscribed or encapsulated lipomas which may be symmetrically distributed (symmetrical lipomatosis) or haphazardly.
4. Dercum's disease (adiposis dolorosa, Anders syndrome, adiposalgia, adipositas tuberosa simplex, fibrolipomatosis dolorosa, neurolipomatosis, lipalgia, lipomatosis dolorosa): A disease accompanied by painful localized fatty swellings and by various nerve lesions. Usually seen in women and may cause death from pulmonary complications.
5. Madelung's disease (asymmetric adenolipomatosis, Launois–Bensaude syndrome [41], Buschke's II syndrome): Onset is between 35 and 40 years of age, more prevalent in males, with diffuse tumefaction in the posterior part of the neck. This is followed by symmetric accumulation of masses in the submandibular region and other lipomas on the chest and the rest of the body. Asthenia and apathy are usually present. Compression of peripheral nerves results in pain. Dyspnea, cough, cyanosis, and exophthalmos may develop.
6. Madelung's deformity or Madelung's neck (anulare colli): Haphazard accumulation of lipomas around the neck.
7. Bannayan syndrome (Bannayan–Zonana syndrome, microcephaly-hamartomas syndrome) [42, 43]: A familial syndrome characterized by symmetrical microcephaly, mild neurological dysfunction, postnatal retardation, mesodermal hamartomas, discrete lipomas, and hemangiomas.
8. Proteus syndrome [44]: A sporadic disorder that causes postnatal overgrowth of multiple tissues that include skin, subcutaneous tissue, connective tissue (including bone), the central nervous system, and viscera. Progressive skeletal deformities occur with invasive lipomas, and benign and malignant tumors.
9. Angiolipomas may also be removed with liposuction [45]. Liposuction is a method to remove the tumor with minimal incisions.

61.3.5 Apocrine Gland Disorders

The apocrine or sweat glands may be involved with of variety of problems, such as excessive sweating, and can become foul-smelling or infected [24–26, 46–59]. Liposuction may be the only minimal incision solution to the problem.

1. Bromhidrosis: Axillary (apocrine) sweat, which has become foul-smelling as a result of its bacterial decomposition.
2. Hyperhidrosis (polyhidrosis): Excessive perspiration.

3. Osmidrosis: Same as bromhidrosis.
4. Emotional hyperhidrosis: An autosomal dominant disorder of the eccrine sweat glands, most often of the palms, soles, and axillae, in which emotional stimuli (anxiety) and sometimes mental or sensory stimuli elicit volar or axillary sweating.
5. Fox–Fordyce disease: A chronic, usually pruritic disease chiefly seen in women, characterized by the development of small follicular popular eruptions of apocrine gland-bearing areas, especially the axillae and pubes, and caused by obstruction and rupture of the intraepidermal portion of the ducts of the affected apocrine glands, resulting in alteration of the regional epidermis, apocrine secretory tubule, and adjacent dermis.

There have been no reports concerning the treatment of hidradenitis suppurativa with liposuction. Hidradenitis suppurativa is a chronic suppurative and cicatricial disease of the apocrine gland-bearing areas, chiefly the axilla, usually in young women, and the anogenital region, usually in men. The disorder is caused by poral occlusion with secondary bacterial infection of apocrine sweat glands. It is characterized by the development of tender red abscesses that enlarge and eventually break through the skin resulting in purulent and seropurulent drainage. Healing occurs with fibrosis and recurrences lead to sinus tract formation and progressive scarring. This disorder would have to be treated by liposuction to remove the apocrine glands in the resting phase when there is no apparent infection. The earlier in the disease that treatment is instituted, the less likely infection will be stirred up. The author is presently observing a patient with early hidradenitis suppurativa since the infections have responded well to antibiotics on each occasion of recurrent symptoms and the patient is reticent about surgery.

Field [60] described the use of axillary liposuction for osmidrosis and hyperhidrosis with an aggressive approach that has minor scarring but removes more glandular tissue.

61.3.6 Obesity

Obesity [25, 61–70] is defined as an increase in body weight beyond the limitation of skeletal and physical requirements. Endogenous obesity is excess weight due to metabolic (endocrine) abnormalities or genetic defects that affect the synthesis of enzymes involved in intermediate metabolism. Exogenous obesity is obesity due to overeating.

The treatment of endogenous obesity requires resolution of any endocrine problem but also may include liposuction for improving contour and reducing total fat deposits. Exogenous obesity should be treated with diet and exercise but if this is not successful, liposuction may be performed. This can sometimes stimulate the patient to continue with weight loss regimens.

Giese et al. [71] has shown that the cardiovascular profile can be improved with large-volume liposuction

61.3.7 Hematoma

Hematomas [26, 72–75] can be liposuctioned through small incisions rather than opening the total wound. This less invasive method reduces the morbidity associated with postoperative hematomas. The aspiration of seromas probably could be performed with the liposuction cannula but a simple needle and syringe usually suffices. However, in very large seromas, the use of liposuction with a machine would be easier than aspirating 60 ml at a time with a syringe.

61.3.8 Lymphedema

The treatment of persistent obstructive lymphedema [24, 26, 76–81] can be aided with liposuction, especially with the limited incisions utilized. There can be uniform removal of the lymphedematous tissue with liposuction without the need for major surgery to aid in the discomfort of a large extremity. Long-term results need to be reported.

61.3.9 Steroid-Induced Lipodystrophy

A better cosmetic appearance in patients with steroid-induced lipodystrophy [82–88] can be achieved with liposuction of the excessive areas of fat. The underlying endocrine problem also needs to be addressed at the same time.

61.3.10 Liposuction-Assisted Nerve-Sparing Hysterectomy

Nerve-sparing hysterectomy [89, 90] can be performed more easily with the use of liposuction to remove excess fat and better exposure of the surrounding structures. There may be other surgical procedures that can be made easier through better exposure from removal of fatty tissue accumulation.

61.3.11 Silicone Removal

Silicone is almost impossible to remove from the tissues without removing some normal tissue, even with a siliconoma [25, 91]. The resulting defect may be cosmetically unacceptable. It is very difficult to remove silicone from a mammary prosthesis pocket because the silicone is as sticky as gum and clings to gloves, skin, and pads. If even small drops of silicone accidentally drop to the floor, there is extreme danger of slipping by persons in the operating room. Silicone can be extracted from tissues with less deformity and from the implant pocket with the use of liposuction.

61.3.12 Reconstructive Surgery

Liposuction has been used to aid in reconstructive surgery [25, 26, 92–94], especially in debulking flaps without injuring the blood supply. The author has used liposuction to correct dog-ears following reconstructive procedures and there are probably many other problems in reconstructive surgery that can be corrected with the use of liposuction.

61.3.13 Involuted Hemangiomas

Liposuction of hemangiomas should be performed when the hemangioma is involuted, otherwise there may be extensive bleeding. There have been two reports of hemangiomas having been removed with liposuction [95, 96].

61.3.14 Other Problems

There have been single reports of the use of liposuction to treat certain problems. Shenoy et al. [97] used liposuction to aid in correcting a buried penis. Sonenshein and Lepoudre [98] treated a critically ill obese patient with massive fat accumulation in the neck with the use of liposuction, removing 225 ml of fat, to allow visualization of the tracheal stoma in order to insert a tracheostomy tube. Ad-El [99] reported the use of liposuction to relieve chronic facial swelling following multiple bee stings. Apesos and Chami [29] used liposuction in the treatment of congenital body asymmetry and fat necrosis. Illouz [20] reported the use of liposuction to treat scar deformity. Field et al. [100] showed that liposculpturing can be used to improve submental scar revision by removing submental and submandibular adipose tissue followed by cannula dissection of the submental skin flap. Babovic et al. [101] reported the use of liposuction in debulking plexiform neurofibromas and Thomas [102] showed that the tumescent technique can aid in the resection of neurofibromas.

As physicians become aware of the multiple uses of liposuction outside the cosmetic surgery field, further disorders will be found that can be amenable to liposuction.

61.4 Conclusions

Liposuction is a procedure that has yet to reach its limitations. Started as a limited-incision cosmetic operation, liposuction has progressed to uses that were not even imagined by its founders and many of the early surgeons utilizing the procedure. The future of liposuction in surgery needs physicians who will find innovative uses in areas outside the cosmetic surgery field.

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Ultrasound-Assisted Liposuction for Breast Reduction

Alberto Di Giuseppe

62.1 Introduction

Ultrasound energy has been applied to the adipose component of the breast parenchyma in cases of breast hypertrophy to reduce the volume of the breast mold. As is well known, ultrasound energy was initially used by Zocchi [1–6] to emulsify fat. He created a special instrument composed of an ultrasound generator, a crystal piezoelectric transducer, and a titanium probe transmitter.

This new technology was first applied to body fat to emulsify only fat cells while sparing the other supporting vascular and connective components of the cutaneous network. More recently, Goes [7], Zocchi [1–6], Benelli [8], and I [9–12] have started to apply this technology to the breast tissue to achieve breast reduction and correction of mild to medium-degree breast ptosis.

62.2 Patient Selection

The ideal candidate for a breast reduction with ultrasound-assisted lipoplasty (UAL) is a patient with juvenile breasts, which are usually characterized by fatty parenchyma, or a patient with postmenopausal involution parenchyma, with good skin tone and elasticity present. Between 60 and 70% of women with large breasts are candidates for reduction with UAL alone or combined with surgical resection.

Initial screening of the potential candidates for a breast reduction with UAL included a mammographic study, breast clinical history, evaluation of breast ptosis, and evaluation of the consistency of breast parenchyma.

62.3 Preoperative Mammography

Preoperative mammograms (anteroposterior and lateral views) are taken to evaluate the nature and consistency of the breast tissue (fibrotic, mixed, or fatty parenchyma), the distribution of the fat, the presence of calcifications, and areas of dysplasia or nodularity that might necessitate further studies or biopsy (Fig. 62.1). The presence of fibroadenomas, calcifications, and other suspected or doubtful radiologic findings should be double-checked with ultrasound and a radiologist experienced in breast-tissue resonance.

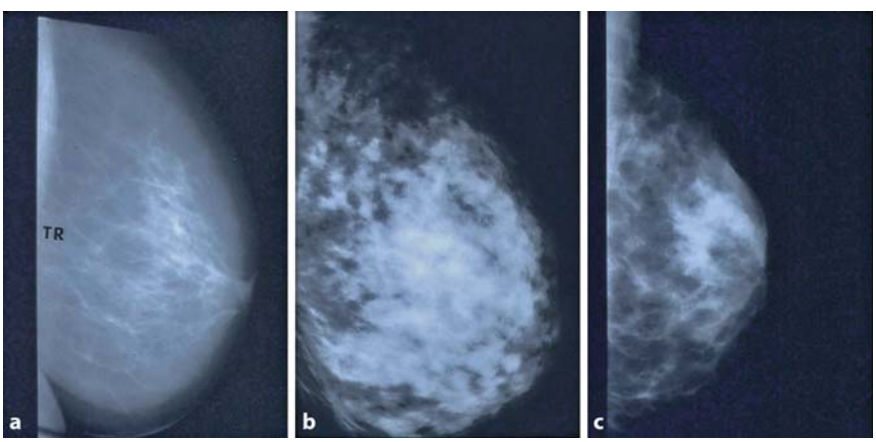

Fig. 62.1. Mammographic evaluation of candidates for breast reduction with the use of ultrasound-assisted lipoplasty (*UAL*). **a** A typical fatty breast. This patient is an ideal candidate for UAL. **b** Fibrotic glandular tissue is a contraindication for UAL. **c** Fibrotic mixed tissue. This patient is a candidate for UAL of the posterior upper and lower cone

62.4 Contraindications

Patients with a history of breast cancer or mastodynia and those fearful of potential sequelae from this new technique were not considered for the author's study. Furthermore, because the amount of fat in the breast is variable as is its distribution (Fig. 62.2), not all women are candidates for breast volume reduction with UAL. If fat tissue and glandular tissue are mixed, penetration of the tissue may be impossible, as noted by Lejour [13] and Lejour and Abboud [14]. If the breast tissue is primarily glandular, the technique is not indicated.

62.5 Infiltration

62.5.1 Anesthesia

When surgery is performed under general anesthesia or intravenous sedation, a wetting solution was used by the author that is a variation of the universally known Klein's tumescent solution. The tumescent solution is used to distend the breast area and induce severe vasoconstriction. Tumescent infiltration is also necessary to allow transmission of ultrasound energy to emulsify the fat cells.

The solution is composed of 1,000 ml Ringer's lactate and 1 ml (or one ampoule) of adrenaline. No bicarbonate or lidocaine was used. The anesthesiologist chose either intravenous or oral analgesics to assure postoperative analgesia. It is also possible to use a standard Klein tumescent anesthesia, using 200 mg lidocaine or more for postoperative analgesia. In this case, the solution is made with 1 l Ringer's lactate, 1 ml adrenaline, and 200 mg lidocaine. If surgery is performed under local anesthesia, a modified Klein solution is prepared (1,000 ml Ringer's lactate, 12.5 mEq bicarbonate, 500–750 mg lidocaine, and 1 ml pure adrenaline). To achieve good tumescence, 500–1,000 ml of solution per side, depending on the breast size, is necessary.

62.5.2 Technique

After preoperative marking (Fig. 62.3), the fatty breast is emulsified in the lateral and medial compartments, the upper quadrants, and the inferior aspect of the periareolar area. All the periareolar area where most of the glandular tissue is localized (5-cm circumference around the nipple-areolar complex) is preserved.

The deep portion, mostly fat, is also emulsified, allowing the breast mold to regain a natural shape through natural rotation and increase the elevation from the initial position, taken from the midclavicular notch (Fig. 62.4). Up to 4 cm of breast elevation is obtained after proper reduction and stimulation to allow skin retraction and correction of the ptosis.

62.5.3 Incisions

Two 1.5–2.0-cm stab incisions, one at the axillary line and one 2 cm below the inframammary crease, are made to allow entrance of the titanium probe (Fig. 62.5).

A periareolar incision can made in patients with very lax skin for further subcutaneous stimulation.

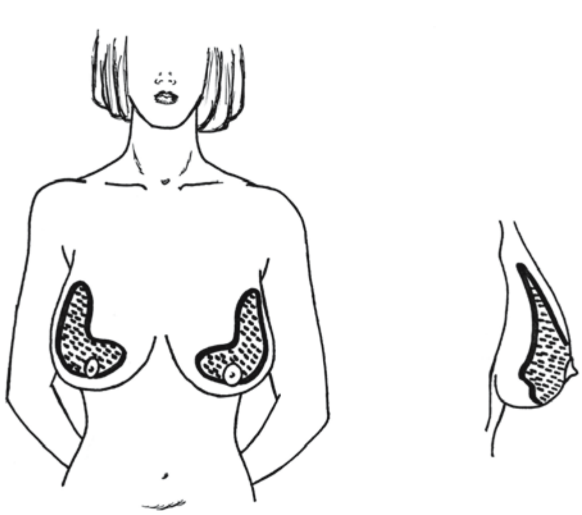

Fig. 62.2. Distribution of glandular tissue in the breast cone

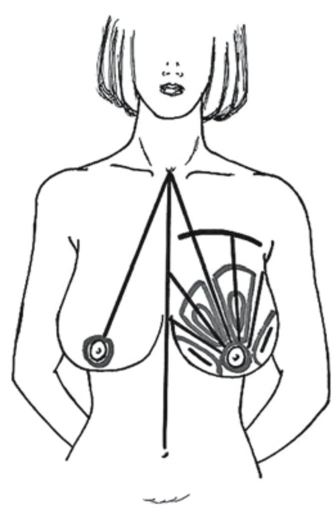

Fig. 62.3. Preoperative markings. *Straight lines* indicate the lines of subcutaneous skin stimulation. *Enclosed areas* indicate areas of thicker breast tissue. A 5-cm *circle* drawn around the areola indicates the limits of the operative area

Through these incisions the surgeon can reach all the breast tissues, working in a crisscross manner. The skin is protected from friction injuries with a specially made skin protector. Recently, the ultrasound device software has been upgraded to provide the same degree of cavitation with less power, which reduces the risk of friction injury and burn at the entrance site, which allows discontinuing the use of the skin protector.

62.5.4 Probe

Routinely, the standard 35-cm-long titanium probe is used. This probe has a diameter that tapers from 5.5 mm in the proximal portion to 4 mm in the distal portion.

With the existing technology, a solid probe has been found to be more efficacious than a hollow probe because none of the hollow probes existing today are strong enough and they can easily break in the tissues as a result of the vibrations produced when ultrasound energy is applied. Moreover, the level of ultrasound energy conveyed by a hollow probe is limited, and consequently the level of the cavitation obtained in the tissues is diminished.

62.5.5 Fat Emulsification

In breast reduction with UAL, the duration of the procedure varies depending on the volume of reduction, the type of breast tissue encountered, and the amount of skin stimulation required. A breast with purely fatty tissue is easier to treat than one with mixed glandular tissue, in which fat cells are smaller, stronger, and denser.

Energy is applied with an SMEI sculpture ultrasound device (SMEI, Casale Monferrato, Italy) set at 50% power for at least 10–30 min, depending on the patient. The application of 10–15 minutes of ultrasound energy in fat tissue usually produces from 250 to 300 ml of emulsion [15]. Recently, the author started utilizing the VASER ultrasound device (Sound Surgical, Denver, CO, USA) with solid probes (2.9–3.7-mm wide). It delivers 50% of the ultrasound energy in comparison with the SMEI unit, while emulsifying fatty tissue much more efficiency. The duration of the procedure and the amount of energy required to liquefy the excess fat may vary depending on the characteristics of the tissues encountered, the volume of the planned reduction, and the type of the breast tissue. Purely fatty breast tissue is easier to treat than mixed glandular tissue, in which fat cells are smaller, stronger, and denser. Treatment of the target tissues starts with 10–15 min of ultrasound energy in fat tissue, which usually produces between 250 and 300 ml of emulsion.

The surgical planes, with good crisscross tunneling and adequate undermining, are routinely followed, as planned in the preoperative drawings. If intense stimulation is required for skin retraction, the superficial layers are treated initially. Then, the deeper planes are reached and more time is spent in thicker areas. In more standard cases, it is possible to start with the deeper planes. Surgeons inexperienced in the procedure should be especially cautious when performing the technique, particularly in the subdermal planes [9–12, 16–20].

62.5.6 Subcutaneous UAL Stimulation

Together with UAL application to the fat layers, starting from the deeper layers and progressing to the more superficial ones, it is advisable to stimulate the superficial layers of the subcutaneous tissue of the upper and lower quadrants by using a different-angles

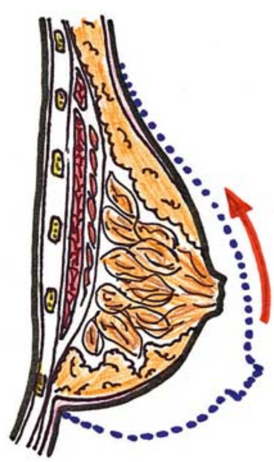

Fig. 62.4. By thinning the lower pole, the breast cone naturally rotates upward

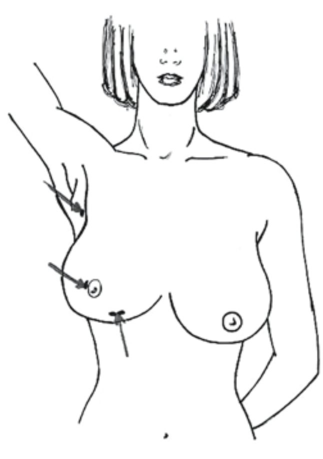

Fig. 62.5. With the thinned lower pole, the axillary, submammary, and periareolar incision lines rotate upward

pattern, as in a standard lipoplasty [21, 22]. This superficial stimulation with low-frequency ultrasound energy helps to enhance the retraction of the breast skin and to redrape the breast skin to the newly shaped and reduced mammary cone. The fibrosis that follows the thermal insult caused by the passage of the ultrasound solid probe is probably responsible for the great skin retraction which normally follows and which contributes to the correction of breast ptosis.

62.6 Postoperative Care

Suction drainage is routinely applied in the breast for at least 24–48 h. A custom-made elastic compression support (TOPIFOAM, Lysonics, Santa Barbara, CA, USA) is applied for 7–10 days and a brassiere completes the dressing. These items together with skin redraping help support the breast in the immediate postoperative period.

62.7 Evaluation

Postoperative mammograms were obtained of the author's patients at 1 and 3 years after the operation. Particular attention was paid to the evaluation for calcifications and the long-term evolution of postoperative fibrosis in the breast. The minimum follow-up for patients was 4 years.

The range of breast tissue reduction was measured on the basis of emulsified breast fat, including tumescent solution infiltrated at the beginning of the procedure. Breast measurements to assess preoperative and postoperative breast size, and the position of the nipple in relation to the clavicle and sternum, were assessed as follows.

Breast sizers (CUI Corporation, Santa Ana, CA, USA) were used to evaluate preoperative and postoperative breast measurements (Fig. 62.6). Breast measurements were assessed as in a classic breast drawing, checking preoperative and postoperative distances of the nipple from the midclavicular notch of the nipple (NM), from the nipple to the submammary line (NSL), from the midclavicular notch to the submammary line (MSL), and from the nipple to the sternum (NS).

62.8 Results

Results were visible immediately after surgery; the skin envelope redraped nicely and contoured the new breast shape and mold (Figs. 62.7, 62.8). The skin and treated breast tissue appeared soft and pliable. The elevation of the nipple-areolar complex resulting from skin contraction and the rotation of the breast mold was immediately visible. The major postoperative nipple-areolar complex elevation was 5 cm.

Emulsification of fatty breast tissue ranged from a minimum of 300 ml per breast in mild reductions and breast lifts to a maximum of 1,200 ml of aspirate for each breast in large breasts.

Preoperative and postoperative breast measurements are in Tables 62.1 and 62.2. The author was often able to easily obtain a mean of 500 ml of fat emulsion from each breast, after infiltration of 700 ml of Klein's modified solution for tumescence, followed by energetic skin stimulation of the subcutaneous tissue, to allow skin redraping. Elevation of the nipple-areolar complex up to 5 cm was obtained in large-volume reductions in combination with stimulation of the subcutaneous layer.

There was no evidence of suspicious calcifications resulting from surgery at the 5-year postoperative fol-

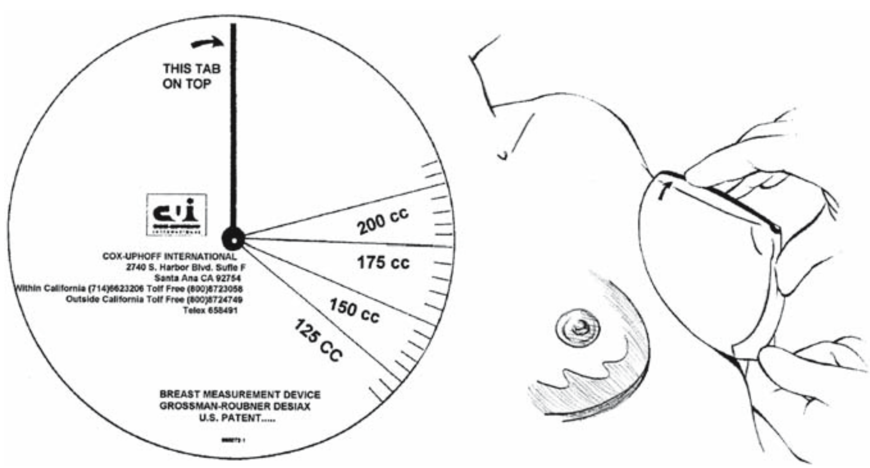

Fig. 62.6. A breast-measurement device (CUI, Santa Ana, CA, USA) was used to assess preoperative and postoperative breast size

low-up. Essentially, an increase in breast-tissue fibrosis was noticeable in the postoperative mammograms, which was responsible for the new consistency, texture, and tone of the breasts. The increase was also responsible for the lifting of the breasts.

62.9 Complications

No major complications occurred in the author's series of patients. It should be emphasized that such good results require extensive experience with UAL. As stated by a task force on UAL established by the American Society for Aesthetic Plastic Surgery (ASAPS), the Plastic Surgery Educational Foundation (PSEF), the Lipoplasty Society of North America (LSNA), and the Aesthetic Society Education and Research Foundation (ASERF), the learning curve for UAL is longer than that for standard lipoplasty.

Specifically, practitioners must learn how to work close to the subdermal layer with a solid titanium probe to defat this layer and obtain good skin retraction while avoiding complications, such as skin burns and skin necrosis. To safely work close to the skin, two conditions are mandatory. The surgeon must be experienced in ultrasound-assisted body contouring, and the correct ultrasound device (one that is able to

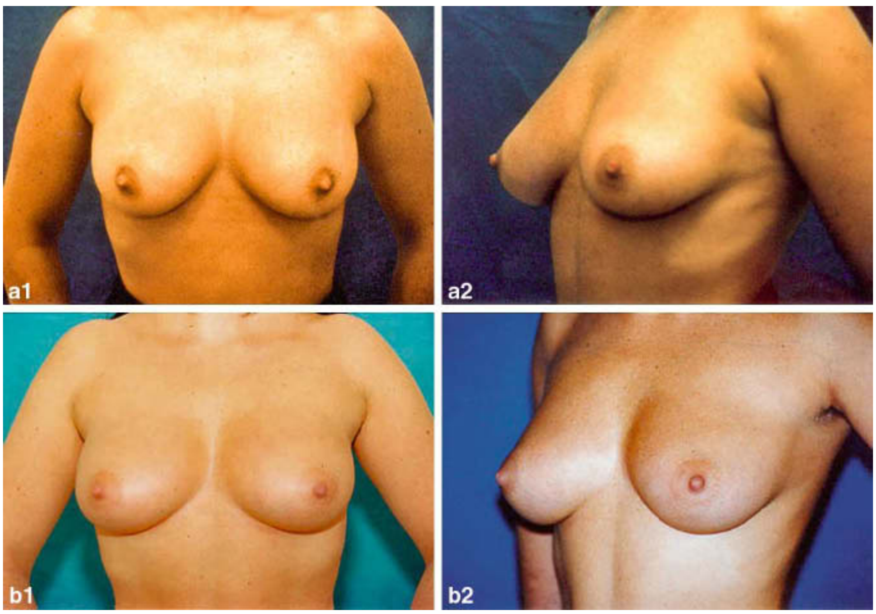

Fig. 62.7. a Preoperative photographs of a 29-year-old woman with moderate breast hypertrophy. **b** Postoperative views 6 months after UAL through a submammary incision removing 500 ml of fat per side

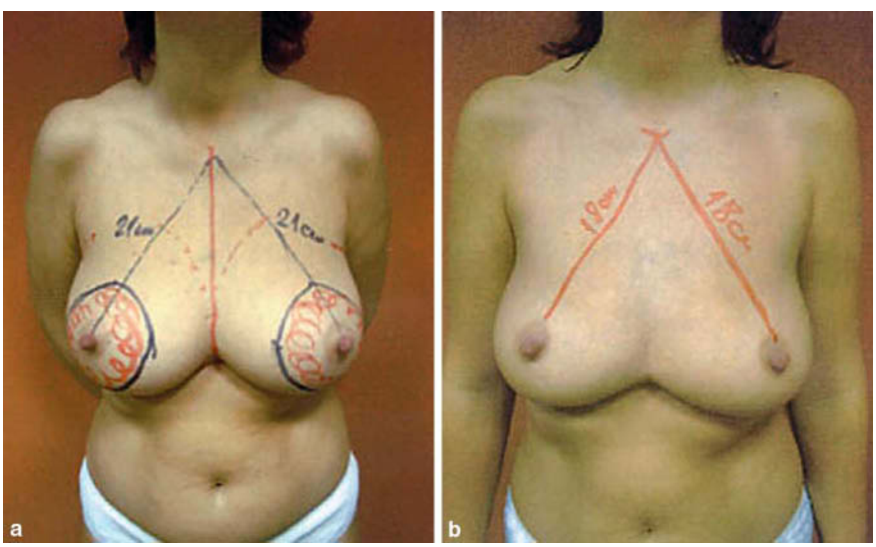

Fig. 62.8. a Preoperative breast hypertrophy and markings (*red areas* indicate fibrotic breast tissue not to be addressed. **b** One year postoperatively with nipples raised from 21 to 18 cm from the sternal notch

Table 62.1. Evaluation of breast procedures with ultrasound-assisted lipoplasty

Procedure (no. of patients)	No. of patients (%)	Reduction (ml)[a]	Total emulsified fat aspirated (ml)[b]
Breast reduction (92)	4 (4.4)	600	1,200
	10 (9.2)	200	300
	28 (30)	400	800
	50 (54)	300	500
Breast lift	9 (30)		500
	19 (70)		300

[a]Evaluated with breast sizers
[b]Emulsified analyses revealed that approximately 75% of aspirate was composed of fat, 5% was blood, and 20% was wetting solution.

Table 62.2. Preoperative and postoperative breast measurement

Unit	Preoperative	Postoperative
NM	19–28	18–24
NS	10–14	9–11
MSL	25–35	24–31
NSL	6–3	6–7

NM midclavicular notch to nipple, *NS* nipple to sternum, *MSL* midclavicular notch to submammary line, *NSL* nipple to submammary line

maximize the cavitation effect while minimizing the thermal effect) must be selected.

62.9.1 Skin Necrosis

A photograph of a case of necrosis was sent to me by a surgeon who used an incorrect technique (Fig. 62.9). After performing a standard breast-reduction procedure, the surgeon tried to further debulk the lateral and medial breast flaps by using ultrasound. No tumescent infiltration was administered before application of the ultrasound energy. The consequent skin necrosis and skin burns were the natural consequence of the failure to minimize the undesired thermal effect of ultrasound by infiltration of a wetting solution.

Fat necrosis with secondary tissue induration is a typical sequela of ultrasound surgery. When it is localized in small areas, such necrosis can be treated with massage or local infiltration of corticosteroids to soften the area.

62.9.2 Loss of Sensation

Loss of sensation is generally limited to the first 3 weeks after surgery. Recovery is rapid because the central cone of the breast is composed mainly of pure parenchyma and is not touched during surgery. Skin sensation is recovered in a few weeks' time.

62.9.3 Hematoma

Hematoma formation is another potential complication, though no cases occurred in this series. A photograph of a case of hematoma in a patient treated by another surgeon was sent to me (Fig. 62.10). This hematoma was localized in the subaxillary region, where the tumescent infiltration was initially administered. The surgeon who performed the operation revealed that the anesthesiologist, who regularly performed the tumescent anesthesia infiltration, incorrectly used standard sharp needles rather than blunt infiltration cannulas. The formation of the hematoma, which appeared immediately after the infiltration, was thus related to an incorrect tumescent infiltration technique and not to the breast reduction with UAL.

62.9.4 Mastitis

Mastitis, an inflammatory response of the breast parenchyma to surgery, occurred in a few patients early in the series. Once surgery was avoided for patients at or near their menstrual period, only a minor inflammatory response was noted. When encountered, mastitis rapidly subsided with immediate treatment consisting of oral anti-inflammatory drugs and wide-spectrum antibiotics for 3 days.

62.9.5 Seroma

Seroma formation is a potential complication of any breast surgery. Regular application of suction drainages and breast compression for several days with a

Fig. 62.10. Postoperative breast hematoma

Fig. 62.9. Skin necrosis of the breast medial flap. The surgeon performed a standard breast reduction and then attempted to debulk the medial flap without infiltration of tumescent solution. Skin necrosis resulted, with spontaneous healing after 3 weeks. (The patient was referred by another surgeon.)

brassiere and foam pads dramatically reduced the incidence of this complication.

62.10 Discussion

Ultrasound waves are the result of the transformation of normal electric energy into high-frequency energy [higher than 16 kHz (16,000 cycles/s)] by a high-powered ultrasound generator. The energy from the generator is transmitted to a piezoelectric quartz crystal or ceramic transducer and then transformed into mechanical vibrations that are amplified and transmitted.

As described by Loomis and then reported by Suslick [23], Fischer [24], and Fischer [25], the physical effects of ultrasound on biologic tissue include mechanical effects, thermal effects, and cavitation effects. Any device expressly developed for UAL should be able to enhance the cavitation effects while minimizing the mechanical and thermal effects.

Cavitation refers to the formation of partial vacuums in a liquid by high-frequency sound waves. In a living system, gases exist in solution in the form of microbubbles. At a certain frequency, ultrasound energy can cause expansion and compression cycles, with a progressive growth of the bubbles until a critical size has been obtained (stable cavitation). The oscillating bubbles can cause a secondary motion in the fluid of the medium, termed microstreaming. These two mechanisms (cavitation and microstreaming) can lead to a localized region or regions of very high shear and stress that are sufficient to break down subcellular structures. When adipose tissue is targeted, the application of ultrasound energy results in the progressive emulsification of fat [6].

The use of UAL in breast surgery is a relatively new technique. Lipoplasty was first used by several surgeons as an adjunctive procedure for breast reduction. Since the work of Illouz [26], Pitman [27], Lejour [13], and Lejour and Abboud [14], many authors have suggested that lipoplasty could have a significant role in breast contouring.

Zocchi [1–6] and Goes [7] started to use the ultrasound probe to dissolve and emulsify the fatty component of breast tissue. Later, other authors, including Toledo and Matsudo [28] and Grazer [29], reported aspiration of breast fat to reduce the volume. Becker [30] and Courtiss [31] reported a few cases in which volume reduction of the breast was accomplished with a sharp cannula to suction glandular as well as fatty tissue. Suctioning of glandular breast tissue, however, is quite another matter. Most investigators recommend the suctioning of only fat from the breast and the use of blunt, not sharp, cannulas, which do not penetrate the parenchyma [32].

Initially, lipoplasty of the breast was used as a temporary measure in juvenile fatty, hypertrophic breasts until breast growth was complete and a more definitive operative procedure could be performed. More frequently, lipoplasty has been performed to complete a standard open-surgery breast reduction to defat the axillary aspect of fatty breasts.

62.10.1 Selectivity and Specificity of Ultrasound

Large amounts of fat are often found in patients with breast hypertrophy, even among thin adolescents. Lejour and Abboud [14] emphasized that once the fat is removed by lipoplasty before breast reduction, the proportion of glandular tissue, connective tissue vessels, and nerves is increased.

These structures are important for maintaining vascularity, sensitivity, and lactation potential. Unlike fat, they are not likely to be affected by patient weight fluctuations. Lejour [13] affirmed that if the breasts contain substantial fat, weight loss may result in breast ptosis. The degree of recurrent ptosis can be minimized if lipoplasty is performed preoperatively to reduce the fatty component of the breasts. This observation anticipated the great potential of UAL for breast surgery.

The clear limits of standard lipoplasty with mechanical indiscriminate destruction of fat and surrounding elements followed by powerful aspiration of the destroyed tissue are particularly enhanced in breast surgery, where specialized structures (e.g., lactation ducts, vessels, sensitive nerves, elastic bounding structures of the subcutaneous tissue) have to be carefully preserved.

Because it is a selective technique, UAL may be applied in breast surgery to destroy and emulsify only the fatty component of the breast tissue without affecting the breast parenchyma for which the ultrasound energy has no specificity. The specificity of the technique is connected with the cavitation phenomenon and the efficiency of the system hinges on the type of titanium probe used and the energy level selected. Lejour [13] argued that the suctioning of breast fat also made the breast suppler and more pliable, which facilitated shaping, especially when the areola pedicle was long. This consideration is particularly important with fatty breasts, which have a less reliable blood supply. These benefits are significantly increased by the use of UAL because the specificity of this technique spares the vessel network.

The selectivity of UAL was demonstrated by Fischer [24], Fischer [25], and Palmieri [33] in their studies on the action of the ultrasound probe in rat mesenteric vessels. Later, Scheflan and Tazi [34] introduced endoscopic evaluation of UAL. They used a Stortz endoscopic system and camera (Stortz, Tuttlingen, Germany) to videotape the action of the titanium probe within the ultrasound device in the superficial layers of the subcutaneous fat, verified by needle depth, after standard infiltration with the tumescent technique.

UAL was performed with crisscross tunnels, and the procedure was recorded on videotape. An adjacent area was treated with standard lipoplasty. The technique was compared with standard lipoplasty, which was also endoscopically assisted and monitored. The authors found that standard lipoplasty appears to be the more aggressive technique, characterized by the mechanical destruction of the subcutaneous tissue, including vessels, nerves, and supporting structures, despite the use of 2–3-mm-wide blunt cannulas.

By contrast, UAL spared vessels, nerves, and elastic supporting fibers. Alterations in breast tissue resulting from the use of UAL were a thickened dermal undersurface, markedly thickened vertical collagenous fibers, intact lymphatic vessels, and intact blood vessels. The horizontal and vertical thickening and shortening of the collagen in the dermis and ligamentous fibers are responsible for the remarkable skin tightening that follows subcutaneous stimulation with the ultrasound probe. The closer to the skin and the more complete the removal of fat from the intermediate subdermal space, the greater the skin-tightening effect. This is of great value in breast surgery, where volume reduction has to be accomplished by skin redraping and recontouring of the breast shape.

As noted by Lejour [13], retraction of the skin after standard lipoplasty cannot be expected to be sufficient to produce a satisfactory breast shape. Subcutaneous aspiration must be extensive to obtain the necessary skin retraction, and the risk of localized skin necrosis resulting from excessive superficial liposuction cannot be ignored [30].

62.10.2 Calcifications

Lejour [13] and Lejour and Abboud [14] argued that the risk of postoperative fat necrosis or calcifications was the reason many surgeons avoided the use of lipoplasty in the breast. The main cause of fat necrosis is breast ischemia brought about by extensive dissection or mechanical direct damage, with resultant venous drainage. This phenomenon is typical in open breast surgery. Calcifications in breast-reduction surgery may derive from areas of fat necrosis or breast necrosis and subsequent scarring. Such calcifications are most often located at the incision lines (periareolar, or vertical scar in the inverted-T approach), where more tension is placed in approximating the lateral and medial flaps. However, when the tension is too high, areas of necrosis could arise from the approximating suture and later cause calcifications that are visible on mammography. However, the risk of such complications in UAL procedures is quite low.

Calcifications in breast parenchyma are to be expected after any mammoplasty procedure. In reduction mammoplasty, it is preferable that they be localized along the breast scars [35]. When lipoplasty is performed in addition to the mammoplasty procedure, benign macrocalcifications are slightly more numerous in the parenchyma than they are in breasts reduced without lipoplasty. This may occur because of the trauma caused by lipoplasty or because lipoplasty suction is applied to the most fatty breasts, which are more prone to liponecrosis [36]. However, 1 year after fatty-breast reduction with UAL, follow-up mammography revealed only a slight increase of small microcalcifications, similar to those found after other mammary procedures.

62.10.3 Potential Risks

In November 1998, a conference on UAL safety and effects was held in St. Louis, MO, USA, sponsored by the ASERF and the PSEF [37]. The panel was organized in response to an article by Topaz [37] that raised questions about the safety of UAL. Topaz speculated that thermal effects and the free radicals generated during UAL might result in neoplastic transformation and other long-term complications, as a consequence of the physical effect known as sonoluminescence. Those attending the conference represented multiple scientific disciplines, including plastic surgery, physics, lipid chemistry, cancer biology, and mechanical biophysics. The participants agreed that scientists did not yet understand the mechanism of UAL action, though multiple mechanisms were probably involved, such as mechanical forces, cavitation, and thermal effects.

Additional research has revealed that long-term complications or negative bioeffects (including DNA damage and oxidation-free radical attack) are probably not serious safety concerns for UAL.

With reference to the application of UAL to breast surgery, we investigated the histology of the breast fat tissue before and after UAL breast surgery (with serial biopsies at 6 months and 1 year after surgery) and the mammographic appearance of the breast before and 1, 2, and 3 years after surgery, particularly with respect to calcification. The results were evaluated by a senologist not directly involved with the clinical research [38]. Histologic studies revealed an increased fibrotic response to thermal insult, with a prevalence of fatty scar tissue, in all specimens evaluated.

Mammography showed a significant increase in breast parenchymal fibrosis, with a denser consistency and thicker breast trabeculae that were constant over time. The calcifications that appeared were benign and were typically small, round, less numerous, and more regular than those characteristic of malignancy. Comparison of the mammographic results typical of a standard breast reduction and those typical of breast reduction with UAL showed that microcalcifications are less likely to develop with UAL.

It is likely that scar tissue caused by breast reduction with electrocautery or by necrosis resulting from the tension of internal sutures may more frequently cause calcifications or irregular mammographic aspects of the operated parenchyma. Particularly, in standard breast-reduction surgery, they can appear at the areola line and at the site of the vertical scar.

From a mammographic viewpoint, the typical appearance of a breast reduction with UAL demonstrates predictably less scarring and fewer calcifications than occur in the standard open technique. Courtiss [31] reported similar mammographic evidence in a denser breast after breast reduction by lipoplasty alone. No malignancies were reported.

The question of whether potential lactation is affected by UAL remains unanswered. The technique was used for breast reduction and mastopexy in younger and older patients. In the younger group, 16 patients breast-fed their babies regularly. The other 14 patients were lost to follow-up. However, none of these patients or their gynecologists reported any problems to the surgeon or the hospital, and no complications have been reported by other surgeons around the world who use this technique.

62.11 Conclusions

The use of UAL for reduction of fatty breasts and mastopexy is effective and safe when applied in selected patients and performed by a surgeon with expertise in ultrasound-assisted body contouring. The selectivity of UAL enables emulsification of the fatty component of the breast parenchyma while sparing the glandular tissue and vascular network. Furthermore, long-term mammographic studies have revealed no alteration of morphology of the breast parenchyma resulting from this technique. The typical mammographic appearance of breast tissue after UAL is a denser breast.

Acknowledgement. Portions of this work are reprinted from Ref. [39] with permission from the *International Journal of Cosmetic Surgery and Aesthetic Dermatology*, Mary Ann Liebert, Inc.

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Large-Volume Liposuction for Obesity

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63.1 Introduction and General Concepts

Liposuction surgery has generally been divided into volume liposuction and liposculpture [1]. In the former, large volumes of fat are aspirated in order to substantially improve the shape and contour of the body. This is a form of surgery directed towards the control of aesthetics and health in general and it can even be used in cases of true obesity. In liposculpture, small fat deposits are aspirated with the sole purpose of giving the body a better shape. This surgery is basically practiced for aesthetic reasons. However, a new technique has been developed in which large volumes of fat are aspirated and body contour is improved at the same time. Attention is paid to detail, especially in the flanks, back, waist, and hips [1].

The word sculpture come from the Latin *sculpere*, meaning to carve or scratch. It is a variant of *scalpere*, from which the English word scalpel is derived. Its past participle, *sculptus*, and the noun *sculptura* are other variants from which the word sculpture gets its origin [2].

The traditional volume liposuction implies performing large aspirations from specific sites of the body [3]. The authors' goal is to perform liposuction surgery for the whole body. In other words, the surgery is performed in different parts of the body at the same time. This is a combination of volume liposuction and liposculpture called volume liposculpture [1] (Table 63.1).

Because of cultural, social, and ethnic reasons, most of the patients operated on are overweight.

Table 63.1. Volume liposculpture emphasizes body contouring: abdomen, waist, and hips

The three types of liposuction
Volume liposuction
Liposculpture
Volume liposculpture[a]

[a] A combination of volume liposuction and liposculpture

63.2 The Evolution of Liposculpture

In 1921, Dujarrier, a French surgeon, tried to remove adipose tissue from knees and ankles of a ballerina with a uterine curette. Severe complications resulted and the leg had to be amputated. The procedure was forgotten until the German surgeon Schrudde [4], in 1964, attempted to remove fat from the lower extremities and later on from other parts of the body using a curette. He named this procedure lipoexheresis. It had the frequent complication of seroma formation, which he partially solved utilizing prolonged drainage.

In the mid-1970s, Giorgio Fischer and his father Arpad Fischer, in Rome, began experimenting with a suction instrument, the cellusuctiotome [5]. In 1977, Giorgio Fischer went to Paris to demonstrate liposculpture on a patient of Pierre Fournier's at the Clinique La Mouette. The French magazine *Paris Match* published an article on the procedure of liposculpture carried out with Fournier. This fact increased the popularity of liposculpture [4]. Fournier promoted the concept of crisscross tunneling to minimize surface irregularities, as well as liposuction through the use of a syringe.

The involvement of dermatologic surgeons in liposculpture began in 1977, when Lawrence Fields, a dermatologist form California, visited Paris and observed cases of liposuction [6]. In 1982, otolaryngology-based cosmetic surgeons led by Julius Newman joined with several dermatologic surgeons to form the American Society of Liposuction Surgery and live education courses in liposuction began in Los Angeles in June 1983 [7]. Stegman and Tromovitch [5] made the first presentation on liposuction at the American Academy of Dermatology in 1983.

The most important advancement to perform liposuction in a safer manner was developed by Jeffrey Klein in 1986. As a pharmacologist and dermatologic surgeon, he introduced the tumescent technique with a very dilute local anesthetic mixture that could be used in large volumes and achieved excellent anesthesia without the need for general anesthetics [5].

Finally, the concept of megaliposculpture (*megalipoplastie*) was developed by Fournier [8]. In this area, as Fischer says "Fournier is a real pioneer" [4] and also we can add "a generous teacher."

63.3 Development, Structure and Biochemistry of Fat

63.3.1 Development and Structure

The subcutaneous adipose tissue develops from specific reticulo-endothelial structures known as primitive organs appearing in the subcutis during the third or fourth fetal month [9]. It originates in the subdermal perivascular connective tissue from the adipoblasts which develop into preadipocytes. The preadipocytes convert into mature fat cells by accumulating triglycerides.

Adipocytes grouped in an organized manner form a lobule having its own blood supply with a central artery feeding a capillary network surrounding every fat cell. These lobules are separated by fibrous septa which, when organized in a large number, form what is known as adipose tissue. This represents 20% of the total body weight.

Subcutaneous tissue receives its vascularization from the fascial network, which form a subdermal plexus. From there, branches arise to form a subpapillary plexus, which is the origin of the papillary loops. The fat lobules receive their blood supply from the descending branches of the subdermal plexus. Where the adipose tissue is thick (more than 10 mm), it receives its blood supply both from the descending branches of the subdermal plexus, which feed the upper layer of fat, and from the ascending fascial arteries, which feed the lower layer [9]. When adipose tissue achieves a certain thickness, the descending and the ascending vessels meet at a level where a third subcutaneous vascular plexus is formed. A septum is not unusual at this level creating two relative separate layers of subcutaneous fat [9]. The number of fat cells and consequently lobules increase until late puberty to adolescence (see later). This process takes place in a phasic manner, reaching its peak in late childhood. Recent evidence points to the existence of adipocyte precursor cells in adults [9]. New adipocytes are formed with large weight gains to store excess lipids. This is stimulated by the growth of existing fat cells to a critical size. The initial phase is termed hypertrophic fat deposition. Once cells have reached a critical size, the formation of new adipocytes is termed hyperplastic fat deposition [9]. The lipid content of the cells can be decreased by dieting, but cells cannot be eliminated. This is termed the "rachet effect" [9]. This theory could explain the gradual increased deposition of fat in localized areas. Race, gender, and heredity could determine exact distribution of excess fat [9].

63.3.2 Fat Biochemistry and Adipose Tissue Metabolism

Fifty percent of the daily metabolic energy requirements come from fat metabolism [10]. There are two metabolic functions of adipose tissue. First, it provides storage of triacylglycerol (formerly called triglyceride) as a long-term energy reserve and, second, it has a very dynamic pattern of metabolism, which responds on a minute-to-minute basis to the energy requirements by modulating the supply of lipid energy released to the rest of the body in the form of non-esterified fatty acids.

Pure carbohydrate or protein liberates 16–17 kJ/g (about 4 kcal/g), while pure triacylglycerol liberates around 36 kJ/g (9 kcal/g). Of course, the body cannot store pure triacylglycerol without some associated cellular structure, and that is why the adipose tissue has evolved to fill this lipid-storage role [11]. Therefore, the primary function of the adipose cell is the storage and release of energy. Fat is stored as triglyceride, is deposited in the adipocyte by lipoprotein lipase (lipogenesis), and is released by hormone-sensitive lipase (lipolysis). Glucose from the blood vessels is converted into α-glycerolphosphate, which forms triglycerides utilizing free fatty acids in the fat cells. The free fatty acids reach the fat cells by the action of lipoprotein lipase on triglycerides in the blood vessels, which form free fatty acids and glycerol. Free fatty acids are utilized in the formation of triglycerides in the fat cells, where they are interconvertable with the triglycerides. The free fatty acids from the fat cells reach the blood vessels, where they are carried by albumin. Glycerol from the fat cells and released from the triglycerides by the action of lipoprotein lipase reaches the blood vessels, where it combines with the free fatty acids to form triglycerides.

Over a 2–3-week period, all of the stored triglycerides in an adipose cell are turned over, that is, catabolized for energy production or broken down into free fatty acids to be reformed into new triglyceride molecules [10]. In association with its function in energy production and release, the adipocyte participates in insulin regulation and glucose metabolism [11]. The liver is the second primary organ of fat metabolism. It can metabolize fatty acids for energy production, synthesize triglyceride from carbohydrates and to a lesser extent from proteins, and esterify fatty acids to form other lipid compounds such as triglycerides and phospholipids. After carbohydrate intake, the amount in excess of that used for energy or stored as glycogen is converted by the liver into triglycerides, which are then stored in the adipocytes [12]. Exogenous dietary fats are hydrolyzed in the gut and then packed into chylomicrons by the intestinal cells, which are finally released into the lymphatics and the blood stream. Endogenous fatty acids are synthesized by the liver from carbohydrates and to a lesser extent from proteins. These fatty acids are then metabolized into triglycerides, packed as the very low density lipoproteins and released into the circulation [12].

Lipolysis is under the influence of hormone-sensitive lipase. It can be activated by epinephrine, norepinephrine, corticotropin, glucocorticoids, growth hormone, thyroid hormone, and decrease in plasma insulin. Regarding lipogenesis, the action of lipoprotein lipase is the rate-limiting step that mediates the uptake of free fatty acids into the adipocyte. An integral part of the formation of triglycerides is the formation of α-glycerolphosphate in the fat cells. Glucose transport is facilitated by insulin receptors on adipocytes [12].

Finally, there are some mediators of fat metabolism. In fact, insulin and catecholamines are the most important. Catecholamines primarily stimulate lipolysis. β-adrenergic receptors promote lipolysis and predominate over α-adrenergic receptors, which promote lipogenesis. α-adrenergic receptors predominate in certain abnormal metabolic states such as fasting, diabetes mellitus, hypothyroidism, and possibly pregnancy, all of which are associated with greater fat deposition. Other mediators of lipolysis include adrenocorticotropic hormone, thyroid-stimulating hormone, growth hormone, and vasopressin [12]. Insulin promotes lipogenesis by activation of lipoprotein lipase. Obese patients exhibit insulin resistance and glucose intolerance, however, other insulin-mediated pathways of glucose metabolism persist, such as hepatic conversion of glucose to triglycerides for fat storage. Thus, glucose ingestion in obesity leads to increased fat stores and a vicious cycle is initiated [12].

63.4 Obesity

Obesity is defined as body weight 20% or more above the normal. Obesity has been subclassified into hyperplastic (referring to increased fat cell number) or hypertrophic (referring to increased fat cell size). Childhood onset obesity is hyperplastic, whereas adult-onset obesity is characterized by hypertrophic changes.

An exception is the morbidly obese adult, defined as being greater than twice the normal weight, in whom hyperplastic as well as the expected hypertrophic changes are demonstrated. In this situation, adipocytes reach a maximum size and when no further increase is possible a message is sent to the adipoblast/preadipocyte pool for recruitment of new cells [13].

63.4.1 Regional Fat Distribution by Gender and Race

There are some gender differences in fat distribution. The male or android distribution is characterized by subcutaneous fat deposition in the upper body as well as by central visceral fat deposits [13]; thus, the typical adult man has disproportionate fat deposits in the subcutis of the abdomen, the waist, the shoulders, and nape of the neck. These deposits are associated with androgen receptors on adipocytes. The female or gynecoid distribution refers to fat accumulation in peripheral stores, specifically those below the waist, like the femoral and gluteal areas. These deposits are associated with estrogen receptors on adipocytes [12, 13]. Peripheral fat deposits, characteristic of women, tend to be fixed and become active during lactation and pregnancy. Truncal deposits (android shape) are more metabolically active, change with dietary habits and correlate with disease risk. With fasting, in the first week, lipolytic activity appears centrally but not in peripheral stores. Paradoxically, these peripheral stores in obese and non-obese women increase in the face of diminished food supply. These peripheral deposits of fat are not significantly affected by diet restriction [1].

Finally, there exist ethnic differences in the shape of the body. In Latin American women the fat distribution occurs predominantly in buttocks and thighs, but in others fat is seen mostly on the shoulders.

63.4.2 Health Implications of Regional Obesity

Abdominal obesity is a strong risk factor for the development of diabetes mellitus [14, 15], hypertension [16–18], and possibly some female cancers (endometrial, ovarian) [16, 17]. A measure of the relationship between central and peripheral obesity was developed and compares the circumference of the abdomen to that of the hips. This waist–hip ratio (WHR) has been shown to be a predictor for those health risk factors related to central obesity [19, 20]. The WHR very accurately predicts intra-abdominal adipose collections [21]. However, simplest by far, measurement of the degree of obesity is calculated through the traditional height and weight measurements, that is to say the body mass index (BMI). The BMI represents a concise, objective, mathematical formula and pivotal to the BMI concept is that the body surface is directly proportional to height squared and body surface area essentially is independent of weight. In plain words, the BMI normalizes body weight per unit surface area, that is, weight divided by squared height (w/h^2) in metric units of kilograms and meters.

This estimation requires only a hand calculator to divide the patient's weight in kilograms by the height in meters, then dividing the result by height again, to yield the BMI (ordinarily rounded to one decimal place precision) in units of kilograms per square meter. Using the BMI, the surgeon is able to objectively classify a patient's obesity as one of the following:

1. Class I: Lean range (18.5–19.9)
2. Class II: Optimal (normal) (20–25)
3. Class III: Overweight range (25.1–29.9)
4. Class IV: Obese range (30–34.9)
5. Class V: Morbidly obese range (35–39.9)
6. Class VI: Extremely obese (40 or greater)

BMI is gender-independent in adults and is as applicable to women as it is to men. Finally, and very important, BMI is an estimator of sedative or anesthetic risk. Morbid obesity (BMI>35) imparts a threefold to fourfold greater risk of respiratory depression from sedative drugs, perhaps because sleep apnea is several-fold more common in that group. Determination of the BMI should be made as a routine part of the preoperative record like blood pressure or hemoglobin content [22].

The visceral fat cells are hypothetically of particular importance because of their relationship to the portal circulation. The breakdown products of lipolysis from these adipocytes drain directly into the portal circulation and can expose the liver to high concentrations of free fatty acids; these, in turn, can cause hypertriglyceridemia [16]. Obesity also plays a major role in the development of insulin resistance and impaired glucose tolerance, which are the likely precursors of type 2 diabetes [23]. Insulin resistance also seems to be a part of a cardiac dysmetabolic syndrome which includes hypertension, dyslipidemia, obesity, impaired glucose tolerance or diabetes, and macrovascular arterial disease resulting in atherosclerotic cardiovascular and peripheral disease [24]. Hyperinsulinemia has been shown to promote arterial smooth muscle cell proliferation in vitro [25].

Arora [26] has shown that patients with diabetes and deficient glucose tolerance and even first-degree relatives of diabetic patients have impaired vasoreactivity and endothelial dysfunction. This is thought to be a result of hyperinsulinemia or insulin resistance.

63.5 Impact of Liposuction on General Health Risks

The scope of liposuction has progressed from a small amount of regional fat removal to circumferential body contouring with increased safety. A significant evacuation of subcutaneous fat by large-volume liposuction creates marked changes in body composition by rapidly decreasing the amount of subcutaneous adipose tissue. There has been concern that removal of subcutaneous adipose tissue by liposuction may result in a redistribution of fat with an increased deposition of intra-abdominal fat cells [27], which, in turn, could potentially increase health and specifically cardiovascular risk factors; however, these are hypothetical considerations only.

There is a very good body of evidence demonstrating the health benefit effects of liposuction. In fact, the future derivations of these studies in the long-term follow-up of patients with metabolically different health problems seem to be promising.

The correction of the abnormal level of serum lipids after liposuction was demonstrated in one study [28]. The patients showed improvement in cholesterol, low density lipoproteins, and triglycerides 4–12 months postoperatively. The conclusion was that reducing the large amount of adiposity by liposuction in patients with elevated serum lipid values may be a factor regarding circulating lipids through the equilibrium of adiposity, circulating lipids, and fat metabolism.

In another study, by Giese et al. [29], 14 overweight and obese but otherwise healthy premenopausal women with a mean BMI of greater than 27 kg/m^2 underwent large-volume liposuction, achieving a mean weight, a BMI and fat reduction of 6.5 kg, 2 kg/m^2 and 17%, respectively, by 4 months after surgery. An additional benefit was a reduction in fat content in the non-suctioned areas of the body, such as the arms. There was also a significant reduction in the mean fasting plasma insulin level by nearly 50%. More importantly, patients who had higher preoperative fasting insulin levels had a more marked reduction in that parameter, at both 6 weeks and 4 months after surgery. Insulin resistance also declined dramatically by 4 months. Finally, there was also a significant decrease in systolic blood pressure. The authors found that liposuction positively impacts some vital cardiovascular risk factors such as obesity, systolic blood pressure, and high plasma insulin levels. This beneficial effect might translate into reduced cardiovascular morbidity and mortality in these patients. If insulin levels can be brought down by liposuction of the subcutaneous fat in these patients, one might be able to prevent significant cardiovascular morbidity and mortality with the procedure by preventing or slowing the development of atherosclerosis. As Arora [26] concludes, "to go one step further, one might even be able to prevent the development or delay the development of diabetes in the patient population."

Nowadays, in our talks concerning liposuction we use the statement, "At this time liposuction is performed not only for aesthetic reasons, but also for general health purposes."

63.6 Technique

63.6.1 Preoperative Preparation

The authors prefer to work only with patients classified as ASA I and II. Irrespective of the age, all patients are sent to the cardiologist for a complete cardiac and vascular checkup and hematological studies are carried out which include fasting blood sugar and HIV tests. An abdominal ultrasound/computed tomography scan is carried out in cases of suspected visceromegaly or mass in the abdomen. A careful check of hernial orifices is carried out and any suspected hernias are carefully excluded. Diabetes is not a contraindication for liposuction as is generally speculated. With careful control of the blood sugar using insulin/oral antidiabetic agents, light sedation, and medium to large liposuctions in one sitting, these patients do well. With careful control of the blood pressure, hypertension is also not a contraindication for medium to large liposuction. Generally, both of these parameters improve with liposuction. Careful assessment and written agreement by the endocrinologist/cardiologist is needed. It is convenient to stress the importance of the careful sterilization of all the instruments (autoclave or gas, and not antiseptic solutions).

Unnecessary medications are specifically prohibited, mostly aspirin, beta blockers, estrogens, vitamins, and the so-called herbal drugs 10 days before surgery. Three days prior to surgery, the patient uses an antiseptic soap containing povidone-iodine or chlorhexidine. One day before surgery, a prophylactic antibiotic is given (cefadroxil), and this continues for 3 days after surgery. One hour prior to the surgical procedure, all the patients receive 150 mg, one tablespoonful, of oral ranitidine, 10 mg metoclopramide, and 0.1 mg clonidine. Clonmidine is used only if the blood pressure is not less than 90/60 mmHg and the pulse rate is not less than 60 bpm. Preoperative marking of the operative areas that include important blood vessels in the groin are carried out in the operating room with the patient standing up.

All patients sign an informed written consent form. Immediately before surgery all are weighed in kilograms and measured in centimeters. Careful circumferential measurements (in centimeters) of the areas to be operated upon are performed. This is usually repeated after 1 month. Pulse and blood pressure are carefully determined.

63.6.2 Anesthesia and Sedation

Regardless of the volume to be aspirated, all cases are handled on an outpatient basis. Intravenous sedation/analgesia is performed by a certified anesthesiologist in a fully equipped operating room. The drugs combined to obtain this sedation/analgesia are mostly midazolam and fentanyl. The total dose of midazolam varies from 15 to 20 mg (0.3 mg/kg). The total dose of fentanyl fluctuates from 300 to 500 µg (5–10 µg/kg). If adequate sedation is not reached, propofol is added as a continuous infusion up to a total of 100–200 µg/kg/min or a maximum of 4 mg/kg/h. Only rarely is there need to add small doses of ketamine.

These drugs are short-acting; therefore, there is no risk for the patient who is being carefully monitored (non-invasive pulse oxymetry, blood pressure, pulse rate, temperature, EKG in three derivations). Parenteral fluid replacement is hardly necessary and Ringer's solution is infused only to allow the administration of sedatives and in order to have an intravenous line [1].

Concerning local anesthesia, a minor modification of the classic formula developed by Klein [30–35] is utilized. Our local anesthesia consists only of 0.05% lidocaine plus $1{:}1\times10^6$ epinephrine in saline solution. Some authors suggest using different concentrations of lidocaine depending on the area to be worked on [32]. According to those authors, higher concentrations may be necessary in places that are recognized for special sensitivity, such as the periumbilical and trochanteric areas.

The authors use the same concentration in all the areas. In the more sensitive ones larger volumes of the solution are tried. The procedure is well tolerated with minimal discomfort in some sites where it is transitory, of low intensity, and can be controlled by the analgesics and sedatives. The use of various concentrations could possibly result in a mistake or confusion in the dose and possible toxicity. Corticosteroids and sodium bicarbonate are not used in the solutions. The steroid is given intravenously. There exists the possibility that sodium bicarbonate can increase and prolong the inflammation, as well as shorten the duration of anesthesia. Under intravenous sedation the patients do not experience any conscious pain when the local anesthesia is administered [1, 33].

63.6.3 Total Injected Volume

There are two fundamental principles of the tumescent technique: (1) use of the Klein formula (highly diluted lidocaine and epinephrine), and (2) injection in large volumes until true tumescence is reached (swollen and firm tissue hard as wood or rock). Only in this manner can profound, enduring anesthesia, and vasoconstriction be obtained. Some surgeons do not understand this. The injection of modest amounts of Klein's solution is nothing more than a wet method. What then should be understood by large volume? It is the volume necessary to cause tumescence. The volumes injected and aspirated are barely the same (1:1 ratio approximately). If aspiration of 3, 6, or 8 l of fat is planned, the injection should be 3, 6, or 8 l of Klein's solution, respectively (Table 63.2). The surgeon's left hand should determine the necessary stiffness or firmness (the true tumescence). Although greater volumes have been injected without evidence of toxicity, owing to the principal concern for patient safety, the authors prefer to stay below a ceiling of 55 mg/kg body weight range in relation to lidocaine, which has already been extensively tested [33].

Traditionally, the maximum safe dose of lidocaine is 7 mg/kg body weight, which we call one San Salvador unit (1 SSU) [36]. Based upon this figure, the total amount of Klein's solution to be infused can be estimated (Table 63.3). Even though the injected and aspirated volumes should ideally be the same, we generally bypass this rule by injecting somewhat more and aspirating somewhat less. If the tumescent preparation is good ("the real tumescence has to be seen and felt" [33]), the fat aspiration will be simple, safe, and without ecchymoses in the postoperative period. In any case, since large-volume infiltration is used, it is safer to inject by sections, even if it means the duration of the procedure is prolonged. In this way a specific area is injected and extracted and then the next area is treated. Under intravenous sedation, it is not necessary to use warmed local anesthetic solution [12]. Chilled (cryoanesthesia) solutions are used to increase the vasoconstrictive effect [1]. To maintain the safety of the procedure, the body temperature is continuously checked by non-invasive monitoring. The authors try to avoid complications by setting reasonable limits and taking into consideration the fact that we are dealing with ambulatory patients.

Table 63.2. The amount of aspirated fat is almost the same as the amount of Klein's solution injected

Injected/aspirated	Minimum	Average	Maximum
Klein's solution	250	4,500	11,600
Aspirated fat	400	4,500	13,400
From 220 cases			

Table 63.3. Estimation of the total amount of Klein's solution to be injected is generally easy when using this method. Correlation of body weight, San Salvador units (*SSU*) and volume to be infiltrated

Body weight (kg)	Milligrams per SSU	volume (l)[b] Total
70	490	7.5
80	560	9
90	630	9
100	700	10.5
130	910	12.5
150	1,050	15

To get the central column, multiply the left figure by 7; this will give a number in SSU. For example, 70×7=490. Then, approximate this to the nearest figure, i.e., 490=5. For the right column, always multiply by 1.5 (a constant). This will give 55 mg/kg/body weight. This is an upper limit. Try to be always below it.

[b] Volume of Klein's solution

General versus local anesthesia plus intravenous sedation: In the past, local anesthesia was reserved for the treatment of small and localized fat deposits in liposuction surgery. Now, using careful intravenous sedation, and the true tumescent method, current liposuction procedures, regardless of the volume extracted, can be carried out under local anesthesia. If the intravenous sedation is administered by a certified anesthesiologist, there is no reason for the patient to experience any pain or discomfort during the administration of anesthesia or during the procedure itself. Any surgicenter should be properly equipped to handle any emergency.

Aspiration volumes: Previously, the most important limiting factor in the extraction of large volumes of fat was the degree of blood loss. Using the true tumescent method, blood loss is less than 1% of the total extracted volume. Major aspirations of 8–10 l imply a blood loss of no more than 80–100 ml, which in no way compromises the patient's safety. Strict application of the current technique allows us to carry out large liposuction procedures at ambulatory facilities with no risk.

What do we understand by large liposuctions?: Until recently, 2,500 ml was considered a safe and reasonable upper limit. Technical innovations have also modified our concepts. The authors consider a liposuction to be "large" when it is over 4,000 ml. In general, we try not to extract over 10,000 ml per session. Although it is still very safe for patients over this limit (with minimum blood loss and normal vital signs), the duration of the procedure is prolonged, which involves fatigue for both the patient and the surgeon.

While performing large liposuctions, the anesthetic solution is injected simultaneously with two infusors, and the extraction procedure is performed using two suction machines at the same time through small incisions (Fig. 63.1). If extraction over 10 l is considered, it is preferred to do the liposuction in two sessions. Since the blood loss is minimal, the surgical trauma

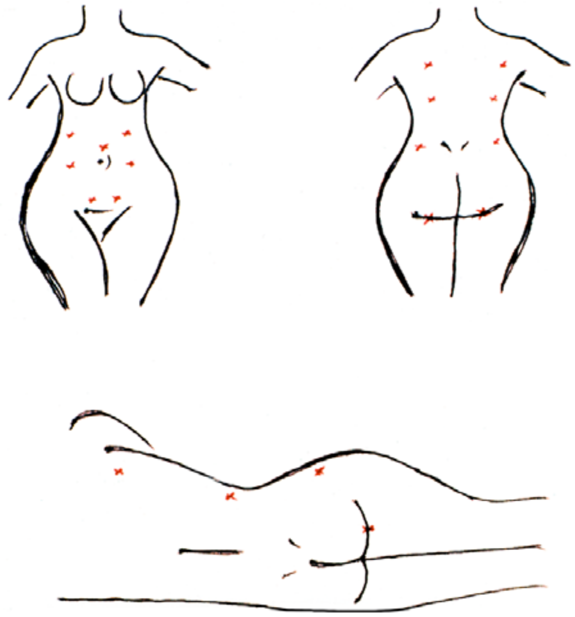

Fig. 63.1. The incisions must be very small and easy to camouflage

is low, and the drugs used as sedatives and analgesics are quickly metabolized, the second procedure can be done 1–2 weeks later. In some cases, 17 l of fat has been extracted in two sessions, with only a 10-day interval. In other instances, up to 26 l of fat has been extracted in three sessions with a 2-week interval between each session. In these cases, there was excellent recovery. Sometimes, for foreign patients, three sessions in 1 week have been scheduled (Wednesday, Saturday, and Wednesday liposuctions). In this way, if a patient comes from outside of our country and needs to return very quickly, as much as 24 l of fat is aspirated in three sessions, 8 l each time. No problems have occurred using this regimen.

The most important advantage of tumescent local anesthesia is to eliminate the risk of general anesthesia and the massive bleeding that was associated, in the early days, with liposuction [33]. The pharmaceutical principles of tumescent anesthesia are (1) more diluted lidocaine is safer, (2) a large volume of anesthetic solution is infiltrated better, and diffusion and a uniform anesthetic effect is obtained, and (3) because of the great liposolubility of lidocaine, the relative avascularity of fat, and the vasoconstriction induced by epinephrine, there is slow absorption of the anesthetic and very late plasma peak levels [34]. It has been demonstrated that the maximum peak levels of lidocaine are reached 14 h after the infiltration but always in a safe range (1.2 µg/ml) [35].

It is necessary to know the drugs interacting with lidocaine, because they inhibit cytochrome P450 3A4 in the liver, which metabolizes 70% of the lidocaine that enters the hepatic circulation. The commonest interacting drugs are terfenadine, astemizole, cisapride, ketoconazole, itraconazole, erythromycin, clarithromycin, and some dietary factors like grape fruit juice that can also inhibit cytochrome P450 3A4 [37].

63.6.4 Transoperative and Postoperative Facts

A strict sterile operating room technique is followed. Each surgeon and the assistants use povidone-iodine for 10 min for scrubbing the hands and forearms up to the elbows, following a double brush technique. Disposable sterile surgical gowns are worn during the procedure. Double cleaning of the operative area and well beyond is carried out with povidone-iodine. Excess povidone-iodine is wiped away with sterile roller towels, which are discarded.

Incisions are small, no more than 2 mm, and do not need suturing at the end. It is good to remember the saying, “In cases of liposuction, entry points are small, but the wound is large.” The approach is essential to get nicer results with almost imperceptible scars or no scars at all.

Generally, abdominal and hip liposuctions are started with a 4-mm Keel Cobra tip cannula and final touchups are carried out with a 2–3-mm Keel Cobra tip or lightweight French cannulas [38]. Handling of the tissues is gentle at all times during the procedure. Both hands are used for the procedure, the working hand and the brain hand. While the working hand performs the liposuction, the brain hand feels the tip of the cannula and molds the tissues for the proper functioning of the working hand. When the working hand is tired, the brain hand becomes the working hand and vice versa. In this way, the procedure becomes less tiring. The base of the cannulas are always protected by a padded gauze to avoid trauma to the lips of the entry points during the procedure. The assistant surgeon or the nurse takes care to protect the skin with the gauze. This is the method that better protects the lips of the small incisions.

Liposuction of the periumbilical and trochanteric areas is performed at the end and generally more tumescent infiltration is used here, rather than a higher concentration of Klein’s solution, in view of the higher sensitivity of these areas. For the hips, only deep liposuction is performed [38]. In the hip and thigh areas, feathering is carried out at the end. Cannula strokes without suctioning are used well beyond the operative area in a radial manner. Both of these maneuvers are helpful in preventing irregularities in the hip and thigh areas.

In the tough upper back, first deep liposuction is used and then relatively superficial liposuction. The area of the lower abdomen is generally more sensitive to pressure and avascular necrosis. Very superficial liposuction is avoided in this area.

Assistants use roller towels to gently remove the remaining saline solution and broken down fat cells from the entry points in the end. Sutures are not applied to the entry points. This allows for easy dripping of the fluids. Sterile padded dressing is applied with Micropore tape. On top of this, French tape is applied in the form of an X (the first application) and later horizontally (the rest of the abdomen) followed by pressure garments when finishing (Fig. 63.2).

At the end of surgery, the patients remain 1–2 h more before returning home by their own means, following the criteria of Aldrete. However, the authors always insist that the patients must be accompanied by some other person (friend or relative). The French tape and gauzes are removed on the second postoperative day. This makes lymphatic drainage easier and promotes, at the same time, a quicker reduction of inflammation. Pressure garments are removed on the seventh day, but the patients are allowed to use them 12 h a day for 1 week more. Moderate physical activity is begun on the second day, and heavy physical activity (including gym, jogging, and all sorts of extreme physical exercise) is strongly recommended starting at the second week.

To improve the body contour further, and to provoke quicker reduction of inflammation, external ultrasound is used starting the next week after the surgery. Transoperative ultrasound is time-consuming and does not add anything to a well-done tumescent liposuction [39]. The new costly reciprocating cannulas have not been found to be of additional advantage as compared with the conventional cannulas.

The most transcendental advancement in the field of liposuction is tumescence, and its impact continues to be enormous [30–35].

Fig. 63.2. French tape is applied on the top of a sterile padded dressing

63.7 Statistics in Our Surgicenter

We reviewed our cases of liposuctions performed between May 1997 and June 1998. Volume liposculpture was performed on 220 patients. Fat was extracted from 815 different areas during this period [1]. The parts of the body most worked on were the upper and lower abdomen, flanks, hips, waist, back, and trochanteric regions. (Figs. 63.3, 63.4)

The oldest patient was 74 years old and the youngest 16 years old, and the average age of the patients was 43 years. There were 190 women (86%) and 30 men (14%). The minimum operating time was 1 h with a maximum of 6 h, and an average of 3 h 18 min.

The volume of Klein's solution infiltrated varied between a minimum of 2,500 ml and a maximum of 11,600 ml, with an average of 4,500 ml. The total supranatant fat extracted fluctuated between 1,400 ml and 13,400 ml with an average of 4,500 ml. Volume liposculpture was small (less than 2 l) in 12% of the cases, medium (2–4 l) in 34% of the cases, large (4–10 l) in 48% of the cases, and mega (more than 10 l) in 6% of the cases (Table 63.4, Figs. 63.5–63.13).

Major complications were not observed in any of the cases. Minor irregularities occurred in 10% of the cases and only 5% of the cases required a touch-up procedure. Seventy percent of the large and mega cases showed variable degrees of postinflammatory pigmentation, which lasted from 1–3 months. This situation is probably related to the skin type of the patients (Hispanics). Treatment consisted of emollient creams and local tretinoin, as well as time and avoidance of sun exposure and rubbing. The authors' figures and the types of complications strongly contrast with those reported by others [40–45].

63.8 Final Considerations

Ninety-seven million Americans (nearly 55% of the adult US population) are obese (BMI more than 30) and/or overweight (BMI between 25 and 30) [22]. As

Table 63.4. Most of the liposuctions in the Center for Dermatology and Cosmetic Surgery are large. The time spent in the procedure may be long

Type	Volume (l)	Percentage	Operating time
Small	<2	12	Minimum 1.00 h
Medium	2–4	34	Average 3.18 h
Large	4–10	48	Maximum 6.00 h
Mega	>10	6	

From 220 cases

the prevalence of obesity continues to increase, so do the accompanying risks to health and lifespan from hypertension, diabetes, coronary artery disease, and increased surgical morbidity and mortality [22].

Large-volume liposculpture can be performed safely on healthy overweight patients and it not only improves body contour and body image but also reduces cardiovascular risk factors such as obesity, systolic blood pressure, and plasma insulin. Therefore, the resultant morbidity and mortality decreases. It may even prevent or delay the development of diabetes or impaired glucose tolerance if the previously mentioned beneficial effects are long-lasting [26, 29].

When fat is extracted simultaneously from various sites of the body in the same session, mainly the waist, hips, flanks, and back, it is possible to obtain increased patient satisfaction. If the patient is very obese, the procedure should be divided into several interventions rather than one.

Liposuction as a cosmetic procedure, in the right hands, is a safe and efficient method to improve body contour [42]. This has been demonstrated in different publications focused on the safety of liposuction [40–44]. The impact upon the self-esteem is so important that we summarize this saying to our patients: “We are going to operate on your body, but the most important effect will be felt on your mind.”

It is worth emphasizing that liposuction is only one of the weapons to fight against being overweight. After surgery patients are better motivated to start a program including a dietary regimen and physical exercise, or in other words, a complete change in their life style.

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Metabolic and Clinical Studies of Liposuction in Obesity

Beniamino Palmieri

64.1 Introduction

In 1992 [1] and 1997 [2], the author outlined the theoretical background, indications, and warnings concerning liposuction for obesity that should be considered from a metabolic and behavioral perspective. This was quite different from the classic cosmetic liposuction, even if some cosmetic purposes are not excluded in a frankly obese patient whose body mass index (BMI, the ratio between weight and height) usually exceeds 25.

When we started with our clinical studies, Fournier [3], Joannidis et al. [4], and Teimourian and Gotkin [5] had already published reports of substantial experience in the area of obesity but very few cosmetic surgeons were taking into account their lessons because of possible lethal complications, fear, and because the removal of a large amount of fat would leave in place an aesthetically frustrating fat tissue mass.

The author's concern regarding liposuction for obesity was the short-term and long-term consequences of this remodeling operation, especially from the metabolic point of view. There is, however, a growing body of evidence concerning the adverse prognostic impact of hyperglycemia or dyslipidemia in untreated obesity, as well as of hypertension or cardiovascular diseases in the obese. The challenge was to try to modify this unfavorable metabolic background by extracting fat tissue with the least surgical trauma and with the lowest risk. In order to minimize the surgical risk, as many healthy patients as possible must be chosen, but if the goal is to perform a clinical study on improvement of serohematologic data, it would be better to enclose a cohort of "unfit-risk" subjects.

In obese patients, if properly prepared, evaluated by adequate laboratory examinations, treated, and correctly follow by preoperative, intraoperative, and postoperative anesthesiologic care (with special attention devoted to cardiovascular, respiratory, coagulative, electrolyte, and hemoglobin homeostasis), liposuction is generally safe and uneventful. Further attention is required in the treatment of the obese patient with disglycemic and dislipemic traits.

Many patients may be either borderline or overweight but they can have a fear of surgical bariatric or major cosmetic operations. The patient's choice may be inspired by the "knife phobia" and the patient would rather have smooth cannulae and liposuction because the procedure is not deep nor is there removal of any part of the body. A very detailed informed consent has to be preliminarily discussed with the patient, not only in terms of preoperative and postoperative steps, but mainly of patient expectancy and of the final cosmetic outcome. The dream to suddenly change the body profile must be reshuffled in terms of realistic limits of fat subtraction and the potential for the need to perform the procedure in two or three sessions with a 4–6 month interval in between. The early need for postoperative physical activity as well as a substantial change in quality and quantity of food intake must be thoroughly explained during the informed consent meeting. A psychologist and a dietician or a bariatric instructor should ideally take part in the team discussion.

The majority of the patients investigated by the author were spontaneously self-admitted subjects who were unaware of their obesity-onset problems. Very few patients with symptomatic cases, whether hypertensive or hyperglycaemic, were spontaneously seeking liposuction, probably for the fear of complications in a fundamentally cosmetic procedure. Only by means of direct collaboration with differently trained specialists who are adequately familiar with this alternative preventive approach might there be an increase in the number of candidates for evidence-based satisfactory investigation.

64.2 Experimental and Preclinical Background

Preclinical investigations were started with Zucker rats (genetically defined as a Fa+ fa+ homozygous trait. The author attempted to understand the effective lipolytic potential of ultrasound that was believed to be the safest and least traumatic way to harvest fat from the stromal tree. The relationship between the amount of fat removed and glycemia–insulinemia–lipemia variation was compared with non-obese, same-age, and same-food rats. These animals represent a very accurate model of adult onset type 2 diabetes.

The protocol included 20 Zucker rats aged 1 month and 20 non-obese, same-age animals that were subdivided in two groups each. Twenty percent of body weight was removed by ultrasound lipolysis or by surgical lipectomy with the same type of skin incision. The omentum fat was included in the protocol of both the surgical and the ultrasound approach.

In the treated obese group significant changes were observed in glucose and insulin concentration ($p<0.005$) that are be related mainly to intraperitoneal and retroperitoneal fat storages. In non-obese rats these changes were not observed.

Substantial changes were detected in triglyceride and cholesterol levels in comparison with the levels recorded using the same procedure in the control group of normal rats (fa+ fa–). Cholesterol dropped proportionately from 756±35 to 237±44 and triglycerides from 8,650±67 to 1,370±53 and the difference was maintained during 3 months of follow-up.

These findings were confirmed in a subsequent investigation by Liszka et al. [6] on Zucker rats, which suggested a direct relationship between the number of cells removed and metabolic modification of the lipid set. In the protocol, however, surgical invasiveness might have modified some hematologic parameters, while ultrasound lipolysis is to be considered a very conservative approach to fat extraction, with probably a lower glycemic peak owing to surgical stress and wound healing.

Weber et al. [7] placed female Syrian hamsters on a high-fat or a low-fat diet and then performed more than 50% subcutaneous lipectomy versus control animals and demonstrated that the animals operated upon increase their intraabdominal fat stores as long as a hyperlipidic diet is followed. As a consequence, serum triglycerides, liver fat content, and insulinemic index are increased compared with those of the control animals. The subcutaneous fat should be a physiological absorber of lipids from diet uptake protecting animals against the metabolic syndrome of obesity. This experimental study adequately stresses the role of diet habits and physical activity changes in the obese after liposuction in order to avoid subcutaneous versus intra-retroperitoneal fat storage imbalance thus increasing the insulin resistance toward diabetes.

Historical clinical experiences have shown that intraabdominal fat is much richer in insulin receptors than subcutaneous fat and we incorrectly figured that we would be able to improve insulin resistance by means of ultrasound during laparoscopic or open abdominal general surgical procedures in prediabetic obese patients.

The author removed omental and retroperitoneal fat in 12 cases (eight men and four women aged between 45 and 64, with a BMI index higher than 30) in patients operated upon for gallstones (six cases), ovarian cysts (one case), adhesiolysis (one case), esophageal reflux (one case), and laparocele (three cases). Using a 75-W ultrasound energy machine at cavitation resonance of 19.8 kHz (Sculpture, Casale Monferrato, Italy) the probe was applied across the mesothelial surface to the fat tissues to induce lipolysis in liquid drops. The procedure was abandoned because it was too time-consuming. Radical omentectomies were performed without achieving metabolic results in the postoperative period.

Faga et al. [8] performed omentum lipoaspiration on dwarf pigs, aiming for a potential clinical indication to reduce insulin resistance. The results were quite discouraging in terms of perioperative mortality and tissue reaction to the procedure. As a matter of fact, intense inflammatory reaction ensued after 1-h ultrasound administration. Fibrous thickening, visceral adhesions, and omental twisting were observed, probably owing to activation of arachidonic acid cascade by liquefied fat.

The author has not noted any complications from the ultrasound-treated omentum cases. Biopsies performed through intraperitoneal drainage at 48, 72, 96 h showed a short-term moderate inflammatory reaction with stromal changes toward fibrosis. There was no opportunity to selectively destroy insulin receptors on the intraabdominal fat since the amount of tissue to emulsify exceeds the cost benefits of the procedure in view of the inflammation risks of complications, either biochemically or thermally induced by the ultrasound.

64.3 Clinical Studies

Samdal et al. [9] treated five consecutive diabetic patients affected by lipohypertrophy. The protocol included a syringe-assisted procedure with a long-term doctor and the patient's evaluation by means of a four-point graded scale. The results were positive and no complications were reported.

Hauner and Olbrisch [10] in an anecdotal report described six different anatomical regions suitable for lipoaspiration in the same type 1 diabetic 22-year-old female patient who had developed lipohypertrophy. Two liters of fat was removed with great cosmetic satisfaction and no complications at all.

Barak et al. [11] reported on a diabetic patient who had successful treatment of two lipohypertrophy masses. None of these authors tried to ascertain the metabolic balance of the consequences of liposuction in terms of diabetes physiopathology

In 1997 the author [2] published data on 205 obese treated patients (ten of whom weighed more than 30–70% of their ideal weight) who had hyperglycemia and hypertriglycaeridemia that was reduced and the glucose tolerance test was improved 8 weeks postoperatively. Triglycerides were reduced by an average of 25%. No cholesterol changes were detected at 4 and 8 weeks postoperatively. Fifteen moderately hypertensive and untreated patients had an average blood pressure reduction of 11% with major impact on diastolic (15.1%) rather than systolic (7.2%) pressure. A 14-year-old moderately obese type-1 diabetic male patient (insulin-dependent, three times a day), had 6 l of fat removed. The insulin requirement was reduced to 20 units twice a day instead of 60 units in total. The liposuction was easy and without complications.

Gonzales-Ortiz et al. [12] investigated six young obese female patients who had large-volume liposuction matched with six obese untreated control patients. All had similar lifestyles and alimentary habits. Preoperative versus postoperative (21–28 days) laboratory evaluations showed significant glucose levels of 4.9±0.4 versus 4.6±0.2 mmol/l with *p* less than 0.005. Uric acid was reduced from 250.8±56 to 224.0±53.4 μmol/l with *p* less than 0.005. Insulin sensitivity improved after surgical intervention from 4.3±0.9 to 5.3±0.8 with *p* less than 0.046.

Giese et al. [13] evaluated 14 women with a BMI of more than 27 kg/m^2 with tests consisting of plasma insulin, triglycerides, cholesterol, body composition (by dual-energy-X-ray absorpitometry), resting energy expenditure, and blood pressure before and after large-volume assisted liposuction. The mean tumescent infusion was 9,052±1,837 ml, the mean aspirate was 9,406±2,238 ml, the mean fat aspirate was 6,733 ml (from 4.675 to 8,825 ml) and the total overall fat removal was 6.1±1.2 kg (range 3.8–7.3 kg).

The average body weight loss 4 months after the procedure was 6.5 kg and the BMI decreased from 35.4±3 to 28.8±0.3kg/m^2, with fat mass reduction from 35.7±6.3 to 30.1±6.5 kg. Plasma insulin levels decreased from 14.9±6.5 to 7.2±3.2 mIU/ml (p=0.007) and systolic blood pressure from 132.1±7.2 versus 120.5±7.8 with p=0.002.

Cardenas-Camarena et al. in 1998 [14] and 1999 [15] reported 161 patients, treated between July 1994 and June 1998 of whom there were 152 women and nine men aged between 19 and 65 years with an average weight of 72 kg (between 57 and 126 kg).

The overweight percentages were between 10 and 25% in 45% of patients, between 26 and 50% in 18% of patients, and 50% in 3% of patients. Additional procedures were buttocks fat infiltration (36 patients), mammary implants (12 patients), mastopexy and mammary implant (nine patients), breast reduction (seven patients), and mastopexy (five patients).

The tumescent solution consisted of 0.9% saline plus 1 mg adrenaline in a total amount proportional to the fat volume to be removed, injected in supine (first operative time) and in prone (second time) positions ventrally and dorsally, respectively. The total volume administered averaged 8,700 ml (between 5.0 and 22.3 l). The surgical procedure, with peridural block, required four hands (two surgeons) in a simultaneous bilateral approach working with Mercedes cannulae, 4 mm, in a deep plane refining the superficial plane with 3-mm cannulae. The treated area in percentage included abdomen, flanks and lumbosacral (100%), the lower scapular region, trochanteric, and medial thighs (58–79%), the upper scapular region (25%), neck (17%), and arms (11%). Fluid replacement consisted of 330 crystalloid milliliters administered for every liter aspirated. There was 10% volume blood loss during the first 6 l and after 7–9 l, the amount of blood loss usually increased, and after 10 l autologous predeposited blood was administered.

Mobilization was immediate and the hospital discharge was 24–36 h postoperatively. Elastic garments had to be worn for 6 weeks. The average weight loss was 6 kg with an average size reduction of 2.6 kg. The recovered fluid composition was 86% fat and 14% liquid, which resulted in a hemoglobin drop of 12% (3.8 g) after 1 week.

The average operation time was 2.25 h and 17% of the cases required 500 ml of autotransfusion blood. There were no major complications but 32.2% of patients had minor problems such as seroma (12%) that required needle aspiration, 14.9% developed nodular irregularity, and 1.2% had superficial necrosis that healed spontaneously. Hyperpigmentation was only described in 4.9% of cases

Albin and De Campo [16] reported 181 patients partly treated only with tumescent liposuction (31 cases) and partly with ultrasound-assisted liposuction (150 cases). The authors' experience suggests that with volumes larger than 5,000 ml of aspirate there is no relationship between the blood recovered in the aspiration fluid and the hemoglobin drop. Part of the blood is spread on the operative field, but has to be taken into account in the final balance. In terms of complications, no deaths were reported but two patients had pulmonary emboli and one had deep lower leg vein thrombosis.

Peren et al. [17], between February 1994 and 1997, treated 120 patients (110 women and ten men) using megaliposuction with an average aspirated volume of 14,000 l (range 800–20,000 ml) without blood transfusion. No major complications occurred except seromas in 12 patients and hypopigmentation in two patients. The authors stressed the role of megaliposuction as a defatting and slimming procedure, rather than as a contour reshaping to improve the patient's symmetrical body proportion.

Commons et al. [18] published a retrospective review of 631 patients operated upon between January 1986 and March 1998, with some technical modifications owing to the introduction in 1996 of ultrasound-assisted liposuction, and use of the superwet technique since 1991. The patients were almost all women aged between 17 and 74 years. The minimal fluid tumescence to be used was 300 ml but total aspirate volumes ranged between 3 and 17 l with 94.5% under 10 l. Most (98.7%) of the patients were within 50 lbof the ideal chart weight. Cosmetic results were satisfactory with a 2–6-in. decrease from the preoperative measures, accordingly, to the anatomic segment treated by liposuction. Ten percent of the patients experienced minor skin contour irregularities which did not require further cosmetic procedures.

As to the complications four patients developed pulmonary edema soon after the operation and one developed pneumonia. Seromas, skin injuries, and burns were the most frequent complications of the procedure. The 1-year postoperative weight showed that 80% of patients had maintained it unchanged with adequate food intake modification and/or proper fitness exercises. The authors' conclusions were extremely favorable for the large-volume liposuction procedure, with a word of caution about fluid replacement balance. The compliance of the patients was high especially in the long run.

64.4 Conclusions

Large-volume liposuction in the obese patient is an easy and effective procedure. We still need to improve our guidelines both in patient selection and in technical skill and in the diagnostic and drug-administration schedule.

The metabolic and clinical parameters benefit from large-volume fat extraction, on a mini-invasive surgical basis require more extensive investigation and more of a joint effort with physiologists, epidemiologists, diabetologists, etc. The preliminary articles are a positive background to build up a rationale on how an originally cosmetic procedure can be endorsed as a general fitness and wellness step for a larger sample of the population.

Acknowledgement. The author wishes to thank Giorgia Benuzzi, University of Modena Medical School, for her kind and outstanding collaboration.

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Large-Volume Liposuction for the Treatment of the Metabolic Problems of Obesity

Beniamino Palmieri

65.1 Introduction

Large-volume liposuction (LVL) according to the 1999 Plastic/Cosmetic Surgery Committee of the California Medical Board relates to liposuction volumes greater than 5,000 ml that should be specifically required to be performed in a proper hospital setting and not on outpatient basis. As a matter of fact, liposuction has become an exclusively outpatient cosmetic procedure as a method to subtract substantial amounts of fat tissue because of the apparent ease and technical simplicity and the expectancy of the moderately or frankly obese patient.

With the wet and superwet tumescent technique, the minimally invasive approach to the treatment of obesity by liposuction or ultrasound lipolysis offers a unique model for overweight patient treatment to obtain sudden weight loss and potentially increase immediate compliance to lower caloric intake and higher physical, calorie-consuming activity. The author explains during the initial doctor–patient communication that treatment of an obese patient with restricted diet or with one of the gastrointestinal-surface-reducing techniques is like preparing the patient to reach the “top of the mountain” to get slim through very difficult and prolonged food abstinence (or whatever might be the alimentary style modifications). When the thin (finally) patient is then asked to perform some physical exercise, very often he or she will not comply because he or she is exhausted and will then gradually start recovering some weight.

In the case of surgical trauma due to major obesity surgery procedures, the patient also has to face the surgical stress, the amount of which has recently been reduced with laparoscopic banding and stapling procedures, but is very relevant, because it is followed by a steady and sudden modification of the gut physiology.

When weight is reduced with fat-trimming liposuction, the patient is brought to the top of the mountain, not climbing on it, as with the other procedures, but rather with an elevator without any sacrifice. When the patient is then asked to perform regular exercise, his or her untried willpower will be more efficiently dedicated to weight maintenance. This psychological reinforcement is even more strongly specifically achieved by a narcissistic self-evaluation of the improved body contour. In addition, fat-tissue trimming and withdrawal by liposuction reduces the number of fat cells and their caloric requirements. This is quite different in terms of appetite and hunger than having stored the same number of adipocytes deflated of their intracytoplasmic contents owing to starvation or hypocaloric diet.

In the author’s experience, a certain number of patients that have been unable in the past to lose weight will start a progressive catabolic process that further reduces their fat volume after liposuction (Table 65.1). This phenomenon is as if some inner weight balance has been cracked, and some lipolytic activation has been facilitated by the operation, through postoperative physical exercise, and the suggested maintenance diet. About 75% of the patients interviewed at 6 months declared themselves to be less hungry and to have less compulsive behavior toward food intake. Half of them were motivated by the psychological change related to the fear of wasting their new beloved body shape.

Liposuction in obesity is worthwhile to consider as a reasonable alternative to other medical and surgical slimming methods, accordingly with some essential physical and psychological details.

Table 65.1. Postoperative late fat breakdown effect of liposuction: enzymatic or hormonal changes probably play a role in enhancing the lipolytic effect of an active behavior that is facilitated by the abrupt weight loss

Breakdown effects of liposuction
1. Hormones?
2. Behavior?
3. Enzymes?

65.2 Technique

The author asks all patients to stop smoking a few weeks before surgery.

Routinely, some meaningful tests are included such as effort EKG, pulse oximetry, end tidal CO_2 respiratory functional tests, and a full coagulation balance including activated partial thromboplastin time, C-protein, antithrombin III, and homocystinemia anticardiolipin antibodies, in an exhaustive up-to-date thromboembolism prevention strategy. Routine preoperative examinations include liver and kidney function tests, glyco-lipid and electrolyte parameters, autoantibody investigation, thyroid function tests, and basal prolactinemia.

Autologous blood predeposits are obtained according to the patient's basic hematocrit, and to the fat volume to be lipoaspirated. In suitable cases, donation of 2–3 units will contribute to partial hemodilution, which means a safer surgical procedure. Erythrocytes will be reinfused during and after the operation, to prevent dramatic hemoglobin drops, and to induce a quick patient recovery. Preoperative erythropoietin injection 60–30 days before surgery (50 IU weekly) should also be considered in the hemoglobin fall prevention.

Low molecular weight 400 U/kg heparin should be added the day before operation and followed up for 15 days after the operation. Cephalosporin (1 g) is administered before starting the liposuction and for the three following days. As to high-dosage adrenaline administration, it has universally been judged safe from the cardiovascular point of view and a very careful anesthetic surveillance with hemoglobin fluid and electrolyte balance is mandatory for a prompt recovery after the procedure has been completed.

The patients are catheterized at the operation time, and the catheter is left in place for 24–48 h. Elastic bandages are applied to the legs and a thermal pad is placed on the back of the patient.

General anesthesia is usually preferred to the spinal one, especially in the low-risk high-obesity patient, where liposuction is addressed to multiple sites. For tumescence fluid, 1 l Ringer's lactate (at 21°C) with 25 ml of 1% lidocaine and 1 mg 1:1,000 adrenaline is used. The maximum advisable safety dosage of epinephrine ought not to exceed 0.150 mg/kg body weight and lidocaine no more than 35 mg/kg. During surgery the anesthetist monitors the blood parameters and infuses 1–3 l of crystalloid solutions and, if necessary, 1–2 units of blood.

The procedure utilizes 2–4-mm Mercedes cannulae when lipoaspirating trying to obtain parallel defatting tunnels, without nodules or thickening of the skin. Usually only one surgeon operates in order to have a homogenous approach to the operative field. It is useful for an assistant to work contralaterally in the deep planes but as long as lipoaspiration approaches the subdermal fat, the main operating surgeon refines the surface.

Two vacuum drainage tubes are applied and left in place for 3–5 days.

The patient is wrapped with Reston polyurethane (3M) and inelastic adhesive bandage (Tensoplast). Elastic stockings (*collants*) are applied in the operating room and fissured with scissors in the perineal area for bladder and rectum voiding. These garments will not be removed for at least 1 week. Mobilization starts as soon as possible but not until after the first postoperative day. An antiemetic drug (granisetron) and hydrocortisone (500 mg) are administered at the end of the procedure and furosemide plus aldactone can be injected in case of postoperative fluid retention.

When diabetes or hypertension has to be managed in surgical patients, a very careful therapeutic regimen is dedicated to the glucose–electrolyte balance and to cardiovascular and renal follow-up. The authors have not had major complications using this protocol and properly selecting cases.

The surgery time was between 2.5 and 4 or 5 h in patients whose body mass indices were over 35 and where more than 15 l of tumescence solution had been required.

In young obese patients with removal of 18–21 l of lipoaspirate, two to four autotransfusion units of blood and 2–6 units of 20% albumin infusions were postoperatively required to counteract hypoonchia and edema. The authors, with moderate or severely obese patients, use two–three step lipoaspiration procedures in order to better cosmetically refine the treated areas, and to prolong the attempt to have the patient comply with diet and exercise (Table 65.2).

The abdominal area is usually approached first, the dorsum and shoulder second, and the arms and legs in the third procedure. The patient usually ac-

Table 65.2. Suggested protocols according to various obesity degrees: one-, two-, or three-step procedures in different anatomic areas with a maximum of 15 l of lipoaspirate perfusion

Optional steps	Session	Area	Lipoaspirate volume (l)
HVL	1	Total body	5–15
HVL	1, 2	Abdomen, back	5–15
		Flanks, thighs	5–15
HVL	1, 2, 3	Abdomen, back	5–15
		Flanks, thighs	5–15
		Legs	5–15

HVL high-volume liposuction

cepts this program and substantial shape changes can be achieved, at low risk, removing up to 20–30 kg of total fat tissue. As a rule we remove 8–12 l, per session, and the results on the body contour are very impressive.

Seromas were usually detected in 15% of patients. Echographic needle exploration and suction after the fifth postoperative day is the author's choice of treatment

65.3 Discussion

The population spontaneously choosing to be submitted to LVL includes obese patients with very definite conservative feelings toward their physical integrity, with a self-image imprinted by a strong narcissistic nuance, but with a less sophisticated aesthetic expectancy of the LVL cosmetic outcome compared with non-obese liposuction candidates (Fig. 65.1). In fact the obese patient is usually very happy to have the reduced body contour even with skin irregularities that are considered minor deformities in comparison with the previously overstored fat. The lean subject, in contrast, does not forgive any mistake by the surgeon and is very concentrated upon potentially suing because of a less than perfect outcome in every detail of her or his aesthetic appearance.

The method is quite effective and even though we lack long-term data, our phone interview at 36 months with the patients showed a 75% compliance with the fitness programs and caloric intake. These patients showed great care in maintaining the new body shape, assuring an improved social self-confidence (Fig. 65.2), even if, sometimes, other concerns such as anxiety and depression might cause some dropout.

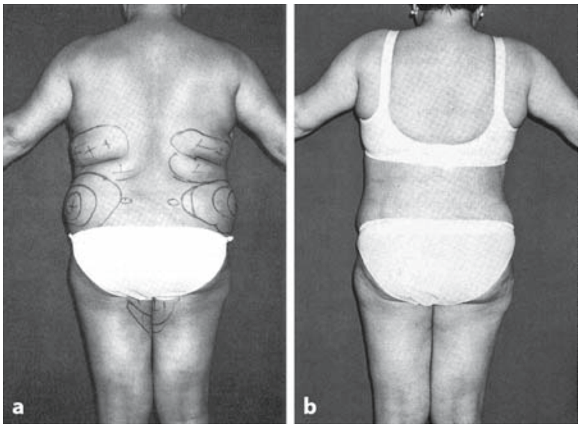

Fig. 65.1. a Preoperative 47-year-old female patient before removal of 12 kg of fat by liposuction. **b** Postoperatively with improved glucose tolerance test

Fig. 65.2. a Preoperative 16-year-old male patient affected by insulin-dependent diabetes. **b** Postoperatively the insulin administration was reduced after 6 kg subcutaneous fat liposuction

The metabolic claims and long-term impact on wellness of LVL need larger mulicentric trials to determine whether LVL might improve the life quality of type 2 diabetic obese patients. The author firmly believes that in the next 10 years a well-defined role for this procedure will be outlined as a major ethical issue, especially if safety guidelines give definite assurance that no major complications have to be expected anymore.

Acknowledgement The author wishes to thank Giorgia Benuzzi, University of Modena Medical School, for her kind and outstanding collaboration.

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Megaliposuction: over 10 Liters

Pierre F. Fournier

66.1 Introduction

Twelve years ago the author proposed the name megaliposculpture for all liposculpture procedures during which 10 liters or more is extracted of a mixture composed of adipose tissue, normal saline from the subcutaneous infiltration, and the patient's blood. The proportions of each of these elements vary according to the case and only the quantity of adipose tissue will be taken into consideration.

The evaluation at the same time of the blood extraction, the visible fraction of the blood loss that conditions the pursuit or the abandonment of the intervention, is of such importance that it is necessary to closely watch over this parameter. The qualitative and quantitative blood loss is important in determining the volume of pure lipoextraction.

For a long time, surgeons hesitated to extract more than 2.5 liters of adipose tissue from a patient. The technique and the conditions in which the procedure took place limited the amount that could safely be removed. This included hospitalization, general anesthesia, the use of large cannulas and of the suction machine, absence of infiltration («dry technique»), infiltration without adrenaline, a large number of blood transfusions, sometimes laborious fluid and electrolyte balance, hypovolemic shock, long convalescence, lack of practice by surgeons, complications or unsatisfactory results, and lack of updating the procedure. Through the years, liposuction has advanced, now allowing megaliposculpture to be performed so that more than 10 liters can be extracted without posing any greater risk to the patient than a conventional aesthetic liposculpture.

Little by little, the quantity of adipose tissue extracted increased, when it was certain that large extractions would not pose any additional risk to patients who were candidates for such operations. The author first practiced megaliposculpture in two stages at 6-month intervals with 8 liters extracted from the lower extremities during the first stage and 6 months later 6–8 liters from the abdominal wall. The maximum amount extracted slowly increased over 12 years to a total of 23 liters.

Eed in Saudi Arabia and Fikioris and Ioannidis in Greece using the same technique were performing similar large extractions [1]. Large-volume extractions must only be performed by a surgeon trained in megaliposculpture with careful selection of patients and an anesthesiologist trained for operations on obese persons and working in coordination with the surgeon and his team. Both the anesthesiologist and the surgeon must know when to stop before going too far and never pose greater risks to the patient than would be possible during the course of a standard liposculpture.

66.2 Why Perform Megaliposculpture?

Failures in current medical or surgical therapies for the obese justify megaliposculpture. Although the cause obesity is not treated by megalipoextraction of adipose cells, the result is reached in part since lipectomy is only concerned with superficial excess and not the deeper excess of adipose tissue.

A certain portion of hypertrophy or hyperplasia of adipose cells is definitively removed from the catastrophic influence of the cause of the obesity. In this way, one can expect an improvement in the physical condition of the patient while provoking disturbances in the generative process of the obesity. One could compare this disease, obesity, to a war in which there is one enemy and several victims. If a counter-stroke leading to victory is not possible, the first thing to do is to protect the victims, or at least, in the case of obesity, to shield them from the catastrophic results of this disorder.

In this way, one can expect that the lower the quantity of fat tissue subjected to the disastrous results, the better the body can fight against this biologic and metabolic anomaly. This attempt to reduce the vulnerable tissue territory can expect the attenuation of potential life-threatening consequences of obesity.

It is well known that obesity can cause or aggravate the following pathologies: cardiac diseases; high blood pressure and stoke; pulmonary diseases; diabetes; gall bladder disease; gout; certain cancers; osteoarthritis of weight-bearing joints; an abnormal level of lipids and plasma lipoproteins; irregularity of the menstrual cycle. In addition, obesity is often an enormous psychological burden. When all the conventional treatments have failed, megalipoextraction is the last operation to be performed. It should be regarded as a major lifesaving operation and not as an aesthetic procedure.

The goals of megaliposculpture or therapeutic megalipoextraction are:

1. To extract in a single operation the greatest possible quantity of subcutaneous adipose tissue for the patient, without running any greater risk than in the course of a normal liposculpture and without the need for blood transfusion (autologous or not). The result of this operation is a numerical reduction of the subcutaneous adipose cells.
2. To provoke biological metabolic or psychological modifications in the operated patient that, following a diet, exercise, or medical treatment, will result in decreasing the intra-abdominal and intramuscular adipose tissue, residual components of the excess adipose tissue. The result of these postoperative biological modifications is a reduction in the volume of the adipose cells in these two areas where a mechanical reduction is impossible to perform.

66.3 Indications

Megaliposculpture above 10 liters of supranatant fat is a major operation that can produce serious complications and is selected only after thorough reflection by both patient and surgeon. Potential patients are failures of other medical or surgical treatments. The patient must be informed of the risks and is asked to reflect for a period of time.

Patients selected should weigh between 100 and 150 kg with no co-morbidities, e.g., high blood pressure, cardiac or pulmonary problems, diabetes. Eventually we may be able to operate on patients over 150 kg. To remove over 10 liters of supranatant fat, the weight of the patient should be at least over 100 kg.

At the present time, we accept, with the agreement of our anesthesiologist, certain obese patients who also have high blood pressure, cardiac, pulmonary, or diabetic problems, if the risk does not appear to be too great.

Megaliposculpture will not bring a solution but is an additional treatment for patients with obesity, high blood pressure, certain cardiac or pulmonary problems, and other problems associated with obesity. In certain cases of ambulatory difficulties, in cases of vertebral osteoarthritis or arthritis of the hip, an abdominal megaliposculpture can reduce chronic vertebral pain, chronic pain in the hips or knees, or as orthopaedic surgeons have suggested, it might prolong the life of hip prostheses by removing the excess weight.

Having obtained positive results, we have become more venturesome in the operative indications. We are convinced the megaliposculpture has a place in the treatment of obesities, whether general or regional.

66.4 Technique

Surgery is preceded by the physical and psychological selection done by the surgeon and the anesthesiologist. Megalipoextraction is possible owing to a large amount of normal saline. We have learned that it is possible to inject into the subcutaneous area 10, 15, or even 20 liters of normal saline, which is cold at 2°C, and each liter can contain 1 mg of adrenaline (1 ml if 1:1,000). This amount of normal saline allows us to avoid postoperative hypovolemia and considerably limits preoperative and postoperative bleeding.

66.4.1 Anesthesia

Simple megalipoextraction or therapeutic megaextraction is done under general or epidural anesthesia. We prefer epidural, which is the least toxic for the obese patients and permits them to be moved, if necessary, without risk. However, the patients often request general anesthesia, even if they are informed that it is slightly riskier and that there will be more bleeding. The anesthesiologist must be accustomed to operations on obese patients and be trained for this type of operation, which is completely different from the current cosmetic liposculpture. The anesthesiologist and the surgeon work in close collaboration with each other [2].

Once the actual operation has been completed, the surgeon must monitor the operated regions and must take part in the follow-up. Our anesthesiologist has the major responsibility for the patient's fluid and electrolyte balance, and the monitoring of the vital functions. His role during a megaextraction is of utmost importance in the selection of the patient, the resuscitation, the follow-up of the operation, and the convalescence.

66.4.2
Technique of Subcutaneous Infiltration

The operation begins as soon as the epidural anesthetic has taken effect or immediately after induction of general anesthesia. The surgeon will inject the solutions either himself or with the assistance of an operating assistant who must be equally competent. The only syringes used are 60-ml syringes with a Luer Lock tip fitted with a cannula of 2.5-mm external diameter and 28-cm length. A second assistant will fill them in a basin that contains several liters of solution, and will hand them to the operating surgeons. The infiltration is done in the thick part of the subcutaneous tissue and is a retrograde injection, each operating surgeon injecting symmetrical locations drawn in advance.

Rapid infiltration should be avoided. It must be done in about 30 min, or longer if the area to be operated upon is very extensive. The infiltration can be done at one time or, if the area is extensive, at three sequential separate times, allowing 30 min between infiltration and lipoextraction. The first infiltration will be in the abdomen, then the sides, the thorax, the breasts, then the hips, outer and inner thighs, the front of the thighs, and the knees. The head of the operating table is elevated 15°. The surgery begins as soon as the abdomen is ready to be operated on, i.e., 20–30 min after the end of the infiltration. An infiltration machine could also be used but we prefer to infiltrate with syringes.

During the abdominal operation, a third assistant will inject the second region to be operated upon, the upper body and the sides, which will be ready for surgery when the abdominal part has been completed. Finally, while the surgeon and his assistant are operating on the second region, the third and last region is injected. We have injected up to 10 or 12 liters of cold normal saline with adrenaline at one time before operating with no major complications. Even so, the occasional occurrence of arrhythmia has made us prefer, in the case of large injections (more than 8 l), to inject the areas to be operated upon in two or three intervals. An intravenous injection of normal saline is instituted at the beginning of the operation with only 1–2 liters given during the course of the operation (this is very important). There is no reason to start this intravenous rehydration in the preoperative period even though certain surgeons do. Fatal complications happen when too much fluid is given intravenously as well as subcutaneously [3].

66.4.3
Operative Technique

The operation is done exclusively with the aid of 60-ml plastic Toomey syringes (Fig. 66.1). The vacuum machine is not used and could even be harmful in cases of aesthetic liposculpture and even more so during therapeutic megalipoextraction. Sixty-milliliter syringes mounted with cannulas of 4- or 5-mm

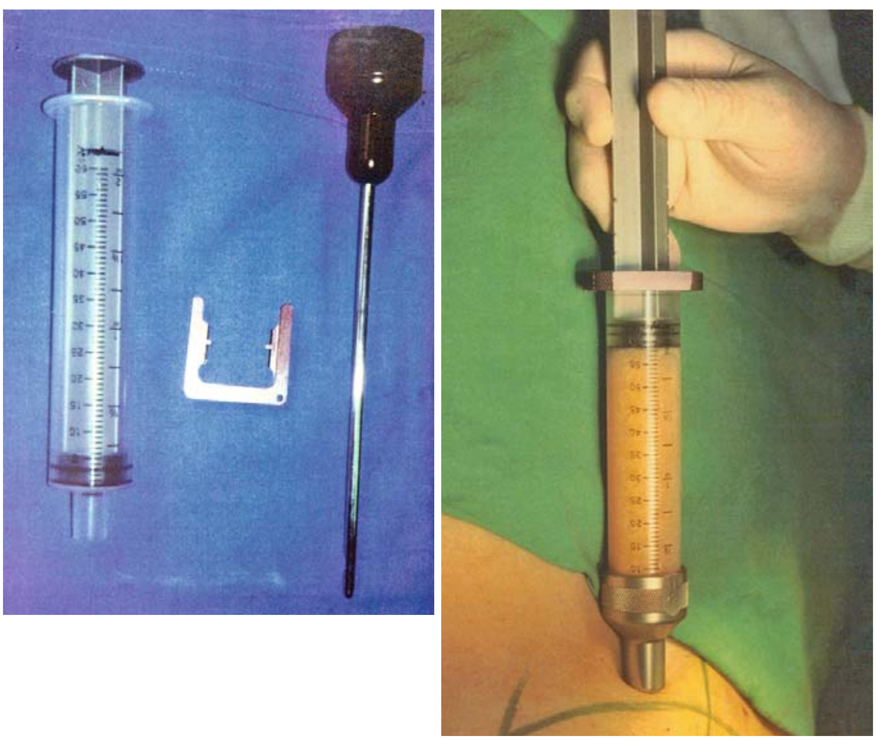

Fig. 66.1. Toomey syringe and attachments

external diameter are used. The cannulas have only one opening with or without four accelerators. The French model of the cannula, passing through the barrel of the syringe, is preferred to the American Tulip cannula, fixed externally on the end of the syringe. In order to lock the plunger of the syringe during an extraction, a groove in the form of a hook is made on one of the wings of the plunger of the syringe (Fig. 66.2).

This system of locking the plunger allows us to avoid the use of metallic, heavy, cumbersome, and useless locks. This instrument is therefore light and thus does not «scrape» the adipose tissue, as did the cumbersome and heavy instruments when the machine was used and there was significant preoperative and postoperative bleeding [2].

A light instrument is more comfortable, more efficient, better controlled, and less fatiguing for the surgeon. In order not to lose time, the surgeon will have at his or her disposal four systems of cannula syringes with intrinsic lockage, and will commence the operation after having waited 30 min once the injection has been completed. Once the syringe is filled, each surgeon will exchange it for another cannula-syringe unit prefilled with 5 ml of normal saline, which will be given to him by a third assistant. The role of this assistant is solely to empty and fill in advance the syringes that are taken from or returned to the two operating surgeons. It takes about 10 s to fill a 60-ml syringe.

This method with two operating surgeons and one assistant allows a considerable amount of time to be gained and is much rapider than the machine technique. Overall it does not have the disadvantage of preoperative and postoperative bleeding, which becomes more important without the buffering action of the 5 ml of normal saline that is present in the syringe at the moment of the extraction.

An average operating surgeon will extract about 5 l/h; thus, 2 hours is necessary to extract 20 liters (Fig. 66.3). The injection itself and the time for it to take effect takes 1 hour. The preparation of the patient and the epidural anesthesia takes another hour. The preoperative drawing which determines the operating regions in exactly symmetrical zones permits each operating surgeon to do his or her job efficiently, rapidly, and with identical quality. The work of the first assistant must replicate that done by the principal operating surgeon.

Throughout the entire operation, the anesthesiologist will inform the surgeon of all possible variations in vital functions and assure fluid and electrolyte balance of the patient. The operation must have the minimal bleeding possible. A prolonged extraction that is too bloody will force the procedure to be stopped. Sometimes it will be necessary to turn the patient over, which will be done with the usual precautions. The operating table is head-up at 15° during the entire operation. The extraction is done according to the usual crisscross technique.

Once the operation has been completed, the cutaneous penetration points are sutured, and an Elastoplast bandage (strips 10-cm wide) is used unless one uses the elastic garment right away. The patient will then remain in the recovery room under strict observation for 2 hours before being taken back to his or her room. Another elastic garment will be used later for 6 weeks.

Fig. 66.2. A groove in the plunger of a 60-ml syringe can be used to maintain suction

Fig. 66.3. Over 20 liters can be extracted during megaliposcu-

During the majority of large lipoextractions, the megaliposculpture was completed when there was no more subcutaneous adipose tissue to be extracted. In the regions that were completely treated, the residual excess of the patient's adipose tissue was represented only by the intra-abdominal or intramuscular adipose tissue. Even for a patient weighing 210 kg, once 21 liters had been removed, the operation had to be interrupted since almost the entire subcutaneous tissue had been extracted. This demonstrates the importance of a postoperative dietary regime, as the problem is not entirely solved by a single surgical operation.

66.4.4 Follow-Up and Postoperative Care

In his or her room, the patient is kept in a semirecumbent position, in order to facilitate easy breathing and to avoid compression of the diaphragm muscle. The same evening the patient will sit up, and as soon as able, he or she is recommended to move his or her legs several times per hour and to breathe deeply.

The postoperative monitoring (electrocardiogram, pulse, blood pressure) is maintained for 24 hours. The epidural catheter is maintained for 24–48 hours, and only the anesthesiologist decides when the analgesic solution should be injected. The urinary Foley catheter is maintained for 24–48 h. Temperature and urine output are monitored, as well as hemoglobin, serum proteins, and electrolytes. The anesthesiologist must be accustomed to such operations because hemodilution can persist for several days. Antibiotics are routinely administered (100 mg Vibramycin BID for 5 days), as well as anti-inflammatories (Reparil or extranase, two pills TID). In our patients, the anesthesiologist does fluid and electrolyte balance. In general, one gives either 1 liter of normal saline or Ringer's solution every 6 hours for 2–3 days.

The surgeon observes the dressing, which sometimes needs to be changed owing to light bloody saline discharge. The importance of this discharge should be explained before the patient's operation in order to avoid useless worries. It is psychologically beneficial to tell the patient that the greater the discharge, the better the postoperative result and the less residual edema. Thus, the patient views this unavoidable discharge favorably.

66.5 Results

In the days following the operation, an inflammatory reaction occurs that lasts 6–8 weeks. The operated tissues will harden and become sensitive, which is completely different from the immediate postoperative period when they were soft.

When the bandages are changed after 24 hours, the modification of the silhouette is impressive. Then, over a few days the inflammatory reaction begins and the patient finds himself or herself with the same configuration as in the preoperative period. It is this inflammatory reaction that explains why the patient's weight is not always modified in the first few weeks.

It is not until 2, 3, or sometimes 4 weeks that weight loss will begin. It will be more or less rapid right away, but it varies from one patient to the next. It is also associated with a softening of the operated tissues, which become less tender, allowing the patient to move more easily. The urine output also increases considerably.

This weight loss will be approximately equivalent to the weight of the quantity of adipose tissue that was extracted. After this weight loss begins, it is determined whether the patient should follow a diet. In about 20% of patients, the weight loss in the months following the operation is less than the quantity of adipose tissue extracted.

The majority of patients noticed a sudden loss of appetite that lasts several months. Whatever its origin, whether psychological or due to metabolic modifications, it is very frequent.

Fatigue is variable from one patient to another, and is not necessarily linked to the volume of blood loss. The drop in hemoglobin is not as important as one would think. Megaliposculpture of 15 liters does not vary the hemoglobin level by more than 1 mg. The drop can sometimes be greater than 1, 2, or 3 mg, but one must take into account the hemodilution, which makes the appreciation of the true blood loss difficult. Strict iron therapy is, however, routine for several weeks.

The hospital stay varies from 2 to 5 days according to the patient. Following discharge from the hospital, convalescence of 1 week is necessary. Normal activities may be resumed 10–15 days after the operation.

Aided by a nutritionist, the patient commences dieting after 8–10 days. Iron supplements, vitamin C in normal doses, and a high protein diet are recommended. The patient will see the surgeon at frequent intervals.

66.6 Complications

Moderate anemia, fatigue, and a loss of appetite may occur postoperatively. It is unavoidable that a large extraction of adipose tissue causes localized as well as generalized reaction, and a patient that cannot understand this should not be operated on. The psycho-

Fig. 66.4. a Preoperative patient. **b** Six years postoperatively. Lost 26 kg in the first 6 months

logical motivation of the patient is indispensable for a favorable outcome. It is a question of an operation that is therapeutic and not aesthetic even if aesthetics play a role (Fig. 66.4). The goal is to obtain an almost certain weight loss due to the lipoextraction that is followed in most patients by a second weight loss which is related to dieting, exercise, and to therapeutic medication administered postoperatively.

Fig. 66.5. Thigh skin necrosis that healed in 2 months

66.6.1 Local complications

In three patients, moderate cutaneous necrosis of a few square centimeters occurred on the abdomen and was attributed to a liposculpture that was too superficial. This healed in a few weeks. There was a large area of necrosis of the thigh in one patient that took 2 months to heal (Fig. 66.5). The patient refused a skin graft. Surface irregularities, excess of skin, and depression of the adipose tissue are treated by dermolipectomy if the patient wishes after 6 months, but few patients ask for it since cutaneous retraction is good or the patients do not want to be treated.

A normal appearance is often noted spontaneously because of the thinning process postoperatively. Before the operation the patient is duly informed of the possible local aesthetic discrepancies and the possibility of eventual surgical operations.

When working on the abdominal region, there were several lymphatic effusions. These are frequent when the megaliposculpture reaches 15, 17, or 20 liters. One can notice them on the third postoperative day. They disappear after 5–6 weeks, and can be tapped two to three times. The quantity extracted varies from 1 to 3 l. An infection has not been noted in between the punctures. Patients have moderate compression by the elastic garment postoperatively and also receive antibiotics. Recently, in one case of minor abdominal effusion we injected sterile air as recommended by Shiffman [3] and the effusion stopped in 3 days.

66.6.2 General Complications

We have not had hypovolemic shock due to the preoperative and postoperative fluid and electrolyte balance. Aside from the cold saline injections, the intravenous therapy is left entirely to the anesthesiologist. This intravenous therapy discontinued 24–48 hours after the operation.

In one patient, acute pulmonary edema occurred the night following the operation. Bloodletting of 1 liter rapidly improved the condition of this 150-kg patient from whom 15 liters had been extracted without difficulty. The 15-l lipoextraction corresponded to the essential excess of subcutaneous adipose tissue from the abdomen and thorax, the remaining excess being mostly intraabdominal. The patient left the hospital on the fourth postoperative day, and when he returned 6 weeks later, he had lost 26 kg. The analysis of this unusual and dramatic complication was a learning experience. The obese patient was breathing mostly with his diaphragm and a little with his ribs, which were laden with adipose tissue. The cause of this acute edema appeared to be due to the abdominal bandage made of Elastoplast strips that were unintentionally too compressive, and also to the strictly horizontal position of the patient in his bed. This excessive compression and the vertical pressure due to the weight of the intraabdominal internal organs (where excess blood had accumulated) considerably hindered the movements of the diaphragm, further accentuated by the strict horizontal position of the patient on the operating-table and then in his bed.

The 15° head-up position of the operating-table has subsequently been adopted as a matter of routine. Also in the bed, this semirecumbent position is maintained long after the operation. The bandaging should be occlusive, but not compressive. One could think that this acute edema was due to a fluid excess, owing to the 8 liters of normal saline that was injected subcutaneously. However, we have injected in all patients large quantities of normal saline at 2°C (with 1 mg of adrenaline per liter) and sometimes up to 21 liters, without problem.

We have never experienced complications due to the utilization of normal saline at 2°C. Sometimes we register a moderate decrease in the central temperature of 0.5°C in the postoperative period, but without serious consequences. The 2°C cold saline injection produces a better quality anesthetic than with a pure local anesthesia, either classical or using Klein's tumescent formula, and above all a more important local vasoconstriction.

66.7 Discussion

Fischer, in 1974, used a specially built suction machine and blunt cannulas of different diameters for the extraction of adipose tissue from localized fat deposits on the body. The equipment used was simplified in 1977. The abortion cannulas and suction machine of Karmann allow the surgeon to perform a procedure identical to that of Fischer. In 1985, 60-ml plastic syringes were used, and a special cannula was passed through the syringe mounted on the tip of the barrel. For many surgeons, the syringe replaced the suction machine. Lipoextraction is simple, efficient and rapider.

Liposculpture is indicated for patients having excess fat in some part of the body. Lipoextraction of over 10 liters of supranatant adipose fat is now routine. To achieve this, the surgeon has to inject large amounts of normal saline at 2°C with epinephrine (1 mg/l). The lipoextraction is performed with 60-ml syringes, by one or two surgeons to decrease the duration of anesthesia. Up to 20 liters of adipose tissue mixed with normal saline and some blood can be extracted in one session without blood transfusion.

In most patients, we only inject between 5 and 10 liters, and in only a few patients have we injected 15–20 liters. It appears that adrenaline is quickly metabolized after the injection. In many cases we inject in two or three stages during the operation to avoid major modifications in blood pressure.

Most of our patients are healthy and obese and weigh more than 100 kg. Now we operate also upon patients with weights between 100 and 130 kg without major diabetes, high blood pressure, heart or pulmonary disease, who have tried diets, medical, and surgical treatment without success. Patients should understand that this is not intended as an aesthetic procedure, that complications may occur, and that «touch up» may be necessary as well as other operations to get rid of skin excess, should it occur. Lipoextraction can be performed in patients with a maximum weight of 160 kg, but these patients should understand that the risks of the operation are slightly increased.

Contraindications are (1) patients who have never tried dieting, exercise, or medical treatment, (2) patients who do not understand that this is a major procedure, and that there are some risks, and that a «touch-up» or a future skin resection may be necessary, and (3) patients who have serious disease secondary to their obesity.

Our main goal has been to prove that major amounts of subcutaneous fat can be removed with minimum risk and without blood transfusion. Our patients who understood that it was a lifesaving operation and not a cosmetic procedure have accepted the complications that we had.

Gastrointestinal operations for massive obesity have significant morbidity. In the long term, regain of weight may occur. All bariatric abdominal operations leave the fat cells in place and these can once again hypertrophy if the cause of the obesity was not suppressed at the same time. Only large dermolipectomies, which are major operations, reduce the number of adipose cells. They are burdened with a significant morbidity in the obese patient.

In contrast, closed megaliposculpture reduces greatly the number of adipose cells. This treatment is minor compared with large dermolipectomies.

If a large number of adipose cells remain and can once again hypertrophy, megaliposculpturing is the only moderately aggressive treatment compared with other techniques. Although it does not treat the cause of the obesity, it considerably diminishes the number of the patient's adipose cells. Megaliposculpture has shown that large quantities of adipose tissue can be extracted with minimal risk and that large, localized obesities provoking a functional hindrance can be definitively improved or eliminated. It opens new horizons in the treatment of osteoarthritis of the lower extremities and possibly of the co-morbidities. This operation can be used to treat residual adiposities following gastroplasties or bypass procedures, and may be used for patients who have insufficient weight loss from dieting.

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Cardiovascular Risk Profile Improvement with Large-Volume Liposuction

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67.1 Introduction

Atherosclerotic vascular disease (AVD) continues to be the leading cause of mortality in the USA and most of the developed world [1, 2]. Beyond the mortality attributable to AVD, the toll of morbidity and economic cost (reflected both in direct costs of disease management as well as in expenses incurred from work hours lost) dwarf the costs of cancer, infectious diseases and all other major categories of human ailments [1, 2]. Included under this broad heading are cardiovascular AVD (including but not restricted to acute coronary events such as acute myocardial infarctions and unstable anginal syndromes), cerebrovascular AVD (including but not restricted to ischemic and hemorrhagic strokes as well as transient ischemic attacks and reversible ischemic neurologic deficits) and peripheral AVD (including but not restricted to acute peripheral arterial occlusive syndromes and chronic peripheral arterial insufficiency manifesting as intermittent claudication).

Despite the considerable strides in knowledge regarding AVD risk factors and determinants derived from large epidemiologic studies, improvements in standards of living, and improvements in medical and surgical management, AVD remains the prime cause of mortality in the USA [1, 2].

There are reasons for significant concerns for the future. The prevalence of the metabolic syndrome appears to be rising. First described by Gerald Reaven, the metabolic syndrome is a cluster of clinical, laboratory and metabolic characteristics that portend a particularly high risk for developing AVD and its complications [3–5]. Known by various acronyms such as the insulin resistance syndrome and syndrome X, this cluster was initially described as consisting of hypertension, type 2 diabetes, obesity and dyslipidemia. It now also includes hyperuricemia, microalbuminuria, the polycystic ovary syndrome and non-alcoholic steatohepatitis among other disorders [6–11]. Most recent estimates suggest that the prevalence of the metabolic syndrome is greater than 20% in the adult US population [12].

As alarming as such statistics appear, they may only indicate the tip of the iceberg. The twin epidemics of obesity and type 2 diabetes have the common thread of insulin resistance, which is presumed to be the central pathogenetic mechanism for the development of the metabolic syndrome. Obesity has been clearly shown to be a progenitor for type 2 diabetes, which is in turn associated with extraordinary risk for AVD development. Current estimates suggest that there are fifteen to seventeen million type 2 diabetics in the USA and about one hundred and thirty-five million type 2 diabetics worldwide, of whom about one third are undiagnosed [13, 14]. Diabetes is associated with a threefold to fivefold increase in AVD risk and is the leading cause of blindness, end stage renal disease and amputations in the USA. It contributes to over 15% of the mortality of persons above 25 years old and costs over $100 billion in health expenditure per annum. Data from the latest NHANES survey and the WHO suggest that there are currently 1–2 times more individuals in the US population with impaired glucose tolerance (IGT) (a prediabetic state) as there are diabetics. Such statistics predict that there are between fifteen and twenty million more persons with IGT, who have a 3.6–10%/year conversion rate to diabetes.

The situation is expected to worsen further because of the rising prevalence of obesity (body mass index, BMI, of 30 kg/m2 or more) [15–18]. Most recent estimates suggest a tripling in the prevalence of obesity over the last 30 years, so that now more than 30% of US adults are obese and at least 60% of US adults are overweight (BMI of 25–30 kg/m2) or obese [15–19]. Data from child populations are also worrisome, with latest estimates suggesting prevalence of obesity close to 15% overall and over 25% in some high-risk ethnic groups [15–18]. Obesity is a harbinger for even more diabetes. Estimates suggest that between 68–72% of the attributable risk for diabetes in the US is from obesity and that every kilogram increase in weight over ideal weight contributes, over a 10-year period, a

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diabetes risk of about 4.5% [20]. Similarly, it has been estimated that for every unit increase in BMI above the normal range, the risk of diabetes is increased by 12.1% [20].

Since the overwhelming body of data suggests that obesity plays a considerable role in the increasing prevalence of diabetes, which in turn plays a substantial role in the onset of AVD events and mortality, the necessity for effective strategies for preventing and treating obesity has assumed considerable importance. Large intervention trials from diverse populations in the USA, Europe and China amongst others have clearly demonstrated the capacity of even moderate weight loss to significantly slow the transition from IGT to frank diabetes [21–24]. Some trials of pharmacologic agents including metformin, orlistat, troglitazone and acarbose have also been found effective at preventing progression to type 2 diabetes [21, 25–27].

Several surgical techniques, most notably gastric bypass, have also been shown to be associated with sustained, significant weight loss as well as improvement/resolution in diabetes which would presumably translate to reduced AVD risk [28, 29]. One of the most intriguing of these surgical techniques is large-volume, subcutaneous, liposuction. This chapter reviews the limited data testing the hypothesis that surgical removal of subcutaneous adipose tissue (SAT) can diminish the risks of obesity.

67.2 Large-Volume Liposuction

Liposuction, particularly large-volume liposuction, is not considered a primary therapy for the management of obesity [28–31]. Initially developed primarily as a cosmetic procedure, liposuction is currently the most commonly performed elective cosmetic procedure by plastic surgeons [32, 33]. Small-volume liposuction has undergone considerable evolution in the past few decades [34, 35] and is now increasingly performed by both dermatologists and plastic surgeons [32, 30]. With the improved surgical methods such as use of sonication and tumescent techniques [33] as well as improved perioperative care, larger volumes of fat are now being removed, thus adding the significantly obese to the potential clientele for liposuction.

67.3 Definition

Large-volume liposuction has been arbitrarily defined as the removal of at least 10 lb of body fat, at least 5 l of emulsified body fat and/or at least 25% of total body fat.

67.4 Anatomy and Embryology of Subcutaneous Adipose Tissue

There have been suggestions that there are two biochemically, metabolically, embryologically and anatomically distinct SAT types [36, 37]. There is the so-called metabolically active SAT, which is easily gained and lost, and the so-called reserve SAT, which is easy to gain but more difficult to lose. This SAT component is also called residual fat or localized fat deposit (LFD). Biochemically the two types of SAT have been shown to differ in their relative concentration of beta-1 and alpha-2 adrenergic receptors, thus resulting in marked differences in their sensitivity to the lipolytic effects of catecholamines [36, 37]. LFD type SAT is more efficient in glucose incorporation than metabolically active SAT and thus is often resistant to dietary induced weight loss whilst exhibiting disproportionate weight gain in the setting of global weight gain. There are anatomic and histologic correlates for these findings. The SAT depot consists of the dermal fat, which is organized in dermal papillae and packed between elastic retinacula, and the subdermal fat, which is found between superficial and deep fascial planes and is not as widespread [36, 37]. The subdermal fat layer corresponds to the metabolically resistant LFD fat component that is difficult to lose but relatively easy to gain. This fat depot also appears to be correlated to a greater degree with insulin resistance than dermal fat [38]. These two SAT components also have different embryological origins. The dermal fat is probably ectodermal in origin, while the subdermal fat is mesodermal and more closely resembles visceral fat. The distribution of the subdermal fat layer is variable depending on sex, morphometric build and ethnicity. The areas of the body with the most significant LFD accumulations are in the infraumbilical anterior abdominal wall, shoulders, hips, inner thighs and lateral portions of the buttocks [36–38].

67.5 Intra-Abdominal Adipose Tissue Versus Subcutaneous

67.5.1 Adipose Tissue in the Metabolic Syndrome

A number of studies that have used imaging techniques to assess the regional distribution of body fat have shown that a high accumulation of fat in the abdominal cavity (an excess of intra-abdominal fat), is associated with the cluster of metabolic disturbances typical of the dysmetabolic syndrome, including insulin resistance, hyperinsulinemia, IGT, hypertriglyceridemia, elevated apolipoprotein B (apoB) concentrations, small, dense low-density lipoprotein (LDL) particles, as well as low high-density lipoprotein (HDL) cholesterol levels [39, 40]. Prospective studies such as the Quebec Cardiovascular Study have shown that this cluster of metabolic abnormalities substantially increases the risk of AVD [41, 42].

Intra-abdominal fat constitutes less than 20% of total body fat but has been considered a potential major determinant of fasting and postprandial lipid availability because of its physiological and anatomical properties. The standard theory to explain the correlation of intra-abdominal fat with insulin resistance has been that large amounts of intra-abdominal adipose tissue would release high levels of free fatty acids into the hepatic portal circulation, and thus induce hepatic resistance to the actions of insulin, increase hepatic glucose output, cause excessive tissue lipid accumulation in peripheral adipocytes that remain sensitive to insulin, and contribute to dyslipidemia, beta cell dysfunction, and peripheral muscle insulin resistance. While the veracity of this hypothesis has been recently questioned and though free fatty acids may not be the sole (or even the major) mediator of this so-called portal theory it is still the most consistent with the available animal, clinical and epidemiologic data. Thus, many investigators have concluded that an individual's risk of type 2 diabetes and cardiovascular disease relates closely to their intra-abdominal adipose tissue burden [36, 39, 40, 43, 44].

However, it is also clear that other adipose tissue depots may play important roles in the metabolic consequences of obesity, particularly in the generation of circulating free fatty acids. There is a tight correlation between hepatic glucose output and peripheral free fatty acid concentrations, suggesting one way by which hepatic insulin sensitivity is affected by SAT might be through fatty acid mediated effects. Interestingly, Jensen and colleagues have demonstrated that free fatty acid release by the visceral abdominal adipose depot is not fully suppressible by insulin even in normal-weight, insulin-sensitive individuals. Further, his group has shown that the vast majority of the elevated systemic free fatty acid release of obese individuals appears to come from upper body, non-splanchnic adipose tissue. Thus, dysregulation of upper body, non-splanchnic adipose tissue lipolysis may play an important role in contributing to the health consequences of obesity that are not linked to high intra-abdominal adipose tissue [45, 46].

67.6 Experimental Data for a Metabolic Effect from Removal of Subcutaneous Adipose Tissue

There are few animal data supporting a salutary effect on the components of syndrome X from removal of SAT. Weber et al. [47] found that in hamsters fed a high fat diet, subcutaneous lipectomy of greater than 50% of all the subcutaneous fat of hamsters was associated with development of a metabolic syndrome characterized by intra-abdominal and hepatic fat accumulation, insulin resistance and hypertriglyceridemia [47]. This was suggested to be because the subcutaneous fat depot functions as a «metabolic sink» for the storage and disposal of excess ingested energy [31]. When Kral [48] removed 24% of SAT from non-obese adult Sprague-Dawley rats, there were no changes in metabolic measures, including serum free fatty acids, triglycerides, cholesterol or insulin, and no changes in food intake, weight gain, or compensatory hypertrophy or hyperplasia of adipose tissue compared with sham-operated controls. By contrast, others have found that lipectomy of about 10% of total body weight in Zucker rats is associated with significant improvements in lipid levels [49]. In this study 18 Zucker rats were compared with 18 lean heterozygous Fa+/Fa– rats and were found to have significantly improved total cholesterol and triglyceride levels despite unchanged glucose and insulin levels compared with those of their lean litter mates [49].

Animal models also challenge the notion that long-lasting reductions in adipose tissue are possible following lipectomy or liposuction [50]. Laboratory rats [51, 52] and mice [53–55, 56] and animals that have seasonal changes in adiposity (such as ground squirrels [57, 58] and hamsters [59, 60]) show complete compensatory recovery of body fat following lipectomy and/or malnutrition. In each of these model systems, the lipid deficit is replaced generally through enlargement of the remaining adipose depots, rather than regrowth of excised tissue. There are, however, also a few reports which suggest that this compensatory response is not universal [61].

The possibility that large-volume liposuction and/or lipectomy may have a beneficial effect on the course of obesity, the metabolic syndrome and AVD risk in humans has been suggested by some recent studies. The data are, however, largely preliminary, based on small non-randomized trials, and entirely based on surrogate measures of AVD risk rather than hard clinical outcomes such as incidence of myocardial infarction or type 2 diabetes.

Palmieri and colleagues [62] from Italy, utilizing ultrasound and suction lipectomy in 205 obese subjects, found significant postoperative improvements in blood glucose, triglyceride levels, blood pressures and glucose tolerance tests. Gonzalez-Ortiz and colleagues [63] found similar findings in their cohort of 12 young obese women, six of whom were randomized to large-volume liposuction, while the other six served as controls. At 1 month postoperatively, significant decreases were noted in the blood glucose, uric acid and insulin sensitivity measured by the insulin tolerance test. The major caveat to the findings of Palmieri, Gonzalez-Ortiz and colleagues, however, is that they were only documented in the recent postoperative state (within 30 days postoperatively). It is clearly necessary to demonstrate that such changes persist over extended periods for them to possibly have an impact on overall cardiovascular risk profiles.

Giese and colleagues [64, 65] studied 14 women with a mean BMI of 29.1 kg/m2 and performed ultrasound-assisted tumescent large-volume liposuction. Over a 4-month study period they found significant reductions in weight and BMI (Fig. 67.1) without any significant differences in resting energy expenditure. Fasting insulin and insulin sensitivity assessed by the homeostatic model (HOMA IR) were significantly reduced over the study period (Fig. 67.2), while the fasting lipid profile remained essentially unchanged (Fig. 67.3) [64, 65]. The previously exaggerated beta cell secretory response assessed by HOMA B% also normalized during the study period (Fig. 67.2) [64]. In addition, the systolic blood pressure, the mean arterial pressure and the rate–pressure product, known to be a surrogate of myocardial oxygen demand, all decreased over the study period. (Table 67.1) [64]. Of importance is the fact that these salutary changes in systolic blood pressure, weight and fasting insulin levels persisted at follow-up of this cohort 1 year later [66]. This finding may indicate that liposuction could be valuable because it does not predispose to weight regain or indicate this cohort was atypical, since there is usually substantial weight regain following weight loss caused by behavioral and/or medication-based regimens.

Cazes and colleagues [67] studied 34 obese subjects with the typical android abdominal obesity phenotype of the metabolic syndrome and compared them with 23 controls who though obese did not have this phenotype. Similar to the Giese cohort, fasting insulin levels were lower at 3 months and were still reduced 12 months postoperatively, consistent with a sustained improvement in insulin sensitivity. The total cholesterol, LDL cholesterol and blood pressure levels all significantly declined 3 months postoperatively but were back to baseline at the 12 month follow-up period [67].

Enzi and colleagues [68] studied patients with IGT who first lost of 9.9±1.2 kg through dieting, and

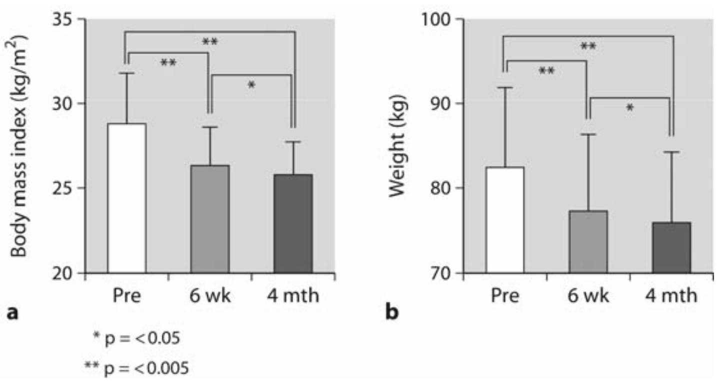

Fig. 67.1. Body weight and body mass index (*BMI*) changes in 14 women following large-volume liposuction [64, 65]

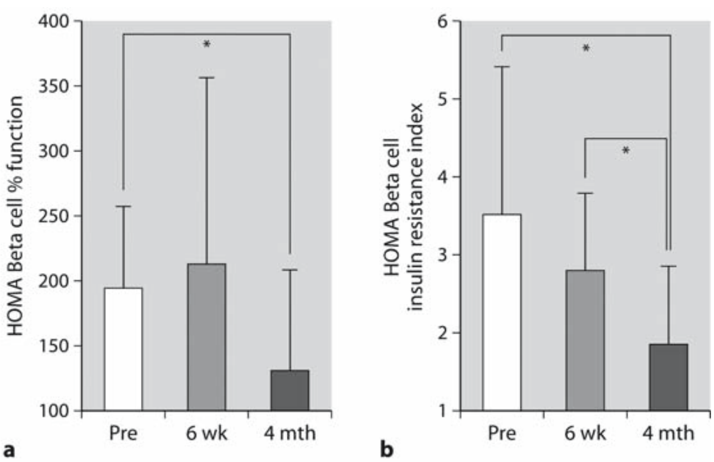

Fig. 67.2. Change in homeostatic model of assessment (*HOMA*) indices for insulin resistance (HOMA beta insulin resistance index) and pancreatic reserve (HOMA beta cell percentage function) in 14 women following large-volume lipsuction [64, 65]. *p<0.05

then underwent surgical reduction of body fat mass (lipectomy) that removed an additional 6.0±0.5 kg By the oral glucose tolerance test (OGTT), such patients had improvements in glucose tolerance and in insulin sensitivity and a reduction in insulin release during the OGTT following the diet, but lipectomy had no further effect upon carbohydrate tolerance, insulin release or insulin sensitivity though a marked decrease in basal plasma free fatty acid values was observed [68].

Talisman and colleagues [69] studied the effects of large-volume liposuction on leptin levels and appetite. In their cohort of 22 women who underwent suction-assisted lipectomy, plasma leptin levels were lower 1 week following the operation, and appetite was subjectively decreased for 12–17 days, but neither of these findings was evident 6 weeks postoperatively, at which time the subjects had lost 7% of their preoperative body weight [69].

Samdal and colleagues [70] studied nine subjects who underwent large-volume liposuction and over the 9–12-month follow-up period noted a significant increase in HDL cholesterol and apolipoprotein A-1 as well as a reduction in insulin levels. Apart from the apoB levels, which increased slightly over the study period, all the other measured indices, including the OGTT, C-peptide, free fatty acids and other components of the lipid profile, remained unchanged [70].

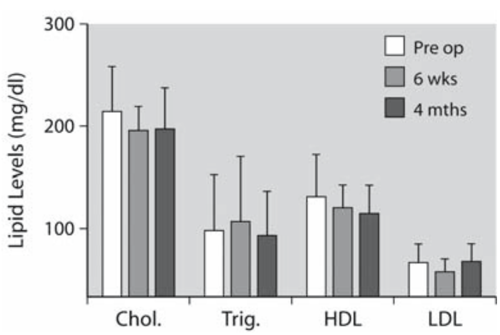

Fig. 67.3. Lipid profiles of 14 women following large-volume liposuction [64, 65]. There were no significant changes in any measured variable

The increased HDL and reduced insulin levels with unchanged glycemic profiles (consistent with improved insulin sensitivity) suggest positive trends as cardiovascular risk surrogates in this study which, despite a small cohort number, had a significant follow-up period.

Berntop and colleagues [71] studied 53 subjects with Dercum's disease (a rare condition characterized by symmetric painful lipomatosis) in whom liposuction was performed. Despite the worsening in procoagulant hemostatic features observed over the study period (2–4 weeks postoperatively), glucose uptake and insulin sensitivity were noted to improve. This is the only study of liposuction thus far in which insulin sensitivity was measured by the "gold standard" for insulin sensitivity estimation, namely, the euglycemic, hyperinsulinemic clamp. These compelling findings are, however, again tempered by the short duration of available follow-up and the fact that these findings were in patients with Dercum's disease and not typical android obesity associated with visceral and anterior abdominal wall adiposity.

The effects of liposuction have also been studied in the special scenario of insulin-associated lipohypertrophy resulting from insulin treatment in diabetes mellitus [72–74], and there have been some anecdotal reports of liposuction in such settings being associated not only with improvement in cosmetic appearance but also reduction in insulin requirements, possibly suggesting improved insulin sensitivity [73, 74].

In contrast to reports of improved insulin sensitivity following liposuction, there have also been a few described cases where patients developed a syndrome of excessive visceral adiposity with metabolic complications following extensive lipectomy [31, 75]. Indeed, the many animal and human [76–81] models of lipodystrophy make it clear that insufficient SAT is quite deleterious. It would appear that, for prevention of the disorders comprising syndrome X, there is an optimal quantity of SAT above and below which the risks of developing syndrome X increase.

In summary, while a number of largely uncontrolled human studies suggest improvements in insulin sensitivity from large-volume liposuction that may

Table 67.1. Cardiovascular changes following large-volume liposuction in 14 women [64]

	Baseline	6 weeks postoperatively	4 months postoperatively
Systolic blood pressure (mmHg)	132 (9)	122 (11)	120.5 (11)*
Diastolic blood pressure (mmHg)	83 (12.3)	77 (5.1)	77 (7.2)**
Pulse pressure (mmHg)	49 (8.5)	45 (7.8)	43.3 (8.6)
Mean arterial pressure (mmHg)	99.3 (10.6)	92 (6.7)	91.6 (7.6)*
Rate–pressure product	10,634 (1,636)	9,542 (1,332)	9,141 (1,744)*

*p<0.05, **p=0.06

last as long as 1 year, the animal data do not support a long-lived effect from such procedures either on body fat or on metabolism. There is also clearly a threshold below which subcutaneous fat depot deficiency can be associated with accelerated development of the metabolic syndrome but it is yet unclear whether clinical large-volume liposuction/lipectomy performed in humans often approaches, or crosses, that threshold. Others suggest that no long-term change in body adiposity can be achieved by large-volume liposuction [50]. Reparation of adiposity has been exhaustively demonstrated to be true in the setting of typical cosmetic small-volume liposuction but not for large-volume liposuction [75, 82].

Beyond the questions regarding the potential deleterious metabolic effects of large-volume liposuction there are also concerns regarding mortality related to thromboembolic events, fat embolism, induction of a procoagulant milieu and malignant arrhythmias which need closer investigation [71, 83–86], despite the existence of some studies that suggest these risks are tolerably low [32, 62, 87, 88].

In an attempt to address in a definitive manner whether or not large-volume liposuction could impact insulin sensitivity and other cardiovascular risk factors, Klein and colleagues at Washington University are in the process of recruiting a cohort of obese diabetic subjects who will undergo large-volume liposuction. The results of this trial are eagerly awaited. The fact that there are some data suggesting potential deleterious effects of large-volume liposuction on metabolic indices and cardiovascular risk factors as well as the known limitations of non-placebo-control randomized prospective trials make it clear that there is still a great need for more studies into the place of large-volume liposuction in AVD risk modulation.

67.7 Putative Pathogenetic Mechanisms

While the exact role of large-volume liposuction in ameliorating the cardiovascular risk profile is yet unclear there are two major opposing hypotheses for the potential pathogenetic mechanisms by which large-volume liposuction may positively impact cardiac risk:

1. Secondary to reduction in the amount of proinflammatory adipokines such as tumor necrosis factor alpha, interleukin-6, angiotensinogen, resistin, etc., or metabolic fuels such as the free fatty acids, which are produced by adipocytes and which contribute to insulin resistance.
2. Secondary to increased energy expenditure and/or reduced appetite resulting in sustained weight reduction and accompanying improvement in insulin sensitivity.

The data available from the literature as just reviewed do not preclude either of the hypotheses. If large-volume liposuction is subsequently demonstrated to positively impact AVD risk, it will probably be the result of variable admixture of these and other thus-far unidentified mechanisms.

On the other hand the potential mechanisms by which large-volume liposuction may negatively impact AVD risk center around the "metabolic sink" hypothesis of subcutaneous fat and variations of the "portal" hypothesis of visceral fat:

1. The metabolic sink hypothesis suggests that the SAT depot is a storage site for excess energy in the form of triglycerides and cholesteryl esters and thus removal of significant amounts of it results in excess amounts of circulating free lipids, including free fatty acids, triglycerides and cholesterol. These free circulating lipids, by inducing lipotoxicity, may worsen beta cell secretory capacity and insulin resistance, thus creating a metabolic syndrome typical of the dysmetabolic syndrome known to be associated with defective endothelial function, procoagulant milieu and increased AVD risk. In addition, the excess circulating lipids would then be accumulated in the liver and the other visceral depots, resulting in increased hepatic glucose output and thus worsening hepatic insulin resistance.
2. The process of large-volume liposuction, by inducing a state akin to traumatic and/or physiologic stress, may induce an acute or chronic phase reaction with cytokine activation which creates a procoagulant milieu associated with increased AVD risk.
3. The process of large-volume liposuction, by causing a sudden profound loss of SAT, and a decrease in plasma leptin, may activate the so called lipostat mechanism which then results in compensatory hypertrophy and/or hyperplasia of the visceral fat depot to restore the prior total body fat mass. The excess visceral fat is presumed to be the source of various factors, including free fatty acids, resistin, interleukin-6 and tumor necrosis factor alpha, which by virtue of the increased concentrations in the portal circulation result in increased hepatic glucose output and hepatic insulin resistance.
4. The process of large-volume liposuction may also remove important protective factor(s) that normally shield against insulin resistance and thus against endothelial dysfunction and AVD risk. Among the suggested putative factors are lipoprotein lipase, adiponectin and leptin.

67.8 Concluding Remarks

Large-volume liposuction is a procedure that can remove substantial amounts of subcutaneous fat, including fat from the localized fat depot that has many biochemical features reminiscent of those found in the visceral adipose tissue that is tightly linked to the conditions of syndrome X. Liposuction and lipectomy have been used in some cases as adjuncts to more established bariatric surgery, and recent developments have raised the possibility of the utility of liposuction as a primary surgical option for obesity management. The effects of large-volume liposuction on AVD risk still require intensive, detailed investigation as there are two opposing theories as to what happens to AVD risk following this procedure. On the basis of clinical and animal data it appears that there is a threshold effect: where removal of excessive subcutaneous fat may result in AVD risk improvement, while removal of significantly greater amounts may result in deleterious effects. Clear definition of what determines this threshold in the individual patient is an important issue that needs to be resolved. The results of ongoing human and animal studies on this subject are eagerly awaited.

Acknowledgement. This research was supported by the National Institute of Child Health and Human Development, NIH (ZO1 HD-00641).

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68 Liposuction for Gynecomastia

Enrique Hernández-Pérez, Hassan Abbas Khawaja, Jose A. Seijo-Cortes

68.1 Introduction

Male breasts are one of the four most requested areas for liposuction in men (after love handles, abdomen, and submaxillary fat) [1]. This is true not only in teenagers but also in adult men. The reason being the cosmetic inconvenience and the loss of self-confidence produced by a feminine self-image.

Pseudogynecomastia is defined as an excessive amount of adipose tissue in the male breast, along with a normal amount of glandular breast tissue [1]. True gynecomastia is the increase in size of male breasts due to glandular tissue proliferation [2, 3]. A mixed variety combines excessive fatty and glandular tissue.

68.2 Pathogenesis

Pseudogynecomastia is typically an idiopathic condition [1]. A central issue in the evaluation of breast tissue in adult men is the separation of the normal from the abnormal. A common belief is that no breast tissue is palpable in the normal adult man; however, gynecomastia (less than 4–5 cm in diameter) may occur in normal men [4].

Physiological gynecomastia occurs in at least three circumstances: (1) at a few weeks of age (transitory enlargement); (2) in adolescence (median age onset is 14, it is grossly asymmetric, frequently tender, and regresses spontaneously) [5]; and (3) gynecomastia in elderly men (40% have gynecomastia).

There also exists a pathological gynecomastia that can result from one of four basic mechanisms [1–4, 6]:

1. Deficiency in testosterone production or action (congenital anorchia, Klinefelter syndrome, testicular feminization syndrome).
2. Increase in estrogen production (aberrant production of chorionic gonadotropin by testicular or by bronchogenic carcinoma or even estrogen production caused by true hermaphroditism) [5, 7].
3. Increased conversion of androgens to estrogens in peripheral tissues (congenital adrenal hyperplasia, hyperthyroidism, and feminizing adrenal tumors).
4. Drugs such as digitalis, alkylating agents, spironolactone, cimetidine, busulfan, isoniazid, tricyclic antidepressants, D-penicillamine, anabolic steroids, phenytoin, clomiphene, and diazepam. Abuse of heroin and marijuana also may cause gynecomastia.
5. Consecutive to trauma [5, 7].

When the physician discovers unilateral enlargement in a male breast with obvious asymmetry it is mandatory to rule out a primary breast tumor and a mammogram must be ordered [1].

68.3 Surgical Anatomy

Breast tissue has increased vascularity and the tendency for bleeding with breast liposuction is greatly attenuated by tumescent anesthesia [1]. However, it is important that the surgeon remember the proximity of the pectoralis muscle because it makes this tissue vulnerable (by either infiltration or liposuction) to trauma during male breast liposuction with the potential risk of bleeding and hematoma [8]. Therefore, a careful exploration is important in order to locate the breast tissue–pectoralis interface [1]. In this sense, the patient is asked to tighten the pectoralis muscle so that the surgeon can appreciate the textural difference between soft fat, the firm muscle, and the glandular tissue. Another way to distinguish it is by asking the patient to put his hands behind his head in the supine position. This maneuver will stretch the pectoralis muscle and again the palpation will reveal which tissue is fat.

Another important point is in relation to the adipose tissue; the male breast is very fibrous and therefore additional effort will have to be made in order to perform reduction with liposuction [1].

Finally, true breast glands in men are located subjacent to the nipple-areolar complex and are firmer than the surrounding fatty tissue. When glandular tissue predominates (true gynecomastia), liposuction will not be as successful as with only fatty tissue. A routine mammogram may facilitate the assessment of the amount of glandular tissue versus adipose tissue [1].

68.4 Preoperative Preparation

An extensive discussion about patient expectations related with the procedure is important as well as photographic documentation. Also, it is useful to draw on the patient in order to define the objectives of the proposed surgery.

The increase of male pseudogynecomastia with age and degree of obesity as well as with increasing obesity means that fat may also be augmented along the anterior axillary area and on the lateral chest wall. Therefore, it is important to treat those areas at the same time in order to reach a satisfactory result.

All patients, irrespective of age, are sent to the cardiologist for a complete cardiac and vascular checkup, mentioning especially that we are going to use epinephrine for the procedure. Only patients in categories ASA I or II should be included. Patients with congestive cardiac failure are excluded. Patients undergo a complete hematological checkup which includes especially liver function tests, fasting blood sugar fasting, hepatitis B and C profile, and HIV studies [9]. A detailed history of drugs and other etiologic factors are taken into consideration. Patients are advised to use an antiseptic soap bath 3 days prior to surgery, especially in the areas to be liposuctioned. The authors use povidone iodine or clorhexidine. All medications especially aspirin, β-blockers, vitamin E, and herbal drugs are discontinued 10 days prior to surgery [9]. Patients are advised not to smoke 2 weeks prior to surgery. An oral antibiotic (cefadroxil monohydrate) is started 1 day before surgery and continued for 7 days postoperatively. Clonidine (0.1 mg), as a premedication, is given 1 h prior to surgery to those patients whose blood pressure is greater than 90/60 mmHg. As an α2 adrenergic agonist (besides its hypotensive action), clonidine has hypnotic, sedative, and analgesic actions; therefore, this drug has a synergistic sedative effect which decreases the requirements and the total dosage of intravenous sedation–analgesic medication, with the obvious benefits in the postoperative period [10]. The authors also use 150 mg of ranitidine in a suspension and 10 mg of methoclopramide orally in order to reduce the risk of postoperative vomiting [10].

68.5 Operative Technique

A careful cleaning of the areas is done using povidone iodine from the neck, including the axillae to the umbilicus. A second cleaning of the breasts with povidone iodine is done starting from the nipple and areola and moving centrifugally. After careful scrub-up using a double-brush technique and 10 min for scrubbing using povidone iodine and disposable gowns and sterile disposable gloves, the procedure is started.

A sterile operating room technique is mandatory. Using insulin syringes, 1% lidocaine/1:400,000 epinephrine is injected intradermally in the incision sites in the anterior axillary line. The incision sites are incised using a no. 11 blade. The infiltration is started with a 10-ml syringe using a Lamis infiltration syringe system and chilled Klein's solution [11, 12]. Light intravenous sedation using midazolam and fentanyl is performed by an experienced anesthesiologist, who monitors carefully the patient during the surgery [11]. Immediately prior to surgery, an 1 g of antibiotic (from the same group as a cephalosporin) is administered by the anesthesiologist. If there is excessive hypertrophy, and the procedure exceeds 3 h, the same dose of antibiotic is repeated. A very small incision is made with the tip of a no. 11 blade scalpel. The placement of the incision is different when working in gynecomastia or in pseudogynecomastia (Fig. 68.1). An infiltration pump for the anesthesia is hardly ever necessary. A modification of Klein's solution without bicarbonate (0.05% lidocaine 0.05%, 1:1×10^6 epinephrine) is used [9, 11]. We believe bicarbonate in Klein's solution causes excessive inflammation and shortens the anesthetic period. Triamcinolone is not used [11]. The infiltration is carried out not in the gland, but in the retromammary space between the gland and the muscle (pectoralis major). While one hand is injecting, the other hand feels the tumescence [11–14]. The

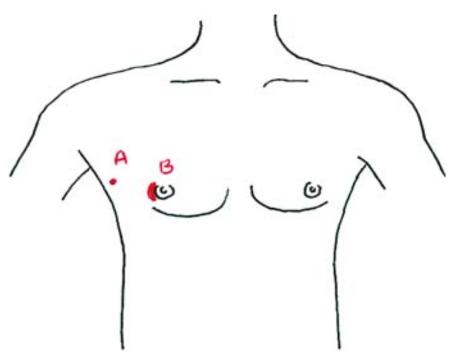

Fig. 68.1. The placement of the incisions is different in *a* pseudogynecomastia and *b* gynecomastia

infiltration is stopped only when the breasts become stony hard.

Liposuction is started using 3-mm keel cobra tip cannulas working in the retromammary space [9, 14]. Liposuction is started using a machine at a pressure of –30 mmHg. Syringe liposuction can also be carried out using a Toomy or a Tulip system and 60-ml syringes. The base of the cannulas is protected with a gauze to prevent damage to the lips of the incision sites. Gentle homogeneous movements are carried out. While one hand performs the liposuction, the other hand lifts the breast tissue upwards in order to prevent unnecessary damage to the breast tissue itself and for smooth working of the cannula in the retromammary space. The idea is not to perform liposuction in the breast tissue itself, but to perform it in the retromammary space that is filled with fat between the gland and the pectoralis major muscle. Tunnels are created centrally from below and from the lateral edge of the breasts [9, 14]. The axillary approach for liposuction is not used. A number of complications (vascular, nerve) can take place with that approach and when using the ultrasonic method of liposuction, especially internal ultrasound [15]. A touch-up is provided with a 2-mm cannula. After the procedure, all the remaining fluid, as much as possible, is pushed out of the incision sites using roller towels. The incision sites are not closed. Sterile padding and French tape are applied over areas of liposuction. The French tape is applied in the form of a plus, corresponding to the direction of the tunnels [9, 14]. The pressure garment is applied on top of the French tape. Steroid injection, 4–8 mg of dexamethasone, perioperatively and an antiemetic injection in the immediate postoperative period are given by the anesthesiologist.

The situation with true gynecomastia is a little different. Once the incision has been made several passes of the cannula are made to dissect and liberate the glandular tissue. The tissue is grasped with a Kocher forceps and all adhesions are dissected carefully and gently. Special care must be taken with the nipple and the areola. All the remaining fluid is removed at the end.

68.6 Postoperative Considerations

All the garments and dressings are removed on the second day postoperatively and the areas are examined and cleaned. Only pressure garments are advised for the next week [16]. Postoperative tenderness usually settles quickly [17]. Low-dose steroids are prescribed, if necessary, which decrease the inflammation. Urea (10%) and 1% hydrocortisone cream, to be used twice daily, is applied over areas of liposuction to improve the inflammation and decrease the hardness. The results are generally excellent (Figs. 68.2–68.5). A touch-up is hardly ever necessary. An anti-inflammatory ultrasound procedure is started after 1 week and is repeated once a week for 4–6 weeks.

Most patients are able to go back to work the day after surgery and can resume full sport activities in 2 weeks.

68.7 Complications

68.7.1 Hematoma

Hematoma can take place if the tumescent technique is not utilized or ultrasonic liposuction is used. Internal ultrasound is dangerous and can damage the

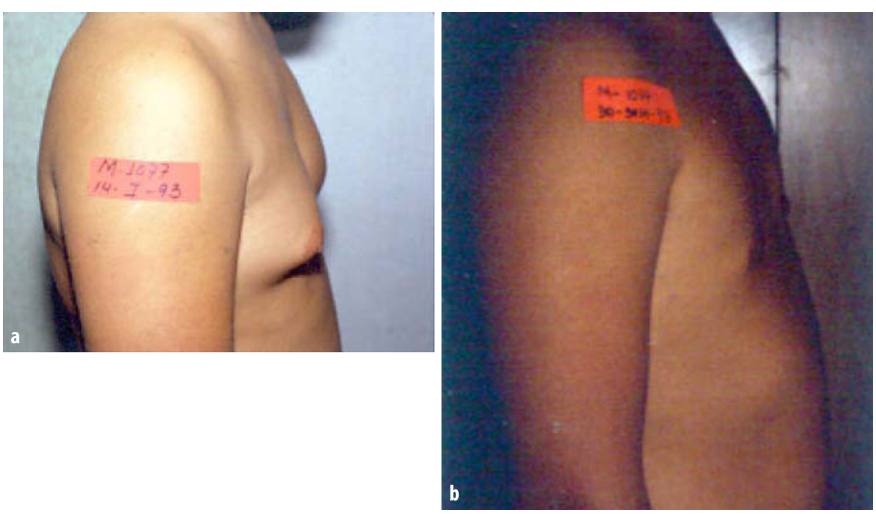

Fig. 68.2. a Preoperative patient with gynecomastia. **b** Postoperative patient

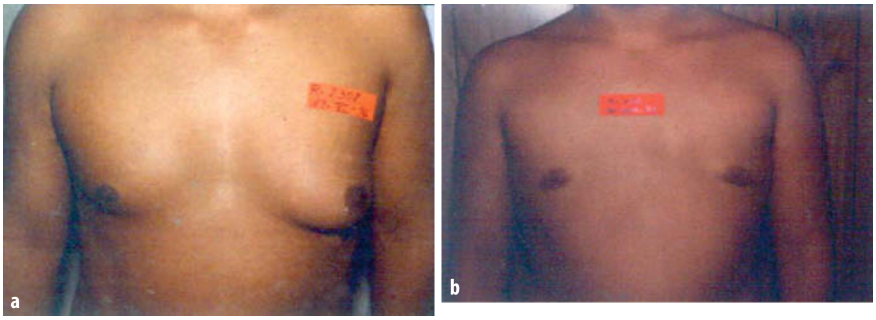

Fig. 68.3. **a** Preoperative patient with pseudogynecomastia. **b** Postoperative patient

vasculature of the breast via penetrating rays. On the other hand, seroma and/or hematoma are/is avoided with the correct compression.

68.7.2 Edema/Irregularities

Postoperative edema usually settles down quickly. Irregularities are generally not seen unless the operation is performed by an inexperienced surgeon [18].

68.7.3 Vascular Injuries

Damage to the perforating branches of the internal thoracic artery, intercostal arteries, lateral thoracic and thoracoacromial branches of the axillary artery, and corresponding veins can take place over the breast, leading to hematoma formation [19, 20]. Damage to the axillary artery, its branches, and the axillary vein can occur if the axillary approach is used with either conventional cannulas or ultrasonic ones. Ultrasonic cannulas over the left breast are very dangerous owing to the close proximity of the heart, while on the right side, damage to the lung and liver can take place.

68.7.4 Nerve Injuries

Damage to the roots, trunks, and divisions or cords of the brachial plexus can take place if an axillary approach is used [15, 20].

68.7.5 Dysesthesia

There also exists the possibility of some degree of nipple hyperesthesia or, on the other hand, loss of nipple sensation. Both are transient.

68.8 Conclusions

Male breast liposuction usually offers very nice results for this common problem of gynecomastia. Improvement in the body contouring as well as in the self-esteem constitutes the aim of this operation.

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Axillary Approach in Suction-Assisted Lipectomy of Gynecomastia

Antonio Carlos Abramo

69.1 Introduction

Gynecomastia or hypertrophy of breast tissue is a serious cosmetic compromise for either adolescent or adult men. Male breast enlargement is a relatively common occurrence during puberty. In the majority of patients no pathologic cause for the problem can be found. A minimal degree of hypertrophy of breast tissue is a normal happening in the adolescent man, regressing spontaneously with maturity. Maintenance of the breast enlargement addresses surgical treatment of the gynecomastia. Breast enlargement in the adult man occurs owing to excess adipose tissue or to combination of adipose and glandular tissue. Spontaneous regression in adult men is occasional and surgical treatment is indicated most of the time.

69.2 Anatomy

The breast is rudimentary in men, although the structure is identical with that of the female breast. The glandular tissue distributes radially from the nipple in fifteen to twenty lobes, which are composed by multiple small ducts of lobules [1]. Adipose tissue fills the interstices between the lobules but is absent or in small amount at the nipple-areola complex. A framework of fibrous strands transverses the breast supporting its lobules, connecting with the skin as the suspensory ligaments of Cooper and reaching back to the pectoralis fascia. Layers of adipose tissue infiltrate into the framework of fibrous strands also extending around the glandular tissue [1]. This rudimentary structure becomes enlarged in gynecomastia with prevalence of either glandular or adipose tissue regarding the etiology of the gynecomastia.

69.3 Etiology

The etiology of gynecomastia is not completely ascertained. In late adolescence and in the adult man gynecomastia can be associated with endocrine disorders, usually related to tumors of the adrenal gland. Hormonal imbalance increases both glandular and adipose tissues. The indiscriminating use of anabolic steroids causes gynecomastia, including its recurrence after clinical or surgical treatment [2]. Congenital anomalies, such as the Klinefelter syndrome, affect men with gynecomastia and feminine fat distribution, exhibiting elevated amounts of estrogen and progesterone receptors [3]. The Peutz–Jeghers syndrome associated with feminizing Sertoli cell tumor, also affects men with prepubertal gynecomastia [4]. Various medications or medical conditions, such as tumors of the prostate gland, develop glandular gynecomastia with moderate acinar and lobular formation. Patients presenting idiopathic gynecomastia have an obscure or unknown cause, with the breast enlargement arising spontaneously owing to the development of adipose tissue, glandular tissue, or both adipose and glandular tissue.

69.4 Classification

Propositions to arrange into classes the multiple expressions of gynecomastia include an oversimplification of the male breast deformities regarding the size of the breast enlargement and the etiology of the disorder.

Simon et al. [5], on the basis of morphological deformities, classify the size of the male breast enlargement according to the breast volume and the skin redundancy, distributing the gynecomastias into four grades:

1. Grade 1: Minimal enlargement of the breast tissue
2. Grade 2A: Moderate enlargement of the breast tissue without skin redundancy

3. Grade 2B: Moderate enlargement of the breast tissue with moderate skin redundancy
4. Grade 3: Massive enlargement of the breast tissue with expressive skin redundancy

Geschikter and Copeland [6] associate etiological and parenchymal disturbances of the male breast to classify the breast enlargement, distributing the gynecomastias in four types regarding the influence of etiological and parenchymal disturbances in the morphological deformity:

1. Type 1 or diffused hypertrophic form: usually occurs during adolescence owing to hormonal imbalance with feminine characteristics for the male breast
2. Type 2 or fibroadenomastosa form: similar to the diffuse hypertrophic form with nodules of either glandular or fibrous tissue spread in the breast
3. Type 3 or true gynecomastia: increase of both glandular and adipose tissue, resembling the female breast in size and shape
4. Type 4 or pseudogynecomastia or adipose form: increase of adipose tissue without compromise of the glandular tissue, usually encountered in the adult man

69.5 Indications

Indication for the surgical correction of gynecomastia by use of suction-assisted lipectomy through the axillary approach is based on careful patient selection and accurate diagnosis of the breast deformity. Clinical examination in conjunction with ultrasonography and mammography is capable of determining the consistency and density of the breast enlargement, making a distinction between soft or adipose gynecomastia, firm or glandular gynecomastia and adipose–glandular gynecomastia. Examination of the patient with the arms in an upright position is helpful to define the limits of the glandular tissue in the breast enlargement. Skin compromise such as flaccidity, redundancy, and striations rather than the breast enlargement must be appraised in detail during clinical examination. Young patients with good skin tone are the ideal candidates for suction-assisted lipectomy; however, old age is not a contraindication. Although a decrease in skin elasticity occurs with increased age, the ability of the skin to shrink still remains. Patients with less than ideal indication are more commonly encountered, but recovery of the chest contour with suction-assisted lipectomy through the axillary approach is almost the same as for those with ideal indication.

69.6 Surgical Procedures

Surgical correction of the multiple expressions of gynecomastia involves subcutaneous mastectomy and/or suction-assisted lipectomy with individual approaches. The commonest approach for direct subcutaneous mastectomy in the treatment of gynecomastia is the semicircular intra-areolar incision described by Webster [7]. Balch [8] proposed the transaxillary approach to avoid noticeable scars after subcutaneous mastectomy in surgical correction of gynecomastia. Ohyama et al. [9] used the transaxillary approach for endoscope-assisted en bloc removal of fat and glandular tissue in treating gynecomastia. However, unpleasing scars, skin redundancy, irregularities on chest contour, and deformities of the nipple-areola complex, as result of subcutaneous mastectomy, address surgical correction of gynecomastia to minimally invasive procedures. According to Abramo [10] combination of the axillary approach with suction-assisted lipectomy decreases, significantly, the morbidity in the treatment of multiple expressions of gynecomastia, avoiding these disagreeable results.

69.6.1 Suction-Assisted Lipectomy Through the Axillary Approach

Suction-assisted lipectomy through the axillary approach can be performed with or without fluid infiltration of the breast tissue. The «dry technique» that does not use preinfiltration of fluid is accompanied by a higher percentage of blood in the aspirate. The «wet technique» uses preinfiltration of fluids with a low-dose of epinephrine and dilute local anesthetic added, regardless of the breast enlargement. Application of the wet procedure reduces the blood loss to approximately 4–8% of the aspirate [11].

69.6.2 Equipment

Accurate selection of appropriate equipment is of utmost importance in suction-assisted lipectomy through the axillary approach. The standard instrumentation technique and the syringe technique are the most commonly employed procedures in surgical correction of gynecomastia because of the excellence of aesthetic results and the very low rate of complications. The standard instrumentation procedure uses an electric pressure vacuum pump connected to the suction cannula by non-collapsible tubing. The syringe technique utilizes a syringe directly connected to the suction cannula, generating the negative pressure required to aspirate breast tissue drawing back the syringe plunger. The repetitive and linear movement of the suction cannula prior to its suction mechanically disrupts the breast tissue.

Despite the effectiveness in aspirating fibrous tissue, ultrasound-assisted lipoplasty and power-assisted lipoplasty through the axillary approach are not widely used in surgical correction of gynecomastia. The higher complication rates and long-term unknown effects of the ultrasonic waves as well as the excessive cost with no prospective studies of the power-assisted lipoplasty have not stimulated its use.

69.6.3 Suction Cannulas

Breast tissue is accessible to the suction cannula. Conventional round-pointed suction cannula are effective to remove fat tissue in treating gynecomastia, but insufficient to penetrate into the glandular tissue. However, the adipose tissue scattered amongst the breast lobules decreases the resistance of the glandular tissue and this becomes accessible to special pointed suction cannulas. Sharp-pointed suction cannulas are employed successfully to penetrate the hardness of the glandular breast tissue, and the residual glandular tissue is removed after suction-assisted lipectomy of the fat tissue. The use of sharp-pointed suction cannulas avoids direct subcutaneous mastectomy in several types or grades of gynecomastia.

69.6.4 Incision

Surgical correction of gynecomastia through suction-assisted lipectomy alone employs a single incision at the axillary fold [12]. Suction-assisted lipectomy, in conjunction with subcutaneous mastectomy, employs more than one incision. Usually, the first incision is made on the axillary fold next to the anterior axillary line for suction-assisted lipectomy and the second incision is made directly over the breast tissue at the periareolar area for subcutaneous mastectomy [12].

As scars follow all incisions, failure in healing is considered an unfavorable effect not a complication. However, either dystrophic or dyschromic scars, caused by the repetitive movements of the cannula against the incision margins during suction-assisted lipectomy, are cosmetically not desirable. Abramo [13] proposes a protector tube guide for the margins of the incision to avoid damage of its borders during suction-assisted lipectomy. The device exhibits a T-shaped design composed by a hard tube with a support plate at its proximal end (Fig. 69.1). The tube is 5.0 cm in length and has a diameter of 0.5 cm, somewhat bigger than the diameters of the suction cannulas employed in suction-assisted lipectomy, using the axillary approach, of gynecomastia. The support plate has two holes located laterally to the tube opening, to fix the device at the incision margins, avoiding injury of the skin during suction-assisted lipectomy. The suction cannula is inserted into the hard tube through the central opening of the support plate, remaining without contact with the incision margins during suction-assisted lipectomy.

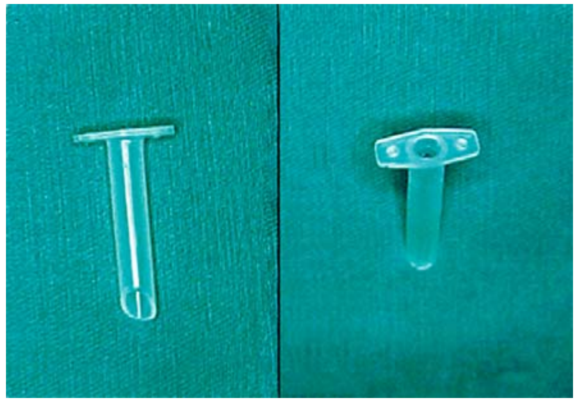

Fig. 69.1. Tube guide for protection of the internal borders of the incision. The holes of the support plate are located laterally to the tube opening

69.6.5 Operative Technique

An electric high-pressure vacuum pump aspirator generating negative pressure up to 1.0 bar (equal to 0.987 atm) has been used successfully for suction-assisted lipectomy of the breast tissue. The average pressure during suction of breast tissue ranges from 0.8 to 0.9 bar of negative pressure. The level of negative pressure is increased as suction is performed in an enclosed space. The dry technique is employed for small volume removals and the wet technique, infusing small quantities of fluid with dilute lidocaine and epinephrine solutions, is employed for moderate to large volume removals.

The marking of the breast enlargement is done with the patient in a sitting position, defining the limits of the breast enlargement (Fig. 69.2). The marking of the patient in the sitting position is important, because the horizontal position added by adduction of the arms on the operating table displaces the breast enlargement upward in the direction of the shoulder, changing the position and circumference of the breast enlargement (Fig. 69.3a). The incision for suction-assisted lipectomy is drawn in the axillary fold, following the projection of the anterior axillary line, at the lateral border of the pectoralis major muscle (Fig. 69.3a). The length of the incision ranges from 0.5 to 1.0 cm, regarding the circumference of breast enlargement. From the incision marking at the axillary fold, several straight lines are drawn toward the boundaries of the breast enlargement, following the direction of the fibers of the pectoralis major muscle, in a fan shape (Fig. 69.3b). The straight lines outlined over the breast surface guide the suction cannula during suction-assisted lipectomy.

A full-thickness incision of the skin over the marking in the axillary fold exposes the superficial aponeurosis of the pectoralis major muscle. From the axillary incision a small tunnel, 5.0-cm long and 0.5-cm wide, is dissected over the superficial aponeurosis of the pectoralis major muscle. The protector tube guide is inserted within the tunnel and anchored in the internal border of the incision margin, through the holes located on the support plate of the device (Fig. 69.4a). The hard tube protects the skin from injury caused by the repetitive movements of the suction cannula, during suction-assisted lipectomy. Through the tube guide a 3.0-mm straight round-pointed suction cannula dissects a narrow tunnel over the superficial aponeurosis of the pectoralis major muscle, along the lateral border of the muscle, to the proximal boundary of the outlined breast enlargement (Fig. 69.4b). From the proximal boundary several tunnels are dissected into the breast tissue following the straight lines marked on the skin of the breast, toward the circumference of the breast enlargement (Fig. 69.5). The breast tissue is aspirated along the tunnels by repetitive forward-to-backward linear movements of the suction cannula. Numerous septa of breast tissue, containing fat and fibrous tissue with intact vessels and nerves, remain through the tunnels, creating a spongy framework between the skin and the muscular plane.

Fig. 69.2. Marking of the breast enlargement with the patient in a sitting position

Suction-assisted lipectomy through the axillary approach employs four different types of suction cannulas.

1. A 4.0-mm straight round-pointed suction cannula with a large central opening and two small openings laterally and backward located in relationship to the central opening.
2. A 3.0-mm straight round-pointed suction cannula with three small openings elliptically arranged (Fig. 69.6a).
3. A 2.0-mm straight round-pointed suction cannula with three small openings elliptically arranged (Fig. 69.6b).
4. A 4.0-mm straight sharp-pointed suction cannula with a single and large opening (Fig. 69.6c).

Suction-assisted lipectomy begins with the 4.0-mm straight suction cannula inserted deep at the central portion of the breast, to remove the major volume of fat and fibrous tissue responsible for the enlargement and projection of the breast (Fig. 69.7a). Suction-as-

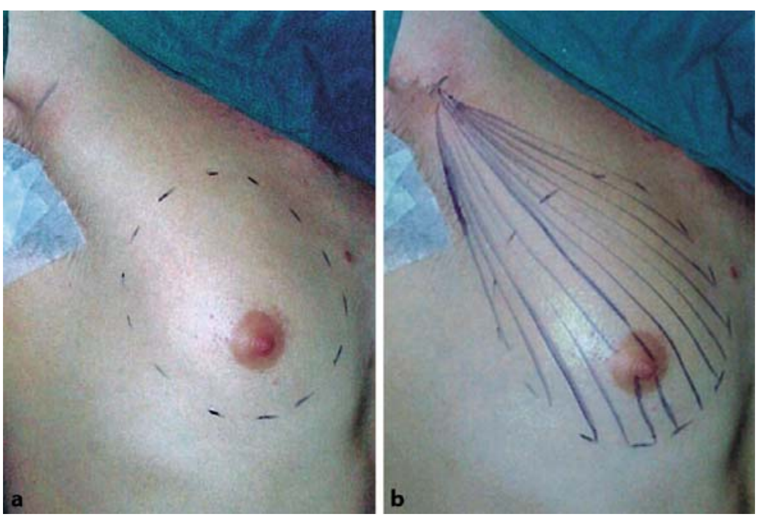

Fig. 69.3. **a** Displacement of the breast enlargement to the shoulder after adduction of the arms on the operating table. **b** The *straight lines*, outlined over the breast enlargement, direct the course of the suction cannula during suction-assisted lipectomy

Fig. 69.4. a The tube guide is inserted into the incision, **b** protecting the skin, at the incision margins, from injury caused by movements of the suction cannula

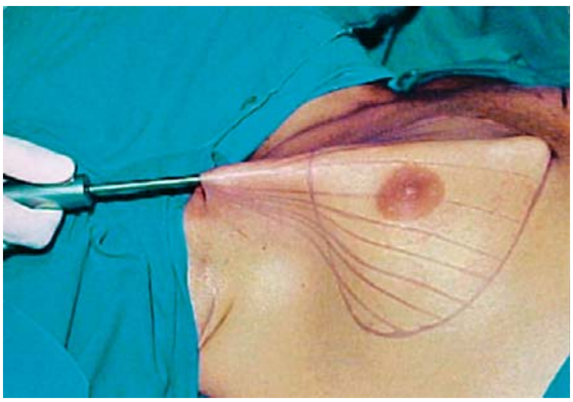

Fig. 69.5. The suction cannula creates several tunnels into the breast tissue from the axillary fold to the boundaries of the breast enlargement

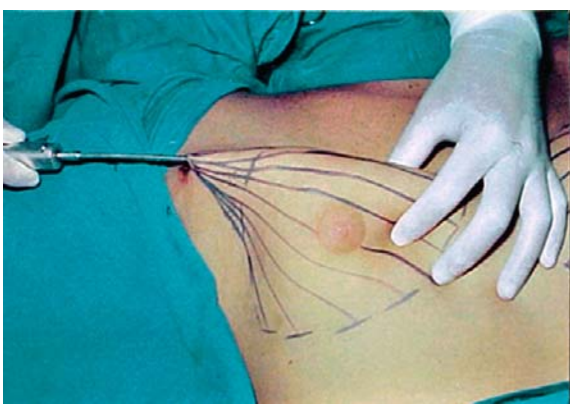

Fig. 69.6. The suction cannula is inserted deep in the breast tissue

Fig. 69.7. Residual glandular tissue resection

sisted lipectomy follows with the 3.0-mm round-pointed suction cannula, more peripherally inserted in the breast enlargement, to aspirate the remainder of the fat and fibrous tissue around the central portion of the breast, defining the glandular tissue resistant to the round-pointed suction cannula. The 2.0-mm round-pointed suction cannula aspirates fat tissue at the outlined boundary of the breast enlargement, refining the chest contour. Finally, the 4.0-mm sharp-pointed suction cannula dissects and aspirates the residual glandular tissue underneath and surrounding the nipple-areola complex, recovering the male chest contour (Fig. 69.7b).

Combination of the high negative pressure provided by the vacuum pump, increased by the enclosed compartment created by the axillary approach, and suitable sharp-pointed suction cannulas allows penetration and aspiration of the glandular tissue of the breast. However, excessive hardness of glandular tissue creates a significant resistance to the sharp-pointed suction cannula leaving an unpredictable amount of glandular tissue, usually at the areolar area (Fig. 69.8a). In such cases, subcutaneous mastectomy is added to suction-assisted lipectomy with the axillary approach to attempt the direct removal of the remaining glandular tissue, without the need for skin resection (Fig. 69.8b). Resection of the residual glandular tissue is done through an inferior periareolar incision (Fig. 69.8c).

A compressive dressing is used to exert strong pressure over the aspirated area for the first 24 h. A simple elastic garment replaces the compressive dressing to apply moderate pressure over the chest during the following 4 weeks. Moderate pressure avoids seroma and hematoma and also aids in the skin adjustment. Drainage is not performed either for the resected area or for the aspirated area.

Acceptance by the patients of suction-assisted lipectomy through an axillary approach is extremely high because the incision is minimal and is placed on a masked area, and exactness in breast contouring is attained with minimal morbidity (Fig. 69.9). In addition, the procedure can be easily repeated to refine the results or accommodate skin redundancy. The axillary approach further provides a small incision in a hidden area and magnifies the intensity of suction because the breast tissue is aspirated in an enclosed space that is distant from the access for the suction cannula.

The narrow tunnels dissected over the pectoralis major aponeurosis, from the axillary incision to the proximal boundary of the breast enlargement, create a compartment without air inside the breast tissue, increasing the level of the negative pressure provided by the vacuum pump. Reinforcement of the negative pressure makes suction of more resistant tissues, such as the glandular tissue of the breast, more effective. Otherwise, suction in all directions, from the axillary incision to the boundary of the breast enlargement in a fan shape, allows better skin adjustment.

Suction of the fat lobules creates a spongy framework in the breast tissue, addressing the skin retraction through the shrinkage of the fibrous septa

Fig. 69.8. a A 15-year-old male patient with hormonal imbalance presenting true gynecomastia of Geschickter or grade 2B of Simon. **b** He underwent suction-assisted lipectomy through the axillary approach in conjunction with subcutaneous mastectomy. The good skin tone and the lack of skin redundancy allow skin adjustment

of the breast located within the septa of the spongy framework. Contraction of the breast septa adjusts the skin, avoiding skin resection even in patients with severe gynecomastia and marked skin redundancy (Fig. 69.10). In addition, tunneling and suction using the 2.0-mm suction cannula refine the peripheral contour of the breast, achieving a natural contour for the male chest. Removal of the breast tissue by aspiration leaves the vessels intact inside the breast septa of the spongy framework. Also, the nerves preserved in the breast septa maintain sensation of the breast.

Suction-assisted lipectomy through the axillary approach alone or in conjunction with resection of glandular tissue has application for the multiple expressions of gynecomastia including severe breast enlargement with significant skin redundancy.

69.7 Surgical Applications

Application of suction-assisted lipectomy through the axillary approach alone or in conjunction with subcutaneous mastectomy takes into account the degree of skin compromise and the extent of the breast enlargement, according to the classifications of Simon and Geschikter for gynecomastia.

Suction-assisted lipectomy through the axillary approach alone is usually performed in patients with minimal to moderate breast enlargement with predominance of fat tissue and minimal skin redundancy. Gynecomastia grade 1 and grade 2A of Simon, and type 4 or pseudogynecomastia of Geschikter are indications for suction-assisted lipectomy through an axillary approach alone (Fig. 69.11). The difficulty in penetrating the glandular tissue of the breast with conventional round-pointed suction cannulas is relieved by using

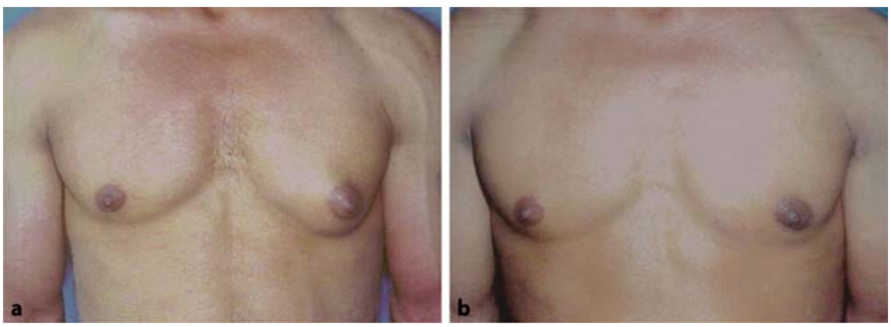

Fig. 69.9. a A 34-year-old male bodybuilder with unilateral pseudogynecomastia of Geschickter or grade 1 of Simon due to indiscriminate use of anabolic steroids. **b** Recovery of chest symmetry through suction-assisted lipectomy alone, only employing round-pointed suction cannulas

Fig. 69.10. a A 17-year-old male patient with hormonal imbalance presenting extreme true gynecomastia of Geschickter or grade 3 of Simon. The massive breast enlargement is determined by increase of fat and glandular tissues with predominance of fat tissue. Severe skin redundancy is also present. **b** He underwent suction-assisted lipectomy through the axillary approach in conjunction with subcutaneous mastectomy and repetitive suction-assisted lipectomy alone using the axillary approach. The skin tone was helpful for skin adjustment

special types of suction cannula [14, 15]. In addition, the layers of adipose tissue spread into the interstices between the breast lobules, allowing sharp-pointed cannulas to dissect and aspirate the glandular tissue. With the use of appropriate cannulas, gynecomastia grade 2B of Simon and type 3 or true gynecomastia of Geschikter with no significant amount of glandular tissue are also treatable by suction-assisted lipectomy through the axillary approach alone (Fig. 69.12).

Suction-assisted lipectomy through the axillary approach in conjunction with subcutaneous mastectomy are also a minimally invasive technique. This association is the most frequently employed procedure in surgical correction of moderate and severe degrees of gynecomastia with mild or moderate skin redundancy. Subcutaneous mastectomy is performed as an adjunct to suction-assisted lipectomy, removing the residual glandular tissue resistant to the suction cannula, in patients with a significant amount of extremely dense glandular tissue. Suction-assisted lipectomy through the axillary approach in conjunction with subcutaneous mastectomy has application in gynecomastia grade 2A and grade 2B of Simon, and type 2 or fibroadenomastosa form and type 3 or true gynecomastia of Geschikter. An alternative to avoid excessive skin resection with unacceptable scars in treating severe gynecomastia with significant skin redundancy is achieved by suction-assisted lipectomy through the axillary approach in conjunction with subcutaneous mastectomy, followed by repetitive suction-assisted lipectomy alone employing the axillary approach (Fig. 69.13). Repetitive suction-assisted lipectomy stimulates contraction of the skin adjusting its redundancy, and is beneficial to patients with severe breast enlargement and significant skin redundancy, gynecomastia grade 3 of Simon.

69.8 Complications

The magnitude of subcutaneous mastectomy and the lack of tissue between the skin and the pectoralis aponeurosis increase the rate of complications in relation to non-scarring, minimally invasive procedures in the treatment of gynecomastia. Major complications with long-term effects such as seroma, hematoma, wound infection, scarring, adherence of the skin to the deep plane, and breast asymmetry are significant and are related to the magnitude of the subcutaneous mastectomy [17]. The most frequent complication due to excessive resection of breast tissue is a permanent hypesthesia of the nipple-areola complex, eventually extending to the breast surface [18].

Extensive resection of breast tissue creates a virtual space between the skin and the pectoralis muscle with depression of the mammary area and deep skin adherence. Enlarged subcutaneous mastectomy can compromise the bloody supply of the nipple-areola complex with hypopigmentation and necrosis of the areola [19]. Extensive subcutaneous mastectomy with resection of a large amount of skin can be associated with major complications such as nipple distortion, skin necrosis, and cosmetically unacceptable scars. An usual permanent hyperpigmentation surrounding the areola can occur after hematoma or prolonged ecchymosis.

Suction-assisted lipectomy techniques alone or in conjunction with inferior periareolar subcutaneous mastectomy decrease morbidity and provide reliable improvement of the chest contouring with minimal complications in the treatment of gynecomastia. Standard instrumentation techniques, ultrasound-assisted lipoplasty, and power-assisted lipoplasty have identical aesthetic results with an unequal rate of complications. Waviness of the chest contour has not been observed with suction-assisted lipectomy techniques in treating gynecomastia.

69.8.1 Standard Suction-Assisted Lipectomy Through an Axillary Approach

Currently, suction-assisted lipectomy with wetting solutions is considered the most widely used standard procedure capable of producing few complications and excellent aesthetic results. Minimal complications are related to the use of the standard instrumentation technique or the syringe technique in conjunction with the wet technique. Breast sensation most of the time is similar to that present prior to surgery, despite a transitory hypoaesthesia from 2–4 weeks. Seroma, hematoma, and skin depression or adherence in the deep plane are rare. Small quantities of serum or blood are naturally drained through the numerous breast septa with intact vessels distributed through the tunnels of the aspirate breast. The same fat septa avoid adherence of the skin in the deep plane of the chest and provides an accurate contour for the aspirated breast. Depressions in the aspirated area are avoided by using suction cannulas with small diameters used in the peripheral areas of the breast. Skin necrosis is rare in the treatment of gynecomastia with standard suction-assisted lipectomy. Uncommon complications such as unilateral traumatic rupture of the pectoralis major muscle can fortuitously occur during suction-assisted lipectomy in surgical correction of gynecomastia [20].

69.8.2 Ultrasound-Assisted Lipoplasty

Ultrasound-assisted lipoplasty has potential benefits to aspirate fibrous tissue, for large volume removals, and for utilization in reoperations. However, the numerous complications and the increase in operating time have not been addressed in ultrasound-assisted lipoplasty for surgical correction of gynecomastia. Higher levels of seroma seems the most frequent of the complications [21]. Combination of heat and a large amount of saline with a high concentration of lidocaine infiltration, and large volume removals can lead to skin necrosis [22]. Cavitation is another important complication in ultrasound-assisted lipoplasty. Thermal injuries from superficial skin blistering to full thickness skin loss occur because of the higher rates of heat potentially caused by cavitation. A true loss of blood and albumin occurs with ultrasound-assisted lipoplasty even when blood is not observed in the aspirate. Troilius [23] verified a significant reduction in the levels of hemoglobin, hematocrit, and albumin after ultrasound-assisted lipoplasty through blood tests carried out 1 week after ultrasound-assisted lipoplasty with mild and moderate volume removals. Long-lasting consequences of internal ultrasound-assisted lipoplasty are still unknown.

69.8.3 Power-Assisted Lipoplasty

Power-assisted lipoplasty is in a learning curve. Its mechanism of action is not clearly defined and complications are not readily well known. In addition to the cost, the major disadvantages of power-assisted lipoplasty are the excessive vibration of the cannula and the high level of noise produced by the powered system, becoming significantly uncomfortable during either short or prolonged use of the system [24].

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70 Ultrasound-Assisted Liposuction for Gynecomastia

Alberto Di Giuseppe

70.1 Introduction

In the past it has been widely felt that the treatment of ptosis requires cutaneous scars. This is a fallacy, as, in male gynecomastia (which is a reduction mammoplasty in man), by ultrasound-assisted lipoplasty alone, the nipple-areola complex (NAC) rises to a new level. The author's experience, which is clearly reproducible, has shown that breast reduction with ultrasound-assisted liposuction (UAL) decreases the weight of the breast by gently elevating the gland and the NAC rises. As in pexy correction with UAL, there is a limit to the degree of ptosis of the NAC which can be corrected by decreasing the weight of the breast. Another consideration arises when treating male breast hypertrophy with emulsification with UAL when the volume of the breast is reduced and the areola decreases in size.

It is not true that the reduction of the size of the NAC requires direct excision, and thus cutaneous visible scars. This is because when the breast is reduced in volume, tension of the areola is decreased.

All these considerations made surgical treatment of male gynecomastia (with an open approach through an inframammary incision, or a periareolar incision, in order to perform direct excision of male gland or fat tissue) an obsolete procedure in the majority of clinical cases.

70.2 Gynecomastia

Male gynecomastia can be pure, fatty, or mixed. The "pure" type (Fig. 70.1) is exclusively glandular type hypertrophy due to overgrowth of the gland during the puberty period, connected to temporary impairment of male–female hormones. There could be a partial lack of male hormones, or a temporary increase of female hormones, which may affect the secondary sexual characteristics, such as the breast gland. This can rapidly grow, reaching really great dimensions, in significant cases (brassiere cup size B–C).

The "fatty " type is predominant in younger patients, with problems of overweight or obesity during their growth. Obesity is becoming a severe problem in the more advanced and occidental countries. The excess of nutrition may lead rapidly to a new category of young obese patients (age range between 16 and 25 years), who develop larger breasts early, and psychological problems connected to this unnatural aspect of the male thorax.

Fig. 70.1. **a** Preoperative patient with pure glandular hypertrophy. **b** Postoperatively following ultrasound-assisted lipoplasty

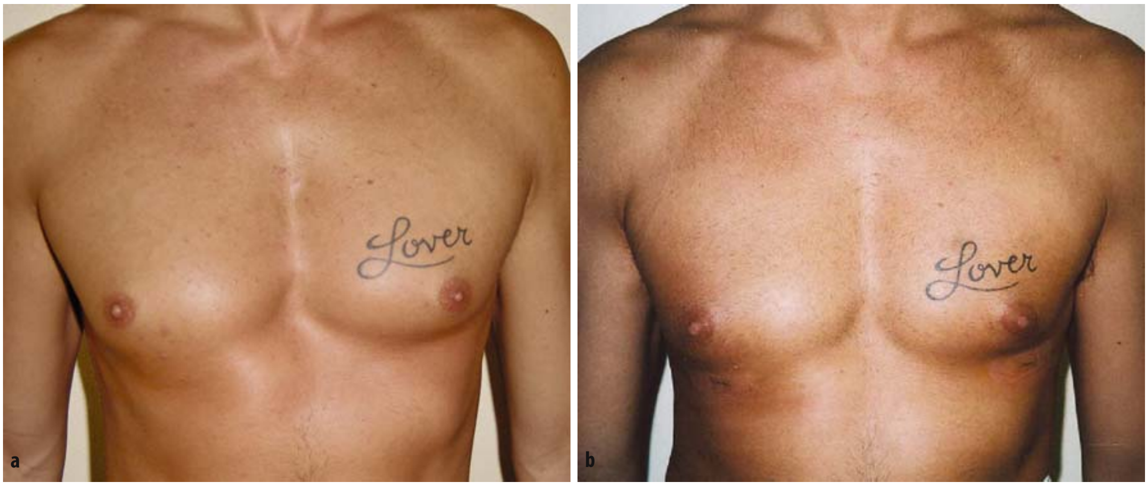

Fig. 70.2. Mixed gynecomastia. **a** Preoperative. **b** Postoperative

The "mixed" type (Fig. 70.2) is probably the commonest in clinical practice to be found. Mild breast hypertrophy is combined with excess of local fat deposition typically in the younger male patient with a slight hormone-related breast hypertrophy that presents with a tendency to overweight, increasing the fat deposits in the thorax and mammary region together with an increase of the abdominal panniculus. The gynoid type with associated obesity can be treated with UAL to the breast and abdominal contouring can also be utilized in elderly patients (Fig. 70.3).

70.3 Ultrasound- Assisted Lipoplasty

When UAL was initially promoted and introduced all over the world, there were many critics and discussions on the indications for patient selection. One of the indications unanimously given to UAL was the treatment of breast male gynecomastia. Male gynecomastia in the pure, mixed, or fatty types are an ideal indication for treatment with ultrasound-assisted lipoplasty. The titanium solid probes can easily break even the dense fibrotic male breast tissue emulsifying the fat component of the breast. The ability of ultrasound to electively target the fatty component of the breast tissues and thus spare the vascular network makes this operation easier, with a minimal trauma to the tissues, minimal blood loss, and the possibility to thin as desired the breast region and the thorax.

In mixed cases, not only the NAC region needs to be reduced (where the majority of gynecomastia is localized), but the remaining fat of the thorax normally presents excessive thickening of the fat component.

With a 1.0-cm skin incision at the inframammary crease and another 1.0-cm incision made at the axilla, it is possible to treat all the male breast tissue. Infusion of tumescence Klein solution is mandatory in these cases to allow ultrasound energy to be delivered efficaciously. A typical Klein solution for pure local anesthesia has been modified as follows: 1,000 ml of Ringer's lactate, 1 mg of epinephrine, 500–1,000 mg of lidocaine.

The fibrosis of the male breast often requires a higher concentration of local anesthetia in order to be really effective. When performed under general anesthesia, lidocaine is reduced to 200 mg/l, just to provide long-term postoperative analgesia. Lidocaine has recently been substituted with other less toxic anesthetics such as articaine and Naropin. Naropin is produced by Astra, the same manufacturer as for lidocaine. It is really effective and less toxic (for the neurovascular and cardiovascular systems) but there is no study of its utilization as diluted anesthetic infiltrated into the fat tissue in association with adrenaline. For gynecomastia, the skin incisions are made at the inframammary crease and at the axilla.

The first stage of the operation consists of infiltration of the tumescence anesthesia. From 500 to 1,500 ml of tumescence solution, depending on the breast size and the extent of the fatty component, can be necessary to obtain a real superwet tumescence in the thorax.

After completing the infiltration, the "port" of entry is stopped with a new device. This skin port protector includes a stopper, which prevents the fluids from refluxing back. It is necessary to wait for between 15 and 20 min to make the local anesthetics and the adrenaline effective. When the operation is performed under general anesthesia, I wait no more than 10 min, just to give the adrenaline time to be effective.

With the VASER pulsating device (Sound Surgical, Denver, CO, USA), I often utilize the 3.7-mm titanium cannula at 70% of the total power (Fig. 70.3). The grooves on the lateral part of the tip of the solid probes increase the efficacy of the system. The number of the grooves (two to three) depends on the kind of tissue encountered.

When utilizing the Sculpture-Smei ultrasound device, I place the total power setting at 55–60% of the total, and utilize the 5.1-mm solid titanium probe. The amount of fibrofatty tissue which can be emulsified is variable and 100–200 ml of fat is obtainable in 2–3 min of cavitation, with both devices.

The VASER Pulsate mode device has actually three main advantages over other machines:

1. For emulsifying the same amount of fat, it delivers 50% of the ultrasound energy of previous devices, thus decreasing the thermal energy employed, and decreasing the risk of complications and side effects.
2. The solid titanium probes employed are smaller and have a higher efficiency, and emulsify with the tip and with the lateral part of the tip. These smaller probes (Fig. 70.3) allow smaller skin incisions.
3. The VASER can deliver continuous ultrasound energy or pulsating ultrasound energy. When working with the pulsating mode, the energy delivered is reduced by 50% in the same fraction of time, thus decreasing the total ultrasound energy delivered and the thermal energy inside the treated area. As a consequence, potential risks of complications, such as seromas, burns, skin necrosis, and fibrosis, are really nearly cancelled. The pulsating mode is indicated in very fibrotic tissue where a lot of resistance might be encountered by the titanium probes during attempts at tissue fragmentation.
   In pure gynecomastia, where most of the glandular tissue is fibrotic, the VASER pulsating mode is helpful, together with the utilization of a one-groove probe, which is particularly efficient in thicker fibrotic areas.

The ideal situation is to deliver lower amounts of ultrasound energy, thus obtaining higher tissue fragmentation; thus, the efficiency of the device and the probe is high and the potential risk of complications is really low. In a mixed gynecomastia, the ultrasound energy is used for 10–30 min depending on the size and the extent of the tissue to be fragmented.

Ultrasound-assisted lipoplasty not only destroys the glandular tissues responsible for the glandular hypertrophy but also emulsifies the fat tissue normally present all over the mammary region, including the axillary sides. That is why, with UAL, remodeling of the thorax is more complete. Normally in men there is no real skin laxity associated with the tissue hypertrophy. Working with UAL at the intermediate fatty layers and at the same time inside the gland (in multiple layers) is sufficient to reduce and contour the whole area, which allows significant retraction of the skin envelope. In cases where significant superficial skin stimulation is required for skin tone and elasticity, as in the majority of male gynecomastia, the results are excellent and retraction is the consequence of the reduced volume of breast and fat tissue.

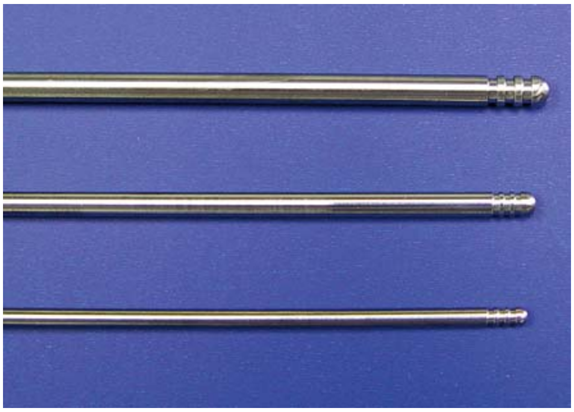

Fig. 70.3. VASER probes of 3.7, 2.9, and 2.2 mm with two grooves

After the application of ultrasound energy for the hypertrophy of the gland, the “cleaning” of the emulsified, fragmented tissues begins. Normally, the emulsion that flows away and is aspirated is clear, yellow, with a really small blood content. Every surgeon who has experienced the “bloody” fibrotic male gland well understands the advantage of a smooth, bloodless procedure, with nice contouring of the thorax not just limited to the glandular tissue, but also extended to the lateral axillary component that is often hypertrophic.

At the end of surgery, manual remodeling of the region is required to check symmetry, new NAC position, and NAC projection. Aspiration drainage is always used to compress the surgical area, together with an elastic garment, which is maintained for 4–8 weeks (Design Veronique, Richmond, CA, USA) (Fig. 70.4). The foam pads are maintained for 10 days (EPIfoam, Biodermis, Las Vegas, NV, USA).

Two weeks after surgery, a cycle of intensive massaging with Endermologie is begun twice a week, for smoothing and softening the local edema and fibrosis. Results are normally complete 2 months after surgery.

70.4 Complications

Seroma
The incidence of seroma is low. Having always utilized a solid titanium probe with a high efficiency for cavitation and thus tissue fragmentation, the amount of thermal energy dispersed through the tissue is minimal, and does not cause long-lasting seroma or fluid accumulation. Seroma has to be attributed to an inside burn with consequent liquefaction of tissue, and interruption of lymphatics draining the area

Fibrosis
Local areas of induration despite being rare may still occur in breast reduction with UAL, in women as well as in men for gynecomastia treatment. Localized fibrosis is due to an internal small, limited burn of the fibrofatty tissue. Postoperative early massaging and eventually an intralesional cortisone injection are advised to prevent and treat occasional areas of induration

Burns
No case of skin burns was observed in the author's experience

Skin necrosis
No case of skin necrosis was observed in the author's experience

Asymmetry
An impairment of the symmetry of the 2 breasts may still be present at the end of surgery, or 1 month after, when the reabsorption of the edema is completed. When the asymmetry is conspicuous, the patient may require a secondary revision. Usually this is an office procedure, under local anesthesia

Loss of sensation
Loss of sensation has always been temporary, limited to the first 3–6 weeks after surgery

Hematoma
Five cases of hematoma, which required closed evacuation and compression, were observed in our series (2 of the patients were heavy smokers)

Fig. 70.4. Elastic garment – Design Veronique

70.5 Conclusions

From 1992 to 2002, 150 gynecomastia patients were treated with ultrasound-assisted lipoplasty. It became the technique of choice for pure, mixed, and fatty gynecomastia, despite the amount of breast tissue and the degree of breast ptosis associated. Results have been extremely gratifying for patients and the surgeon. The technique was shown not to be aggressive and traumatizing as in the past with the open-surgery approach or as with traditional old-fashioned liposuction. The majority of patients were operated upon under tumescence anesthesia and intravenous sedation, or with laryngeal mask assistance and no endotracheal intubation. All the patients were kept overnight in hospital. Drains were removed in 24–48 h.

Fig. 70.5. a Pre-op frontal view: 33-year-old man with lipodystrophy of abdomen with pure gynecomastia. Note extreme laxity of abdominal skin. **b** Pre-op oblique right view: 33-year-old man with lipodystrophy of abdomen combined with pure gynecomastia. **c** Pre-op lateral right view: 33-year-old man with lipodystrophy of abdomen with pure gynecomastia. **d** Pre-op lateral left view: 33-year-old man with lipodystrophy of abdomen with pure gynecomastia. **e** Post-op frontal view: 2 months after VASER liposelection (breasts 1110 ml aspirate bilaterally; abdomen 900 ml aspirate). **f** Post-op oblique right view: 2 months after VASER liposelection (breasts 1110 ml aspirate bilaterally; abdomen 900 ml aspirate). **g** Post-op lateral right view: 2 months after VASER liposelection (breasts 1110 ml aspirate bilaterally; abdomen 900 ml aspirate). **h** Post-op lateral left view: 2 months after VASER liposelection (breasts 1110 ml aspirate bilaterally; abdomen 900 ml aspirate)

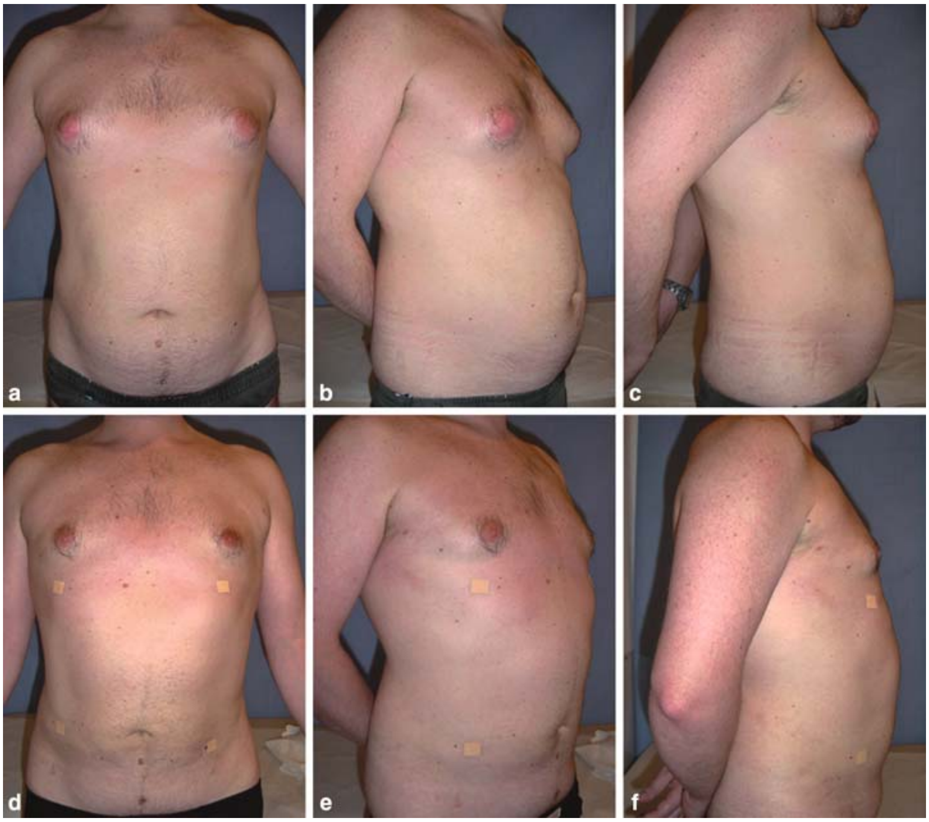

Fig. 70.6. **a** Pre-op frontal view: 28-year-old man with pure gynecomastia and lipodystrophy of abdomen. **b** Pre-op oblique right view: 28-year-old man with pure gynecomastia and lipodystrophy of abdomen. **c** Pre-op lateral right view: 28-year-old man with pure gynecomastia and lipodystrophy of abdomen. **d** Post-op frontal view: 3 months after VASER liposelection (breasts 1400 ml aspirated, bilaterally; abdomen 1300 ml aspirated). **e** Post-op oblique right view: 3 months after VASER liposelection (breasts 1400 ml aspirated, bilaterally; abdomen 1300 ml aspirated). **f** Post-op lateral right view: 3 months after VASER liposelection (breasts 1400 ml aspirated, bilaterally; abdomen 1300 ml aspirated)

Fig. 70.7. a Pre-op frontal view: 25-year-old boy already operated of mixed gynecomastia with standard liposuction. Note still permanence of tissue, cutaneous ptosis and skin laxity. **b** Pre-op oblique right view view: 25-year-old boy already operated of mixed gynecomastia with standard liposuction. Note still permanence of tissue, cutaneous ptosis and skin laxity. **c** Pre-op lateral right view: 25-year-old boy already operated of mixed gynecomastia with standard liposuction. Note still permanence of tissue, cutaneous ptosis and skin laxity. **d** Post-op frontal view: 1 month after VASER liposelection to breast and abdomen. Note great skin retraction of the breast with no need for surgical excision. Breast tissue has been liquefied by VASER. Total 2500 ml of aspirate. **e** Post-op oblique right view: 1 month after VASER liposelection to breast and abdomen. Note great skin retraction of the breast with no need for surgical excision. Breast tissue has been liquefied by VASER. Total 2500 ml of aspirate. **f** Post-op lateral right view: 1 month after VASER liposelection to breast and abdomen. Note great skin retraction of the breast with no need for surgical excision. Breast tissue has been liquefied by VASER. Total 2500 ml of aspirate

Lipomas Treated with Liposuction

John Stuart Mancoll

71.1 Introduction

Lipomas are the most frequent soft-tissue tumor. Typically they are a benign tumor of fat and are thinly encapsulated. They appear as slow-growing bumps of subcutaneous fat. Usually they do not respond to changes in body fat fluctuations. Patients are frequently referred to a plastic surgeon in hope that the mass may be treated with liposuction. Therefore it is important that we as plastic surgeons be aware of what lipomas are, and perhaps more importantly be aware of what they could be.

Lipomas are soft-tissue deposits of fatty material that grow under the skin, causing round or oval lumps. Their reported incidence is 2.1 per 1,000 people [1]. They typically appear as a smooth, soft, non-tender bump under the skin. They feel soft and doughy or rubbery; lipomas range in firmness and can feel rather hard. The skin over the lipoma has a normal appearance. Lipomas rarely grow more than 2 or 3 in. across. They can develop anywhere on the body but are particularly common on the forearms, torso, and back of the neck. However, lipomas have been reported in nearly every organ and body space, including the brain, spinal cord, parotid gland, tendon sheaths, stomach, small bowel and colon walls, and even the bone marrow. Some people have only one, whereas others develop many lipomas. Lipomas rarely cause problems, although they may occasionally be painful if they grow against a nerve. Solitary lipomas are commoner in women, whereas multiple lipomas are commoner in men.

71.2 Epidemiology

Although most lipomas are sporadic in their appearance some do have an inherited mode of appearance. Diffuse congenital lipomatosis, benign symmetric lipomatosis (Madelung's disease), familial multiple lipomatosis, and Dercum's disease (adiposis dolorosa) are all inherited disorders. Diffuse congenital lipomatosis patients who have diffuse poorly demarcated lipomas localized primarily on the trunk characterize this type. These tumors are composed of immature fat cells. Lipomas in these patients are particularly difficult to treat because they often infiltrate through muscle fibers, making them difficult to remove surgically.

Benign symmetric lipomatosis, also referred to as Madelung's disease, was first described in 1888 [2]. Typically patients with benign symmetric lipomatosis have lipomas of the head, neck, shoulders, and proximal upper extremities. Men are affected 4 times as often as women. There will be a history of excessive alcohol consumption or diabetes. Other conditions associated with Madelung's disease include malignant tumors of the upper airways, hyperuricemia, obesity, renal tubular acidosis, peripheral neuropathy, and liver disease.

Familial multiple lipomatosis is a clinical entity characterized by many, small, well-demarcated, encapsulated lipomas that commonly involve the extremities. This is passed as an autosomal dominant gene and a family history of lipomas will be present. Typically, this form appears during or soon after adolescence. The neck and shoulders are usually spared in contrast to the situation for benign symmetric lipomatosis.

Dercum's disease (adiposis dolorosa) is a rare disease characterized by painful lipomas. The lipomas typically occur on the extremities of obese postmenopausal women. Associated conditions include alcoholism, emotional instability, and depression.

Some have also been linked to a history of localized trauma.

71.3 Age

Lipomas can occur at any age, but they typically occur after puberty when the body is gaining fat. They will often appear in patients between 40 and 60 years of age. Frequently patients will claim that they have been present for years.

71.4 Differential Diagnosis

Although lipomas are the commonest subcutaneous mass, one cannot exclude the fact it might be some other subcutaneous mass that is present (Table 71.1).

71.5 Pathology

71.5.1 Histologic Findings

Lipomas histologically resemble normal fat. When completely excised, a thin fibrous capsule surrounding the aggregate of adipocytes may be seen. Without a clinical or gross description, it often is impossible to distinguish between tumor cells and mature adipocytes. Lipomas differ biochemically from normal mature fat. Lipomas have increased levels of lipoprotein lipase.

Recent work by Pierantoni et al. [3] suggests a critical role played by HMGA1 rearrangements in the generation of human lipomas. Whereas the role of HMGA2 has been suggested by Ashar et al. [4], most lipomas, and their benign and malignant variants, have chromosomal abnormalities involving 12q14. The genetic mutation in patients with multiple lipomas, however, is in the mitochondria.

Spindle cell lipoma is a relatively uncommon variant characterized by a mixture of mature adipocytes and bland spindle cells on a fibromyxoid background.

Table 71.1. Differential diagnosis of a subcutaneous mass

Benign
Vascular nodules
Rheumatic nodules
Sarcoidosis
Infections (e.g., onchocerciasis, loiasis)
Hematoma
Ganglion cyst
Angiolipomas[a]
Hibernomas[b]
Neurofibromas
Epidermoid cysts
Erythema nodosum
Nodular subcutaneous fat necrosis
Weber–Christian panniculitis
Desmoid tumor
Malignant
Lipoblastomas
Liposarcomas
Metastatic disease

[a]Typically, these tender, soft, subcutaneous nodules are present in adolescence. Tumors are frequently multilobulated and are somewhat firmer than ordinary lipomas. The associated pain is vague and may be spontaneous or caused by pressure

[b]Tumors are solitary well-circumscribed nodules that typically are asymptomatic. Usually, tumors are located in the interscapular region, axillae, neck, or mediastinum. Histologically, hibernomas are composed of embryonic brown lipoblasts termed mulberry cells because of their appearance

71.6 Diagnosis

Most lipomas can be diagnosed on physical examination alone. Their characteristics leave little doubt about the etiology. However, if there is a history of rapid growth, increasing pain, or other changes are noted, then preoperative studies should be performed to help confirm the diagnosis.

Radiology evaluation may include ultrasound, a computed tomography (CT) scan or MRI. On ultrasound lipomas can have different echogenic patterns depending on the composition of the associated connective tissue and the position of the mass. They could be hypoechogenic, hyperechogenic, or mixed, but are easily distinguished by oval shapes with well-demarcated capsules. Color Doppler sonography can be added to help differentiate malignant lipomas verses benign tumors

Ultrasound evaluation may be feasible to evaluate a suspicious mass. Futani et al. [5] demonstrated the gray scale. Ultrasound was by itself unable to differentiate between well-differentiated liposarcoma (WDLS) and intramuscular lipomas (ILs). Gray scale images showed no differences between WDLS and ILs. However, power Doppler showed more than two flow velocity signals in all WDLSs, whereas only 11% of the ILs had two signals. In all WDLSs, color flow signals occupied more than 30% of the selected area. In contrast, ILs were characterized by a low color-dot ratio. These findings were attributed to histologically increased vascularity found close to malignant cell invasions.

CT scans are very good at differentiating lipomas from other subcutaneous masses. CT enables the definite diagnosis by measurement of density values equivalent to fat. Thompson et al. [6] demonstrated that CT findings were specific for the diagnosis of lipoma in eight of nine patients. CT can also be used to diagnose deeper masses and should be used to evaluate large submucosal masses in the stomach to establish a preoperative diagnosis.

MRI can also be used to differentiate lipomas from other subcutaneous masses. Typically a T1-weighted fat suppression sequence with a chemical shift method confirms the fatty nature of the lesion.

Ohguri et al. [7] set out to evaluate the reliability of MRI in distinguishing between benign lipomas and WDLS. In their study benign lesions had irregular margins, a recognizable non-adipose component, and non-enhancing septa. Malignant liposarcomas on the other hand demonstrated thick septa and nodular or patchy non-adipose components. Also the septa in WDLS enhanced more strongly than did those in benign lipomas.

Pathologic diagnosis can be done with fine needle aspiration. Kapila et al. [8] evaluated cytomorphologic features of benign and malignant lipomatous tumors of soft tissue with fine needle aspirates (FNAs). They determined that lipomas could be diagnosed readily. They noted that arborizing vessels can be seen in lipomas and should be interpreted with caution. Subclassification of liposarcomas on FNAs is possible but not very reliable. Myxoid liposarcomas pose a problem, and aspirates from them can mimic a wide range of morphologic subtypes. The role of FNAs in identification of variants of liposarcoma is limited.

71.7 Surgery

Surgery for lipomas is indicated in any tumor in which the diagnosis is in question. Additional indications include masses compressing nerves leading to neuropathies or lesions causing pain or limiting function by virtue of their location. Although some patients may present for functional concerns most patients are prompted to seek treatment for aesthetic reasons. Therefore, a surgical approach must be selected that will not replace the subcutaneous mass with an unacceptable scar. The options include conventional surgical excision and liposuction.

Traditionally lipomas are excised through large incisions. Hardin was one of the first to suggest teasing or expressing lipomas through small incisions, thus minimizing the scar. As a rule of thumb if a lipoma is as small than 4 cm then there is no significant advantage in liposuction. Small lipomas may be removed under local block but larger or recurrent lipomas will require a general anesthetic. I usually start with an initial incision half the length of the lesion for small lesions (less than 4 cm). For larger lesions I try to keep the incision to one third or less of the total length. For very large lipomas, a combination of liposuction and open excision may be helpful. When one starts to remove the lipoma it does appear distinct from the surrounding fat. In many cases it will border anatomic planes and this will help with the dissection. I find that in anatomically sensitive areas the open technique is essential. Other lipomas that are easier to remove with open techniques include subperiosteal and subfrontalis lipomas of the forehead. The thicker fascia plane surrounding the lipoma makes it harder to completely remove the lipoma with a liposuction cannula.

71.8 Liposuction

Liposuction for the treatment lipomas is the commonest non-cosmetic use of liposuction. The use of liposuction to treat lipomas was first described in 1985 by Rubenstein et al. [9] The advantages of liposuction over open techniques in addition to smaller scars include shorter operative times, diminished postoperative pain, and decreased incidents of hematomas and seromas. It has also been advocated when multiple lipomas are being removed at once. Most authors have suggested that liposuction is best reserved for masses greater than 4 cm. This observation is based on the fact that smaller lesions can be excision through an incision that would be only slightly larger than a typical liposuction access site. Wilhelmi et al. [10] presented five cases of forehead lipomas all less than 4 cm which were successfully removed with liposuction.

When liposuction is used typically I will choose a 4–8-mm cannula. I do use a dilute lidocaine solution similar to cosmetic liposuction, but I try to place the solution around the mass instead of within the capsule. This gives me the hemostasis I desire and I am able to palpate to make sure the entire mass is removed. I rarely feather after the lesion is removed regardless of how hollowed the defect is. After removing the lipoma, the initial contour deformity almost always resolves. This is because unlike gynecomastia or cosmetic liposuction defects the lipomas have a mass effect. After the tumor is gone the compressed native fat cells in that area tend to return to their native positions. A compressive dressing is applied and activities are limited based on anatomic locations.

71.9 Conclusions

Patients with lipomas are frequently referred to plastic surgeons for treatment specifically with the liposuction technique. Therefore it is incumbent on us to not only confirm the diagnosis prior to surgery, but also to make sure that liposuction is the right tool for the job. Proper patient counseling must be given and a potentially high recurrence rate must be explained. But with proper patient selection liposuction can be successfully employed in treating lipomas.

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Treatment of Multiple Symmetrical Lipomatosis with Liposuction 72

Jorge A. Martínez-Escribano, Rafael González-Martínez

72.1 Definition

Multiple symmetrical lipomatosis (MSL) is a rare disease, initially reported in 1846 by Brodie [1]. This disease has been described under the eponyms of Madelung's disease, Launois–Bensaude syndrome, benign symmetric lipomatosis, and lipoma annulare colli. It is a condition of middle age and occurs predominantly in men of Mediterranean descent. MSL occurs mostly sporadically, but some cases with familial incidence have been seen. The disease is characterized by enlarging, painless, symmetric, fatty deposits in specific areas of the body, especially the neck, shoulders, and proximal upper extremities, giving the patient a "horse collar" or "buffalo hump" appearance [2]. Histologically, the tumors are composed of adipocytes indistinguishable from those of normal subcutaneous tissue, but the normal lobular architecture is lost and the fat lobules appear larger than normal. In contrast with ordinary lipomas, fatty deposits in MSL are unencapsulated, although they typically demonstrate fat lobules that are delineated from the surrounding tissue by a thin fibrous pseudocapsule [3].

72.2 Pathogenesis

The etiology and pathogenesis of MSL are unknown, but lipomatous infiltration of affected tissues may be due to a neoplastic-like proliferation of functionally defective brown adipocytes [4]. Adipocytes from MSL lipomas have been found to be relatively insensitive to the lipolytic effect of catecholamines [4]. This underlying primary metabolic defect partially explains postsurgical reaccumulation of fatty deposits. An association with mitochondrial respiratory enzyme dysfunction and mitochondrial DNA mutations has been made in some cases of MSL [5].

72.3 Clinical Signs and Symptoms

The clinical course of MSL is characterized by slow, progressive enlargement of confluent lipomas, whose number may reach as many as over 1,000, and which may range in size between 1 and 20 cm, cosmetically disfiguring the patient, provoking symptoms derived from the compression of vascular and nervous structures and, rarely, dyspnea from compression of the respiratory tract. Lipomatous tissue may surround and infiltrate underlying tissues, making difficult complete excision of the tumors. The face, distal extremities, hands, and feet are always spared [2, 6].

According to the localization of the tumors, two types of MSL can be identified [6]:

1. Type I: Characterized by fatty deposits distributed on the upper part of the body, giving the patient a pseudoathletic appearance. Lipomatous tissue may involve the mediastinum with vena cava compression.
2. Type II: Distribution of the lipomas is more generalized, giving the patient the appearance of simple obesity.

MSL is frequently associated with hepatopathy and chronic heavy alcohol consumption. It has also been reported in association with endocrine and metabolic abnormalities, such as diabetes mellitus or glucose intolerance, hyperlipidemia, hyperlipoproteinemia, hyperuricemia, hyperthyroidism, hypothyroidism, hypogonadism, and renal tubular acidosis. Other conditions associated with MSL include malignant tumors of the upper airway, peripheral neuropathy (sensory, motor, or autonomic) and, less frequently, central nervous system involvement [2, 6, 7].

72.4 Differential Diagnosis

The differential diagnosis of MSL includes obesity, familial multiple lipomatosis, adiposis dolorosa

(Dercum's disease), lymphoproliferative diseases, lymph node metastases, diseases of the thyroid (goiter, carcinoma, etc.), buffalo neck in Cushing's disease, sialadenitis, cervical cysts, neurofibromatosis, and other benign and malignant tumors (angiolipomas, lipoblastomas, sarcomatous processes, etc.).

72.5 Treatment

Neither alcohol abstinence nor hypocaloric diet contribute to tumor regression; however, abstinence from alcohol can help to decrease the rate of recurrence as well as the normalization of laboratory values [2].

Treatment of MSL is usually palliative (Figs. 72.1, 72.2) [8–11]. Classical surgical lipectomy, liposuction, or the combination of both, are the treatments of choice for MSL patients. These treatments must be selected and performed after a careful evaluation of the volume and localization of the lipomatous masses and of the esthetic consequences. The aim of these procedures is to reduce the size of the tumors, especially when the fatty deposits induce clinical symptoms or functional impairment, for example, when there is inability to move the neck freely. Furthermore, surgi-

Fig. 72.1. **a** Preoperative lateral aspect of a patient with multiple symmetrical lipomatosis. **b** Postoperatively following surgical lipectomy

Fig. 72.2. **a** Preoperative patient with multiple symmetrical lipomatosis. **b** Postoperatively following liposuction

cal therapy may also be meaningful for psychological reasons.

The lack of encapsulation and the large size and anatomic distribution of the tumors frequently make complete removal of lipomatous tissue almost impossible. Thus, recurrences are common after surgical procedures, also accompanied by metabolic alterations. These recurrences may require additional surgical procedures that may be more difficult to perform owing to secondary fibrosis.

72.5.1 Lipectomy

Lipectomy, or direct excision of the lipomatous tissue, is the technique which is associated with severer complications. Thus, lipectomy is indicated in some cases of direct compression of cervical or mediastinal structures, and should be restricted to decompression in patients with functional impairment. In cases with cervical involvement, a standard facelift pattern can be used for skin incisions, with good cosmetic results [11].

72.5.2 Liposuction

Liposuction can be considered as the less aggressive surgical technique for the treatment of lipomatous masses in MSL patients, since it is usually associated with less adverse effects than lipectomy [8, 12, 13]. Liposuction, in contrast to lipectomy, avails us of a closed, subcutaneous technique, which can be performed under local anesthesia and can remove the majority of lipomatous deposits through a small incision on the skin, making radial tunnels into the subcutaneous fat, leaving a honeycomb of fat, nerves, blood vessels, and lymphatics. With the tunneling technique, portions of the subcutaneous neurovascular plexus remain intact and the problem of loose redundant skin is avoided [9]. Liposuction allows the benefit of surgical debulking without long skin incisions, significant scarring, the risk of general anesthesia, and a prolonged recovery period. Nevertheless, liposuction must be performed with caution when the cervical area is involved, owing to the possibility of potentially lethal complications such as hematomas or edema which can compress vital structures. For the treatment of cervical lipomas, submental and auricular incisions can be performed. Liposuction can be performed as a single procedure or combined with other techniques like cervicoplasties, or facial or cervical rhytidectomies; in these cases, adipose masses are removed and then the excess skin is reduced by using the formerly mentioned techniques.

72.5.3 Tumescent Technique

The tumescent technique for liposuction was described in 1987 by Klein [14, 15], based on the principles of the wet technique, and ensures a reduction of the blood loss, no shock, and shorter recovery period. In the tumescent technique, large volumes of dilute solutions of lidocaine and epinephrine in saline are infiltrated into the subcutaneous fat before liposuction; the recommended amount of solution to be infiltrated varies for each anatomic region, being 100–200 ml for the cervical area.

72.5.4 Complications

The most frequent complication of liposuction is temporary paresthesia (3%). Other complications, present in less than 1% of cases, are persistent edema, ecchymosis, hematoma, seroma, hypovolemic shock due to excessive fluid loss, permanent cutaneous irregularity, infection, and fat embolism [16]. The majority of these complications disappear after a few weeks or months. The risk of severe neurovascular lesions is minimal when the technique is correctly used. The use of small-bore cannulas (2–3 mm) decreases the risk of hematomas, but 3–5-mm cannulas are frequently used, depending on the habit of each surgeon.

72.5.5 Postoperative Course

The postoperative course of MSL patients after removal of drains and bandages is similar to that of conventional cosmetic liposuction. Careful postoperative follow-up is recommended since, in addition to the frequent involvement of vital anatomic areas, metabolic disturbances and the poor state of health of the patients can increase the risk of complications. When liposuction is finished, compression is required on the treated area and it can be achieved with either elastic tape or fitted compressive garments; sometimes, it is useful to use an aspirative drainage. Compressive dressings will be kept on for 1–3 weeks in most cases.

72.5.6 Additional Techniques

More recently, ultrasound-assisted liposuction has been used, which facilitates preservation of much of the vascular and connective framework of the subcutaneous tissue, reduces intraoperative and postoperative bleeding, and shortens operative time [17]. The use of endoscopy may help in the removal of the lipomatous tissue and reduce complications, since it allows visualization of the tissues involved [18].

72.6 Discussion

The objective of the treatment of MSL is to avoid alcohol intake, to treat metabolic alterations, and to reduce or eliminate the masses of lipomatous tissue. Both lipectomy and liposuction are safe and effective techniques for the treatment of MSL patients, but liposuction may be the ideal palliative treatment for these patients and may be safely repeated. Although liposuction is usually associated with less adverse effects than lipectomy, location of the lipomas must be carefully considered before choosing one technique over the other, and this technique must always be undertaken by a surgeon experienced with the procedure. As the recurrence of lipomas is frequent in MSL, lipectomy and liposuction should be restricted to selected patients in whom vital structures (vascular, nervous, respiratory tract) are compressed or in the case of large deformities which can cause esthetic or psychologic disturbances.

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Treatment of Madelung's Disease with Ultrasound-Assisted Liposuction

Angela Faga

73.1 Introduction

Benign symmetric lipomatosis, also known as Madelung's disease or Launois–Bensaude adenolipomatosis, is a rare condition of middle age, typical of men between 40 and 50 years old, first described in 1846 [1]. About 200 cases have been reported to date. It is characterized by multiple, symmetrical, and unencapsulated accumulations of mature fat in the subcutis and deep soft tissue spaces of neck, shoulders and upper extremities. In the longstanding disease, the massive fatty deposits in the neck can cause compression of the aerodigestive tract and vena cava with mediastinal syndrome.

The deformity is associated with chronic alcohol use, malignant tumors of the upper airways and also with peripheral neuropathy. The etiology of Madelung's disease is still being discussed. It has frequently been reported in association with systemic metabolic abnormalities, like diabetes mellitus, hyperlipidemia and hyperuricemia, and has a familial character [2]. Electrophysiological measures display signs of central and peripheral nervous system involvement too, unrelated to the frequently coexisting alcoholism [3, 4]

The most recent hypotheses acknowledge Madelung's lipomatosis as related to mitochondrial dysfunction; actually lipid metabolism is closely related to mitochondrial respiration and biochemical studies on muscle and adipose cells have shown evidence of mitochondrial respiratory enzyme impairment, consisting of multiple deletions of mitochondrial DNA in muscle and adipose cells [5].

Patients usually complain of their cosmetic appearance and look for a cosmetic relief; when decreased neck motion, aerodigestive problems and mediastinal syndrome are present, as occurs in the severest patterns, some treatment is mandatory.

Surgery is the only real hope for palliation although cases of volumetric regression of masses have been described after correction of nutritional deficiency and the cessation of alcohol abuse. Surgical lipectomy is not free of complications. Direct excision of the masses often results in long skin incisions, skin undermining and relevant bleeding. The infiltration of tissue neighbouring fatty deposits causes some difficulties in radical surgical excision, particularly in areas, such as the neck, where important anatomical structures can be involved (gross vessels, nerves, aerodigestive tract). Actually recurrence is very common.

Liposuction was first proposed for the treatment of Madelung's disease in 1988 [6]. Since that report there have been reports of liposuction, alone or in association with surgical lipectomy, as a less aggressive procedure and with less adverse effects than lipectomy. Most surgeons recommend liposuction just for minor fatty masses [7–9]. Actually liposuction, both conventional and superwet, tumescent, or by the syringe technique can be too rough in some particular areas such as deep neck compartments where gross vessels and vital structures are present.

Ultrasound-assisted liposuction (UAL), compared with traditional liposuction, allows the surgeon to use more delicate and precise movements. It also allows much of the refined vascular and connective tissue framework of the subcutaneous tissue to be saved, reducing intraoperative and postoperative bleeding, while shortening operative time [10].

73.2 Case Report

For these reasons, we used UAL for the palliative treatment of a very critical patient, suffering from Madelung's disease (Fig. 73.1) [11]. The 51-year-old man had a history of smoking and alcoholism and was affected by liver cirrhosis, chronic erosive gastritis, sigmoid diverticulosis, hiatal hernia, gallstones, chronic bronchitis and blood coagulation inadequacy, and complained of the compression of the upper airway resulting in a stifling feeling due to large masses of adipose tissue in his cervicofacial region. The patient had undergone an anterolateral cervical lipectomy 3 years earlier but the masses had relapsed after 3 months. Considering that the patient was in a poor state of health, with high anesthesiologic risk (ASA 4) and that a radical laterocervical lipectomy might not have prevented recurrences anyway, we were looking for a soft-tissue surgical procedure suited to be stopped at any moment according to potential resuscitation problems.

Under general anesthesia, UAL of laterocervical, paracervical and perimandibular masses was performed. We used a system consisting of an electrical power console, a hand-piece converting electrical energy to ultrasonic energy and a blunt, ultrasound titanium probe (15-cm long with 0.3-cm diameter). The titanium probe was connected to the hand-piece and delivered ultrasonic energy to the tissues. Areas to be treated were injected with $1{:}1\times10^6$ epinephrine in 0.9% saline solution. A pump was used in order to draw up the emulsion produced. The cannula was introduced for tunnelling through short incisions (0.5 cm) and moved respecting, to a great extent, the anatomic structures. A total of 300 ml of liquid and fat was aspirated from the neck and the face. Two suction drains were positioned, respectively, on the left and on the right, close to the mandibular rim and site access incisions were sutured with a single nylon suture. Gauze dressings and elastic moderate compression garments were applied. A perioperative intravenous single-dose prophylactic antibiotic (2 g ceftriaxone) was used, then for 10 days with half dose (1 g) until the drain was removed. Each drain collected 150 ml of fluid material. Both aspirated and drain-collected liquid were submitted for a cytological test that revealed the presence of blood, injection fluid and liquid adipose tissue.

In the first 2 weeks after the surgery, the massive inflammatory response disguised the real result of the liposculpture and caused pain in the treated regions. This symptomatology spontaneously resolved in 1 month. Six months later only a modest cosmetic result was detectable, but the aerodigestive symptoms improved significantly and the patient was satisfied (Fig. 73.2). Unfortunately, the patient continued to be a heavy smoker and an alcohol abuser and at the follow-up 1 year later recurrence both of morphological and of functional symptoms was observed.

Fig. 73.1. Patient affected by Madelung's disease: preoperative view

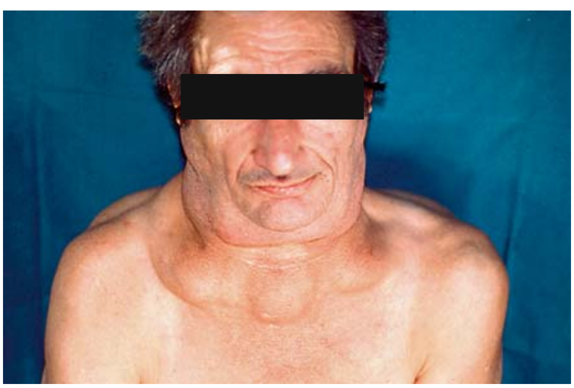

Fig. 73.2. Same patient, 6 months after ultrasound-assisted liposuction. Despite the modest reduction of premandibular fat pads, aerodigestive symptoms are significantly improved

73.3 Conclusions

According to our clinical experience, UAL can be a useful and safe technique when a less-than-radical excision of fat is required, particularly within delicate anatomical structures.

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74 Treatment of Lipomas or Angiolipomas by Liposuction Surgery

Takehiko Kaneko

74.1 Introduction

Angiolipoma is an encapsulated subcutaneous nodule that is found on the trunk or extremities [1–5]. Recently, liposuction surgery has been widely accepted for body contouring or other non-cosmetic applications, including lipomas and angiolipomatosis [6–22]. Liposuction surgery can be utilized for lipomas or angiolipomas [6].

74.2 Case Report

A 43-year-old man consulted Tokyo Teishin Hospital in 1985 because of several subcutaneous nodules on the trunk. They had been increasing and growing for the past 2–3 years. Physical examination showed soft, mobile, non-tender, subcutaneous nodules ranging in size up to 3 cm in diameter on the left side of the abdomen (Fig. 74.1). The skin overlying the tumors was normal. The patient had no history of trauma to areas of tumor development and no family history of skin tumors.

Excisional biopsy was performed on one of the tumors. Grossly, the nodule was well encapsulated, and microscopically there were mature adipose cells, a few incomplete fibrous trabeculae, and capillaries (Fig. 74.2). No inflammation or infiltration into surrounding structures was found. Pathological diagnosis was angiolipoma. At 49 years of age, the patient complained of multiple new lesions that had gradually developed over the trunk and arms.

On examination, the patient had 119 nodules, the majority of which were distributed over the abdomen (87 nodules) (Fig. 74.3) and back (30 nodules), and the remaining two were found on the arms. The lumps were mobile, non-tender, and measured up to 3.5 cm in diameter. A computed tomographic scan of the upper abdomen revealed no low-density mass of viscera that suggested lipomatous tumor. It was decided that to minimize visible scarring excision of these lesions using liposuction apparatus under general anesthesia would be attempted.

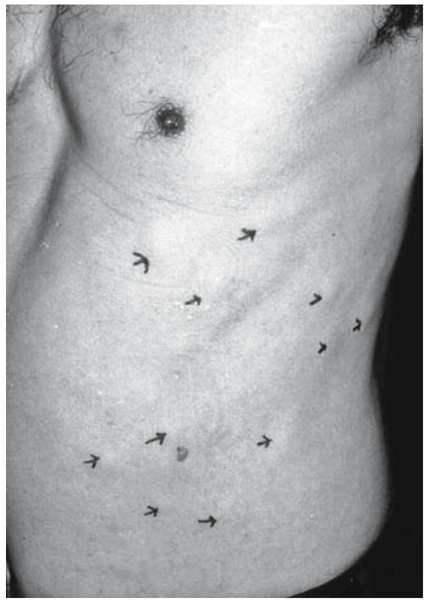

Fig. 74.1. Subcutaneous nodules on the left part of the abdomen

First, the lesions of the abdomen were circled with a marking pen. A liposuction unit (TG-II; Taguchi, Tokyo, Japan) was used with 6-, 8-, and 10-mm suction cannulas. Two incisions were made at the lower abdomen to gain access to the lesions with the suction cannula. A 4-mm blunt dissecting cannula was used to create a tract to the lesions. The tumors were then withdrawn from the lumen of the suction cannula (Figs. 74.4, 74.5). Microscopically, they were composed of adipose cells and capillary-sized blood vessels. Histological findings of those tumors were the same as that of the previous biopsy, and our diagnosis was multiple angiolipomas. Three months later, a second surgery for the back lesions was performed in the same way. The patient was satisfied with the result and has been followed for 2 years with no recurrence noted (Fig. 74.6).

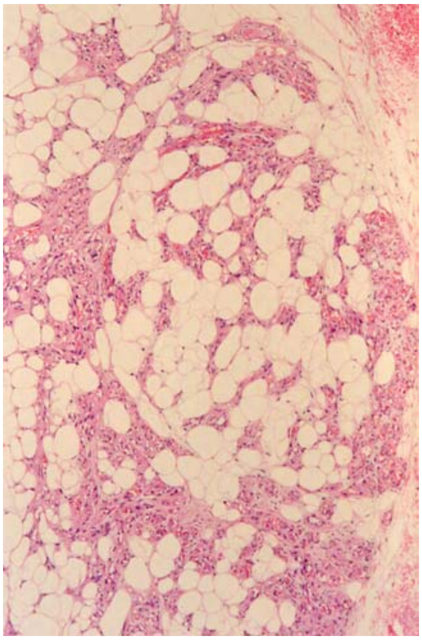

Fig. 74.2. The tumor is composed of mature adipose cells and capillaries (magnification ×40)

Fig. 74.3. Numerous subcutaneous nodules distributed over the trunk

Fig. 74.4. Liposuction was performed with suction cannulas

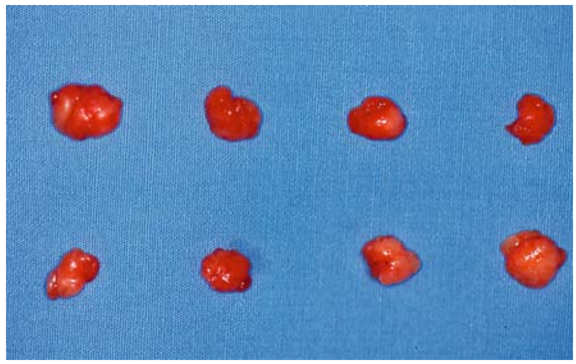

Fig. 74.5. Tumors withdrawn from the suction cannula

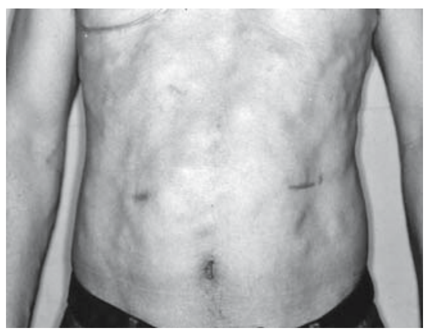

Fig. 74.6. Postoperative view, showing a well-contoured abdomen

74.3 Discussion

Angiolipomas usually first appear in adolescence and are most often found on the trunk and extremities, frequently in sites subject to repeated pressure and irritation [2]. In the present case, the patient first noticed lumps in his thirties, and the majority of those tumors were distributed over the trunk. Angiolipomas histologically differ from lipomas by proliferation of capillary vessels [2]. The proportion of adipose to vascular tissue varies. In this case, some specimens obtained from the lumen of the suction cannula did not exhibit capillary proliferation. This fact suggested to us that some of the tumors taken through the cannula should have been diagnosed as lipomas because they did not have angiomatous areas histologically.

In 1974, Fischer and Fischer [7] developed the technique of blunt closed liposuction surgery. Recently, liposuction has been widely accepted for generalized body contouring and for suction of localized fat deposits [7–9, 11–13, 16], such as gynecomastia [12], breast reduction [9], and buffalo hump [16]. One of the commonest uses is in removing lipomas [8, 10, 13, 15, 18–21]. When lipomas are multiple, liposuction is an excellent alternative to excisional surgery.

In the present case [6], the authors decided to attempt excision of angiolipomas using liposuction because they were numerous and almost all of them were on the trunk. The advantages of this technique for extraction of multiple tumors such as lipomas or angiolipomas are as follows: (1) the scar is smaller, (2) the scar can be selectively restricted to more cosmetically acceptable areas, (3) multiple lipomas can be removed with a minimum number of incisions, (4) less work time is lost than in many other procedures [5], and (5) there is rapid healing [8, 15, 18, 19].

Wilhelmi et al. [23] reported five cases of facial forehead lipomas (3–4 cm in diameter) by removal with liposuction through hair-bearing scalp incisions. All patients were evaluated as completely satisfied with their result and scar. Some literature [23] describes an advantage of using liposuction for the treatment of medium (4–10-cm) or large (more than 10-cm) lipomas. However, especially for facial lipomas including for a child [24], liposuction is quite a valuable technique through strategically placed incisions.

There are some weak points of liposuction. For example, a malignant tumor may be overlooked by the suction method. Because large tumors (more than 10 cm), especially of the buttock and thigh, are more likely to contain sarcoma [25], usual histological examination before liposuction should always be taken into consideration. There have been previous case reports of fat embolism syndrome after liposuction [21]. In those cases, emboli were found in intestinal capillaries and arterioles of the lung [26]. Laub and Laub [22] suggested that conservative patient selection and aggressive postoperative management could lessen the morbidity and mortality of fat embolism syndrome by liposuction. Temporary paresthesias can also result from blunt traumatization of the cutaneous nerve with the liposuction cannula [18, 27]. In order to avoid nerve injury, surgeons should discourage liposuction of lipomas located near significant motor nerve branches [23].

Finally, in 2002, Al-Basti and El-Khatib [28] reported high satisfaction with the use of liposuction in 16 patients with moderate and large lipomas. He also presented no recorded recurrence with 6-years' postoperative follow-up. I believe that liposuction is a very useful surgical technique for lipomas or angiolipomas.

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75 Treatment of Excessive Axillary Sweat Syndromes (Hyperhidrosis, Osmidrosis, Bromhidrosis) with Liposuction

Ren-Yeu Tsai

75.1 Introduction

Hyperhidrosis and osmidrosis (bromhidrosis) of the axillary area are common troublesome disorders encountered in daily practice. Patients often suffer from physical, mental, and social disturbances. Many kinds of treatment modalities have been mentioned with variable success. Liposuction was first described as a treatment for axillary hyperhidrosis by Kesselring [1], in 1983.

Hyperhidrosis is a pathologic condition characterized by the secretion of sweat in excess to the normal physiologic needs of the body [2]. Osmidrosis (bromhidrosis) is characterized by excessive odor that originates in the apocrine sweat glands, which often combines with hyperhidrosis [3, 4].

75.2 Classification

Hyperhidrosis can be classified into two major groups, generalized and asymmetrical hyperhidrosis. Asymmetrical hyperhidrosis may be due to neurological lesions involving any part of the sympathetic pathway from the brain to the nerve ending. Generalized hyperhidrosis may be caused by thermoregulatory and mental sweating. Emotional or mental activities increase sweating, especially on the palms, soles, axillae, and to a lesser extent, groin and face. Axillary sweating may be continuous, or more commonly phasic, and may be precipitated by heat or by mental state. It is uncommon before puberty.

Axillary hyperhidrosis is due to overactivity of eccrine glands, unlike axillary osmidrosis, which is mainly apocrine in origin [5]. Inaba and Inaba [4] classified axillary hyperhidrosis into two subtypes, essential and symptomatic. If the cerumen is dry, essential hyperhidrosis has almost no odor and is only a condition of excessive sweating that does not stain clothing. Symptomatic hyperhidrosis is always accompanied by the "goaty odor" of apocrine bromhidrosis and clothing discoloration.

Inaba and Inaba [4] defined osmidrosis as a condition of excessive odor alone originating in the apocrine glands, and bromhidrosis as a combination of excessive odor and sweating. Clinically, osmidrosis is often used as a synonym of bromhidrosis. Hypersecretion of apocrine or eccrine glands may be an additional factor contributing to excessive odor

75.3 Pathophysiology

Eccrine glands are composed of three segments: the intraepidermal duct (acrosyringium), the intradermal duct, and the secretory portion. The basal coil lies either at the border of the dermis and subcutaneous fat or in the lower third portion of the dermis (Fig. 75.1). The secretory portion makes up about one half of the basal coil, and the duct makes up the other half. Apocrine glands, like eccrine glands, are composed of three segments: the intraepithelial duct, the intradermal duct, and the secretory portion. Because apocrine glands originate from the hair germ, or primary epithelial germ, the duct of an apocrine gland usually leads to a pilosebaceous follicle, entering it in the infundibulum above the entrance of the sebaceous duct. An occasional apocrine duct, however, opens directly

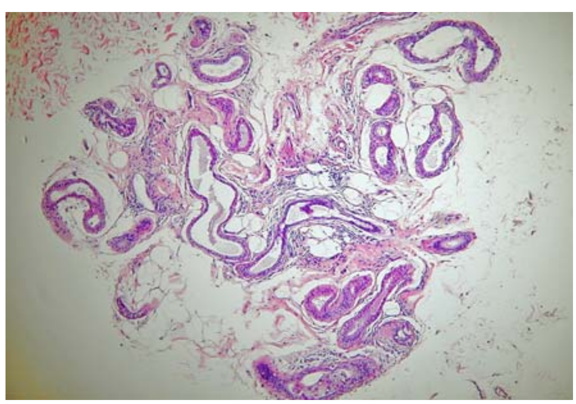

Fig. 75.1. Histology of eccrine and apocrine glands (H&E ×400)

to the skin surface close to a pilosebaceous follicle. In contrast to eccrine glands, the basal coil of apocrine glands, which is located in the subcutaneous fat, is composed entirely of secretory cells and contains no ductal cells [6].

The autonomic nerves, derived from the sympathetic nervous system, supply the eccrine and apocrine glands. The eccrine glands are innervated by cholinergic nerve fibers, while the apocrine glands are innervated by adrenergic nerve fibers [7]. The main function of eccrine secretion is thermoregulation; however, other accessory functions include maintenance of the health and texture of the skin [2]. The apocrine glands are less active before puberty than afterward. They do not have thermoregulatory function. The odor of some apocrine glands may act as pheromones [4].

75.4 Mechanisms of Axillary Odor

Axillary odor mainly originates from interaction of apocrine sweat with microorganisms. Apocrine sweat is sterile and odorless when it first appears on the skin surface. Axillary bacteria degrade the apocrine sweat and produce a malodorous smell within a few hours [8]. The major odor components are short-chain fatty acids and ammonia with typical acid odor [3]. A strong axillary odor tends to be associated with a richer supply of bacterial flora and especially with more corynebacteria [5, 9, 10].

Bang et al. [11] performed axillary skin biopsy from ten normal healthy control subjects without axillary odor and from 20 bromhidrosis patients. In the control group, the apocrine glands were atrophic and lined with flat epithelial cells and showed no decapitation. They proposed that histologic changes of apocrine glands may contribute significantly to bromhidrosis as compared with bacterial decompostion of apocrine sweat.

Axillary hair may increase the odor, since the hair accumulates axillary secretions, debris, keratin, and bacteria. Shaving and scrubbing the axilla may prevent the odor for more than 24 h [4]. Pure eccrine sweat, sterile or non-sterile, will not develop any odor. Only when contaminated with sebum, keratin, or debris does eccrine sweat develop an odor as a result of bacterial decomposition. The odor is mild and quite distinct from the odor developed by pure apocrine sweat. In association with the production of axillary odor, eccrine sweat accentuates bacterial growth and participates in volatilizing odoriferous compounds derived from apocrine sweat [4].

75.5 Management of Axillary Hyperhidrosis and Bromhidrosis

Numerous treatment modalities have been advocated in the treatment of axillary hyperhidrosis and bromhidrosis. These include topical, systemic medical, and surgical methods. All have some limitations because of possible side effects, less of efficacy, or both. Clearly, therapies with the lowest risk of significant side effects should be employed first, followed by more aggressive medical or surgical measures if initial treatment is ineffective or poorly tolerated [12].

75.5.1 Topical Therapy

Aluminum chloride hexahydrate (20%) in anhydrous ethyl alcohol (Brysol) is the safest and most effective topical agent presently available and is considered the first line of therapy in most patients [13]. It can be a useful agent in the control of local hyperhidrosis affecting the palms, soles, and axillae. Excellent results have been reported [14, 15]. Drawbacks to this treatment include its short-lived effect, the requirement of daily application, and skin irritation [2]. However, Shelley found no significant reduction in eccrine or apocrine sweating after the application of aluminum salt preparations. The deodorant effect is based on its antibacterial action [4, 8]. Other topical agents like anticholinergic drugs, formaldehyde, and tanning agents are seldom used owing to their low efficacy and/or undesirables side effects [7].

75.5.2 Iontophoresis

Iontophoresis is the passage of direct electrical current through the patient's palms, soles, or axillae while the patient is in contact with an aqueous ionic solution. The response rate in palmoplantar hyperhidrosis is approximately 90%. Axillae are more difficult to treat by iontophoresis than the palms and soles.

75.5.3 Botulinum Toxin

Botulinum toxin injection for the treatment of axillary hyperhidrosis was first reported by Bushara et al. [16] in 1996. The hyperhidrotic areas are defined by the use of the iodine–starch test. About 50 mU of botulinum toxin is introduced subcutaneously via multiple injections to each axilla, which blocks the release of the neurotransmitter, acetylcholine. Thus, botulinum toxin prevents synaptic transmission and produces an effective chemodenervation of the glands and a temporary cessation of sweating [2, 17].

Odderson [18] reported 71% and 76% sweat reduction following injection, and antihydrotic response lasted for 2–8 months. The duration of the therapeutic effect of botulinum toxin varies, depending on the individual and the dose given, with an average of 3–12 months. Though a longer duration of action has been reported [19], the major drawback to this treatment is the discomfort associated with the mode of application in the form of multiple injections.

Unlike for the palm and sole, injections to the axilla are rather well tolerated, and hyperhidrosis of this area may be a primary indication for the use of botulinum toxin [2]. Apocrine glands are innervated by adrenergic nerve fiber and botulinum toxin injection does not block the secretion of apocrine glands. As a result, bromhidrosis cannot be eradicated by botulinum toxin injection, though it might be improved owing to decreased eccrine gland secretion.

75.5.4 Systemic Medications

Systemic medications, such as anticholinergic agents and benzodiazepines, are effective, but produce multiple side effects, including dryness of the mouth and eyes, and drowsiness [2, 3].

75.5.5 Surgical Treatments

Surgery remains the mainstay in the treatment of axillary hyperhidrosis and bromhidrosis. Several types of surgical methods have been developed. Thoracoscopic sympathectomy is effective for axillary hyperhidrosis, but carries the risk of significant complications, such as pneumothorax, Horner’s syndrome, subcutaneous emphysema, and compensatory hyperhidrosis [20–22]. Hsu at al. [23] reported that T4–T5 sympathectomies provide higher patient satisfaction rates in treating axillary hyperhidrosis and osmidrosis, with fewer sequalae.

Local surgical intervention has been found to be the best curative method for axillary bromhidrosis. There are three basic types described by Bisbal et al. [24] Type I removes the subcutaneous tissue, but not the skin. Type II removes skin and subcutaneous tissue en bloc. Type III involves partial removal of the skin and subcutaneous tissue, as well as the subcutaneous tissue of the surrounding area. The type I procedure appears to be the most applicable to eliminate the malodor and hyperhidrosis, because most of the apocrine and eccrine glands are located in the subcutaneous tissue and the dermosubcutaneous junction and there is no need to remove the skin.

Breach [25] advocated type I procedures that involve the placement of three parallel transverse incisions 1.5 cm in length across the axilla. Through these incisions, the underlying skin of the hyperhidrotic area is undermined and subcutaneous fat is removed in the same fashion as for a full-thickness grafts. Using this technique, over 90% of patients were satisfied or partially satisfied. The complication rate is around 6% and may include hematoma, local wound infection, skin edge necrosis, and prominent scarring [26–29].

There have been several kinds of modified type I procedure for the treatment of axillary hyperhidrosis and bromhidrosis. Inaba and Ezahi [30] developed a radical technique using a subcutaneous tissue shaver. The instrument combined a razor-type blade and a counterpressure component to remove sweat glands and hair follicles via a small cutaneous incision. It often causes accidental tearing of the skin because the edge of the blade cannot be seen. Homma et al. [31] used a disposable plastic razor to excise subcutaneous sweat glands and hair follicles. Among the 40 patients treated, all were satisfied with this technique and experienced no major complications after an average follow-up period of 10.5 months.

Kim et al. [32] combined the CO_2 laser and subcutaneous tissue remover in treating axillary osmidrosis. Eighty-seven of the 88 patients treated (98.8%) had good to fair results, but complications such as ecchymosis and partial skin necrosis with delayed wound healing occurred in four patients (4.67%). Park and Shin [33] compared manual subdermal shaving, liposuction curettage, CO_2 laser vaporization, and ultrasonic aspiration in terms of four parameters: odor, scar, immobilization period, and other surgical complications such as hematoma, seroma, flap necrosis, and wound dehiscence. They concluded removal of subcutaneous apocrine glands by manual subdermal shaving is the treatment of choice for axillary osmidrosis, with a low recurrence rate (7.7%). Other procedures were effective in achieving short surgical scars and a low rate of complications, but there was dissatisfaction in the high rate of recurrence.

75.6 Axillary liposuction

Liposuction is a commonly performed cosmetic surgical procedure. It is an effective treatment for axillary hyperhidrosis, first described by Kesseling [1] in 1983.

75.6.1 Rationale

As a local surgical procedure, apocrine glands as well as eccrine glands are removed by the liposuction technique through one or two tiny incision holes without sacrifice of overlying axillary skin. The success of this technique may be due to disruption of the nerve supply to the sweat glands and removal or destruction of the apocrine glands that are present in high density in the axilla [2].

75.6.2 Technique

The areas of axillae are marked and prepared with or without shaving the axillary hair. The author prefers to shave the axillary hair. After cleaning the skin, 1% Xylocaine is injected into incision sites (upper end of anterior axillary line). A small 3–5-mm incision is made on each side. Tumescent local anesthesia (0.1% Xylocaine) is infiltrated into the axillary concavity. Usually, a total of 200–250 ml of tumescent agents is injected into each axilla.

Twenty minutes following local anesthesia, a 3–5-mm curette is used to scrape subcutaneous and dermal tissue. The scraping technique is performed by curette against underlying skin like moving a windshield wiper in 2–4 cycles (Fig. 75.2). Too many cycles of curettage may cause severe tissue damage, resulting in a contraction scar. After curettage, a 3-mm cannula (one or three holes) is inserted to suction the adipose tissue and debris (Fig. 75.3).

If liposuction is performed alone, a more aggressive cannula should be used in order to remove apocrine glands efficiently. Because most eccrine glands are located in the deep dermis [34], it is not easy to treat axillary hyperhidrosis with simple liposuction. Chung et al. [35] proposed ultrasonic liposuction in the treatment of axillary osmidrosis. While conventional liposuction may be used, ultrasonic liposuction offers the advantage of less injury to blood vessels. Besides the adipose tissue, the glandular tissues in the dermal layer may also be affected by the ultrasound with its thermal and mechanical energy.

Recently, the author developed a new method to determine the endpoint of curettage and suction. A 2-mm axillary skin punch was made after curettage and suction. The specimen was sent for frozen section to see the tissue level that had been (Fig. 75.4). If there were still glands left, the procedure was repeated. Skin punch biopsy can also be done repeatedly to see any residual glands.

Fig. 75.2. Curettage against axillary skin

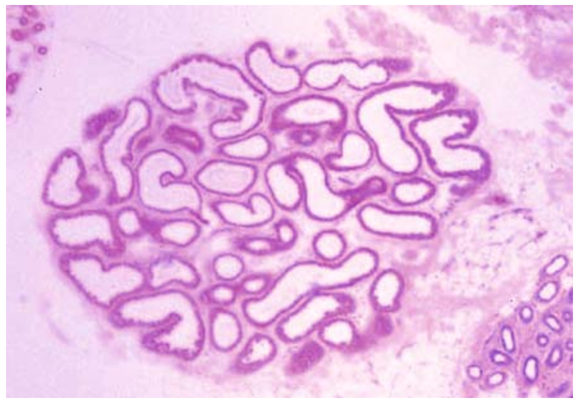

Fig. 75.3. Histopathology of aspirate (H&E ×400)

75.6.3 Postoperative Care

After suction, a bulky compressive dressing is applied to both axillae for the first 24–48 h or longer. The small incision wounds are left open or sutured with 4-O nylon. There are no restrictions in terms of daily activities and minor exercises. Gentle message is allowed 1–2 weeks following the operation to reduce induration and prevent contraction.

75.6.4 Clinical Results

Ou et al. [36] used superficial liposuction to treat 20 patients with axillary bromidrosis. Eighteen patients (90%) had excellent to good results. Park [37] used ultrasound-assisted lipoplasty in the very superficial plane to remove the apocrine gland located in the dermis and the dermosubcutaneous junction. Nineteen patients of 21 treated (95.2%) were graded as excellent and good results with minimal side effects. Chung et al. [35] also performed ultrasound liposuction to treated 87 patients with axillary osmidrosis with a 96.5% satisfaction rate (84/87). Tung [38] combined an endoscopic shaver with liposuction to treat axillary osmidrosis. Malodor elimination was good in 117 of 128 axillae (91.4%) treated. Tsai and Lin [3] reported tumescent liposuction is a simple and safe procedure in the treatment of osmidrosis. Eighty percent of patients

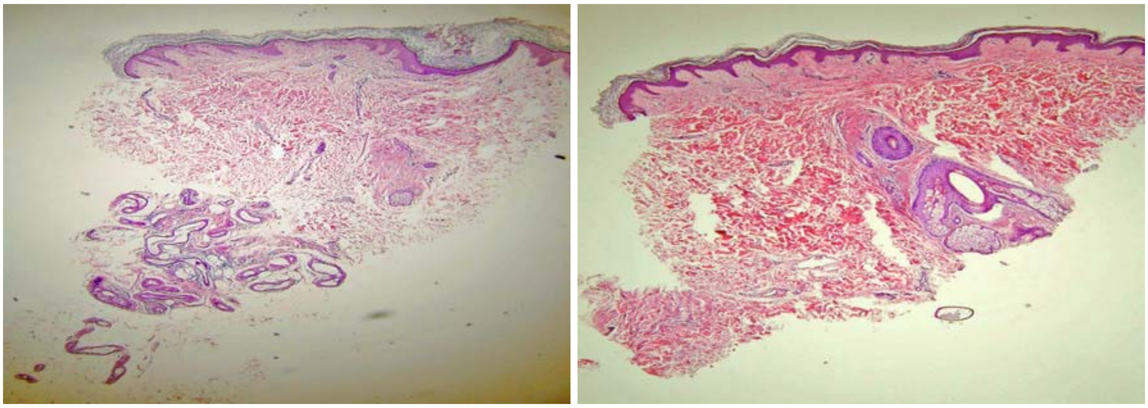

Fig. 75.4. **a** Histopatholoy of axillary skin (before curettage). **b** Histopathology of axillary skin (after curettage)

treated with a combination of tumescent liposuction and curettage were satisfied. From the author's experience, tumescent liposuction combined with curettage is better than tumescent liposuction alone.

75.6.5 Complications

No major complications have been reported in the literature. Minor complications, such as ecchymosis, hematoma, seroma, fibrotic band, and skin retraction, may sometimes be encountered by beginners. With accumulation of experience, the complication rate decreases rapidly. Too aggressive suction or curettage and inadequate dressing are two main causes of complications. Most of the complications will subside spontaneously. If a contraction scar occurs, intralesional steroid injection can be done once a month until revision of the scar takes place.

75.7 Conclusions

Axillary hyperhidrosis and osmidrosis are troublesome and embarrassing diseases encountered in dermatological practice. Although many topical, medical, and surgical treatment modalities are available, none are perfect without any side effects. The most important guideline for clinicians is to choose an effective treatment without major complications. Axillary liposuction is the treatment of choice with high efficacy and a low rate of complications. The advantages of axillary liposuction include high success rate, low complication rate, minimal postoperative care, avoidance of long-term bulky compressive dressing and restriction of movement, rapid recovery, preservation of the normal hair distribution pattern, and tiny-to-invisible scars [36]. There have been several clinical trials to support axillary liposuction in treating osmidrosis, but there have few reports of treating axillary hyperhidrosis. Further clinical studies should be made and refinement of the surgical technique should be investigated.

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76 Treatment of Fox–Fordyce Disease with Liposuction-Assisted Curettage

Stephanie Marschall, Michael Marschall, K. Mireille Chae

76.1 Fox–Fordyce Disease

Fox–Fordyce disease is a rare, chronic, pruritic disorder characterized by small perifollicular papules localized to the apocrine gland-bearing regions of the skin. The disorder affects women more commonly than men and becomes apparent usually during the second to fourth decade of life. Ninety percent of patients with Fox–Fordyce disease are women, usually between ages 15 and 35 [1].

Although nearly a century has passed since its first description in 1902 [2], the etiology and the exact pathogenesis of Fox–Fordyce disease remain unknown. Some have implicated hormonal factors to be involved [3, 4]. Hormonal factors are suggested given that the disease does not occur before puberty and rarely after menopause. Improvement is often seen in pregnant women in the third trimester and the disease is sometimes improved with oral contraceptives. Using means of recent techniques, Turner [5] examined a panel of urine hormonal levels in a patient with Fox–Fordyce disease and found no significant hormonal abnormality. Thus, it remains unclear how hormonal factors may be involved. While the etiology and pathogenesis remain a mystery, it is clear from the distribution of lesions and histologic findings that Fox–Fordyce disease is a disorder of the apocrine glands.

Fox–Fordyce disease affects the apocrine-bearing areas of the skin. Most commonly, axillae and genital areas show numerous papules, but breast and periumbilical areas may also be affected. Pruritis can be severe. Patients with Fox–Fordyce disease usually seek therapy for the pruritis rather than for the appearance of these papules.

Fox–Fordyce disease is also known as apocrine miliaria. Shelley and Levy defined the concept of an apocrine form of miliaria in their description of the histologic findings of hyperkeratosis with plugging of the apocrine sweat gland duct and hair follicle. Diagnosis can usually be made on clinical presentation, and confirmed with skin biopsy. Multiple vertical sections through a biopsy specimen may be needed to show the characteristic findings, namely, follicular plugging and spongiosis of the follicular infundibulum with a mild chronic inflammatory infiltrate. Transverse histologic sections of a biopsy of a papule may allow diagnosis without the need for additional serial sections often required with vertical sectioning [6].

76.2 Therapies

There is no definitive non-surgical therapy for Fox–Fordyce disease. Several reports of useful treatments have appeared in the literature, including oral contraceptives [7], testosterone [8], ultraviolet light [9], topical tretinoin cream [10, 11], topical clindamycin solution [12, 13], and oral isotretinoin [14], Temporary relief may be obtained with some of these measures, but ultimately flares occur with discontinuation. In many patients these measure are ineffective in controlling the pruritis and in decreasing the size and number of lesions. Topical therapies such as tretinoin cream and clindamycin solution are limited as well by local irritation. Although topical corticosteroids may relieve pruritis, prolonged continuous use of corticosteroids is undesirable given the occluded nature of the affected sites and risks of long-term steroid use. At best, these non-surgical therapies offer some relief of symptoms without long-lasting effects.

Surgical removal of the apocrine glands is an extensive surgery and has been done in recalcitrant cases. Few descriptions of surgical therapy for Fox–Fordyce disease have been published. The traditional surgical removal of apocrine glands is an extensive surgery. For the axillae, one approach is to excise the affected region of the axilla [15]. The risks of such a procedure include hematoma, seroma, extensive scar, skin flap necrosis, and long immobilization time. For breast areola, a surgical technique has been described which involves dermal detachment of the areola, then excision of the underlying apocrine sweat glands, and finally placement of the previously detached areola as a skin graft [16].

More recently, liposuction has been found to be beneficial in the treatment of axillary hyperhidrosis.

Permanent removal of sweat glands can be achieved through a modified liposuction technique in which a liposuction cannula is introduced through a stab incision in the axilla and, with the aperture of the cannula turned up towards the underside of the dermis, the deeper dermis is curetted to create inflammation and subsequent fibrosis [17, 18]. An additional variation to this procedure is the use of tumescent regional anesthesia [19, 20]. Tumescent liposuction combined with curettage may prove to be superior to simple tumescent liposuction alone for the treatment of axillary hyperhidrosis [21].

As with axillary hyperhidrosis, eradication of the causal glands is the underlying principle in the use of liposuction-assisted curettage in patients with Fox–Fordyce disease. The apocrine gland is composed of three segments: the intraepithelial duct, the intradermal duct, and the secretory portion. The apocrine gland‘s coiled secretory portion is located at the junction of the dermis and subcutaneous fat. Eccrine glands have their coiled secretory portion within the panniculus near the junction of the dermis and subcutaneous fat. It has been argued that liposuction would not work well for apocrine diseases because of the attachment of the coiled secretory portion of the apocrine glands to the lower portion of the dermis, in contrast to eccrine glands, which have their coiled secretory portion in the fat [22]. Successful liposuction treatment of axillary bromhidrosis, which is apocrine in nature, has been reported, however, with additional findings of apocrine glands and eccrine glands within the aspirate [23]. The combination of the suction and the mechanical scraping of the underside of the dermis likely facilitates the removal of the apocrine glands. The consequent inflammation and fibrosis of the underside of the dermis may also contribute to the overall effect of the liposuction curettage in eradicating the apocrine glands.

Liposuction-assisted curettage can be beneficial in patients with Fox–Fordyce disease. While it may not be appropriate for all patients and for all areas of disease involvement, suction-assisted curettage using liposuction cannulas is a consideration for recalcitrant Fox–Fordyce disease of the axillae.

In our report of a patient with Fox–Fordyce disease treated with liposuction-assisted curettage, the patient reported dramatic improvement with resolution of pruritis and with very few papules remaining in the axillae (Figs. 76.1, 76.2). The patient no longer required any topical corticosteroids to the axillae, and the entry site scars from the procedures are barely visible.

76.3 Description of Procedure: Axillary Liposuction-Assisted Curretage

A modified form of liposuction is performed on the axillae. Under general anesthesia, the axilla is locally infiltrated with local anesthetic such as 0.5% Marcaine and 1:200,000 epinephrine. A small incision is made along the axillary fold and a 4-mm suction

Fig. 76.1. Pruritic papules of Fox–Fordyce disease in the axilla prior to liposuction-assisted curettage

Fig. 76.2. Eight months after liposuction-assisted curettage

lipectomy curette is inserted, with the orifice of the curette placed adjacent to the underside of the dermis. Suction is then applied and the curette is moved in a sweeping fashion over the underside of the dermis throughout the region of involvement. An immediate decrease in the number of papules on the surface of the axilla can be seen during the procedure. The insertion point is closed with interrupted suture.

If tumescent anesthesia is chosen then, approximately 100–200 ml of tumescent anesthesia (0.1% Xylocaine) is injected into each axilla. The suction lipectomy curette is then inserted as described before. Our experience is limited with tumescent anesthesia, but it certainly could be an option and may provide an option for patients who are unable to undergo general anesthesia.

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Laser-Assisted Suction of Axillary Sweat Glands and Axillary Epilation

Martin Klöpper, Gosta Fischer, Guillermo Blugerman

77.1 Introduction

Axillary hyperhydrosis (sweating) commonly causes discomfort and unpleasant body odor, both of which can lead patients to feel socially handicapped. Current treatment options for this condition leave much room for improvement:

- Conservative treatment with drugs is in most cases unsatisfactory.
- Botox therapy is expensive and only helps for a few months.
- Endoscopic transthoracic sympathectomia bears considerable risks.
- Suction in tumescent anesthesia with a blunt cannula alone is less successful than Botox treatment.

Therefore we set out to find a better treatment for this condition. The general approach tested here was to combine suction treatment with subdermal Nd:YAG or diode laser application in tumescent anesthesia.

All patients agreed to be part of this clinical study, were informed about alternative treatment options, and signed an informed consent form. All surgeries were performed on an ambulatory basis.

77.2 Patients

All patients included in this study (*n*=64, 36 women, 28 men) had been suffering from hyperhydrosis axillaris for years. All had tried sprays, powders and other conservative options. In most cases, hyperhydrosis began during adolescence, although in some patients the onset was in the early twenties. A total of 154 axillae were treated because some patients with recurrence in 2002 and 2003 had to be treated up to three times. The age of our patients varied between 19 and 61 years with a clear peak in the late twenties.

77.3 Method

Two preoperative appointments for oral and written consent and a sweat test were mandatory. If there were significant medical risk factors a checkup by a general physician was required. Contraindications were similar to the ones for liposuction. An intravenous line or sedation (midazolam) was only necessary in very sensitive individuals and was not routinely administered. It should be noted that both the patient and the surgeon must wear protective glasses during laser treatment!

Axillary hair should not be shaved. We start with a second simple sweat test (iodine/starch) because sweat production may vary (Fig. 77.1).

Significant differences in the size of sweat-producing areas were observed in different patients. One patient may produce high amounts of sweat in an area of around 8 cm^2, whereas another patient may produce the same amount of sweat in an area of 50 cm^2. A remarkable number of patients had less sweat production after the second preoperative talk in comparison with the test just before surgery. This emphasizes how significant the psychological component of unwanted sweating can be.

The area of concern and an additional 5 cm in diameter around the hairy zone is marked with iodine solution (spray) and dried with a hair dryer. Powdering with corn starch follows. Areas of active sweat production turn black and are outlined with a marker pen (Fig. 77.2).

After surgical disinfection of the skin and sterile draping, Klein's solution is infiltrated at about 200–350 ml per axilla with an infiltration pump. There is no need for deep infiltration. The goal of infiltration is anesthesia, firmness of the tissue and constriction of the vessels to prevent hematoma; however, care must be taken to avoid unwanted deep infiltration, as this may provoke a plexus anesthesia of the arms and hands (Fig. 77.3).

Subdermal dissection is performed with a blunt Blugerman spatula. The tip of the cannula is always directed towards the skin (Fig. 77.4).

Fig. 77.1. Different patterns of sweat gland distribution. Concentration of sweat glands (*upper*). The scattered type of alignment (*lower*) (iodine/starch test)

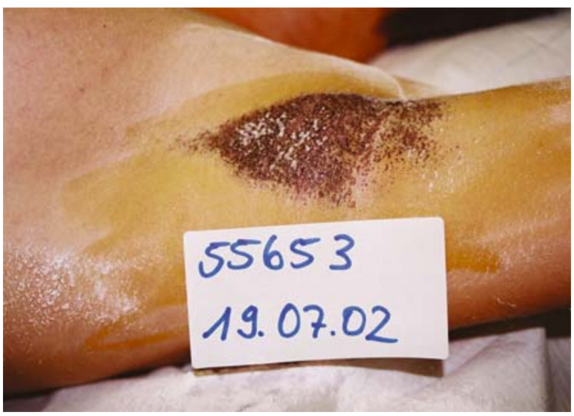

Fig. 77.2. Painting the axilla with iodine solution should be done generously so as not to miss ectopic sweat glands

Fig. 77.3. Infiltration of the axilla with Klein's solution. Pronounced tumescence is necessary for laser treatment and suction

From our past experience, plain suction of sweat glands in tumescent anesthesia alone with a blunt common cannula is definitely not an optimal solution. Although plenty of suctioned sweat glands can be found in the aspirate after suction with a blunt cannula, clinical experience and follow-up analysis tells a different story. Even though patients might be happy with the outcome for a few weeks, only a very small reduction of sweat production in sweat tests was seen in these patients several months after surgery with a blunt cannula.

Progress could be achieved by means of a Becker tip cannula with a rough configuration of the edges of the aspiration holes. This type of cannula serves to nick and "rasp" the subdermis in a manner that exposes both sweat glands and hair follicles to the laser treatment that follows suction (Fig. 77.5).

When should rasping of the subdermis be stopped? After subdermal dissection with the blunt Blugerman spatula a thin layer of subdermal fat remains. During suction two fingertips should always be positioned aside the tip of the cannula following the crisscrossing movement from all stab incisions. The skin becomes thinner and thinner. Stop when you feel the rough edges of the aspiration opening of the cannula in between your fingertips.

Afterwards the laser fiber (0.6 mm in diameter) is introduced into a 2-mm infiltration cannula whose tip was cut and fixed by a fiber lock at the proximal end of the handpiece. It is imperative that the tip of the fiber protrudes from the end of the cannula by 2 mm (Figs. 77.6, 77.7).

Should the tip of the fiber slip back into the open end of the cannula, this can lead to intense heat development, which in turn can burn both the fiber and the cannula. Should this occur, bright flashes can be observed under the skin and the laser must be switched off immediately to reposition the tip of the fiber for reasons of safety. Otherwise overheating can occur without any of the desired effect on the sweat glands or hair follicles. This can happen quite often, mainly in cases of recurrence with fibrotic subdermis.

Stab incisions are left open for drainage and are covered with sterile swap pads. The stab incisions are

Fig. 77.5. Becker tip cannula with rough suction holes

Fig. 77.4. Dissecting the skin from the subcutaneous tissue with a blunt spatula. Blugerman dissection spatula (*inset*)

Fig. 77.6. Laser fiber protected in a 2-mm infiltration cannula with cut tip

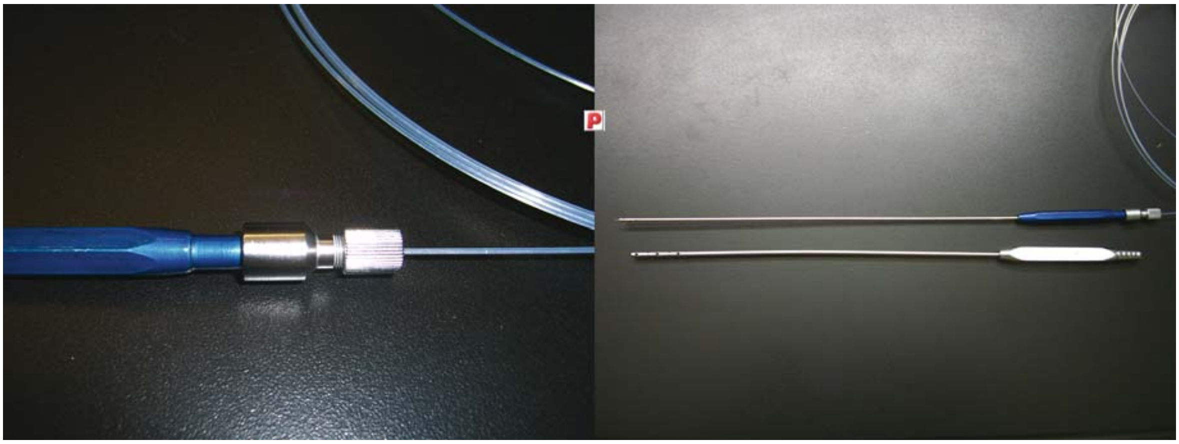

Fig. 77.7. Fiber lock at the proximal end of the infiltration cannula and both cannulas in total view

closed 2 days postoperatively with waterproof suture strips to allow showering.

Clinical examination as a routine is arranged after 2 days, 1 week, 3 months and 6 months or at any time in the case of trouble.

77.4 Objective for Laser Treatment

Sweat glands and hair follicles are situated in the deep dermal layer (Fig. 77.8).As epilation from "outside" is possible, why not apply a Nd:YAG or a diode laser from underneath to destroy both sweat glands *and* hair follicles?

Our objective is a direct approach for removal of both sweat glands and hair follicles. We started applying 6 W at 10 Hz and an impulse width of 20 ms with an cumulative energy of about 0.5 kJ per axilla. The tip of the cannula was elevated against the surface of the skin from underneath at an angle of about 20–30° and moved around in a crisscrossing manner from at least two—better three—stab incisions (Figs. 77.9, 77.10).

Subsequently we increased the applied energy in increments of 5 W. In every case we took a punch biopsy from each side. Later we took the second specimen 10 days after surgery or later and noted a much more intense destruction of our targets, since histologic manifestation of damage needs time to become visible in sections.

Up to 40 W with an impulse width of 20 ms was applied. The maximum total energy applied per axilla was 7.8 kJ in this phase and the first partial dermal necrosis was observed at 450 J/cm^2 on the right side and at 525 J/cm^2 on the left side in very small axillae. Because of temporary loss of sensitivity the patient did not suffer from pain (Fig. 77.11).

This damage was treated for 4 weeks without further complications or complaints.

Because of the massive rise in skin temperature above 30 W of laser power we introduced a skin-cooling device to prevent further skin damage (Fig. 77.12).

77.5 Laser Treatment *and* Suction or Laser Treatment Alone? Which Approach is Superior?

For a few months in 2003 we studied two groups of patients. Group 1 received laser treatment plus suction; group 2 received laser treatment alone. Specification of the data is in Tables 77.1–77.4 and Figs. 77.13–77.15.

There is no doubt that the combination of suction and laser bears fewer risks, is more comfortable for the patient and renders better results. We stopped laser treatment without suction immediately after evaluating the results of the treatment of the two groups (the data were published at the AACS meeting in St. Louis, 2004).

77.6 Safety Measures

- Air cooled to 5°C was applied from a distance of about 25 cm to prevent damage to the skin.

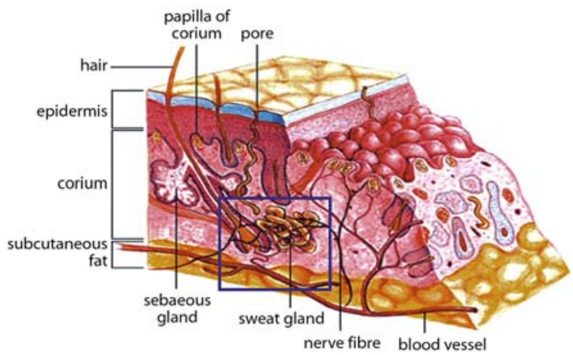

Fig. 77.8. Where is the target of the treatment of hyperhydrosis? The position of the sweat glands and the hair follicles is located in the deep dermis

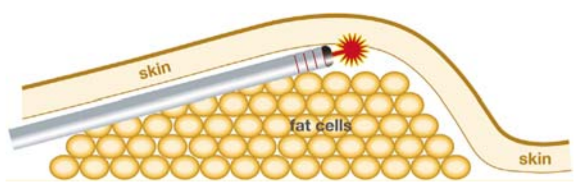

Fig. 77.9. Bare fiber in subdermal position. The tip of the hand piece is elevated, and the skin is struck at an angle of about 30°

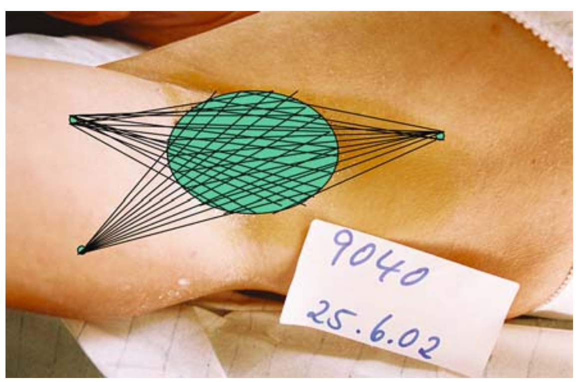

Fig. 77.10. Positioning of stab incisions. No suctioning, no laser application outside the *green ellipse* to avoid irregularities of the surface and skin necrosis

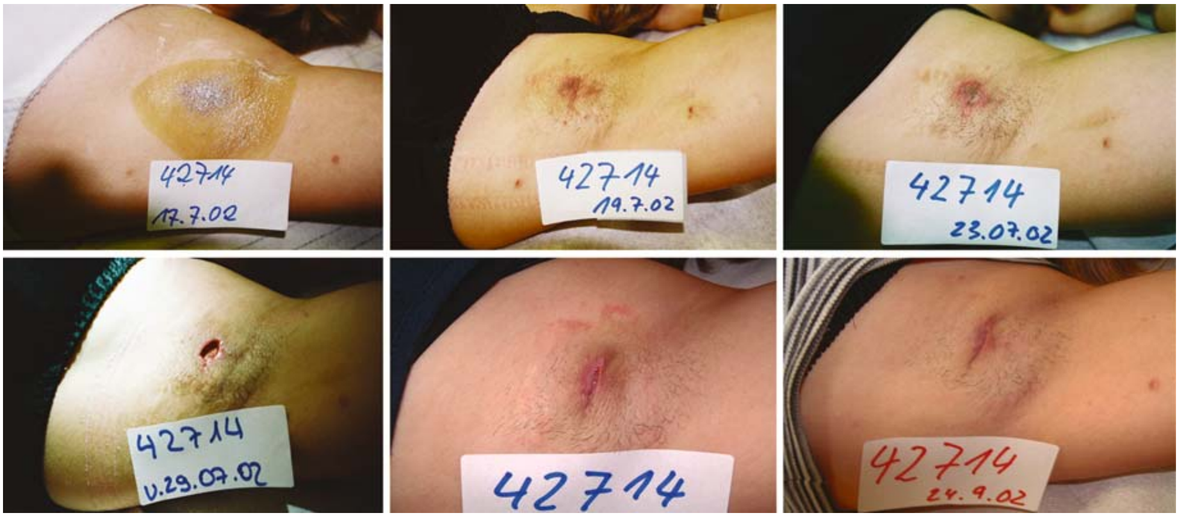

Fig. 77.11. Pitfalls: skin necrosis and healing. First surgery in March 2001, applying 15 W and 1.0 kJ/axilla with limited success for about 2 months. The left axilla is pictured after applying up to 575 J/cm^2. **a** After surgery in March 2002 (2.0 kJ/axilla). **b** Two days after second surgery (4.6 kJ/axilla). **c** Emerging central necrosis. **d** Necrosis after 12 days. **e** Three weeks postoperatively. **f** After 9 weeks

Fig. 77.12. The tolerance of the skin to laser treatment is limited. Skin cooling helped to prevent more damage to the skin

Table 77.1. Patient group information

Group 1: suction and laser	Group 2: laser alone
13 patients 12 female, 1 male Average age 33.4 years Standard deviation 9.2	12 patients 8 female, 4 male Average age 31.4 years Standard deviation 7.4

Table 77.2. Applied energy per square centimeter (Nd:YAG laser)

Group 1: suction and laser	Group 2: laser alone
98 J/cm^2 Standard deviation 42 Settings 30 W 20-ms impulse duration	142 J/cm^2 Standard deviation 30 Settings 40 W 20-ms impulse duration

Table 77.3. Months since surgery

Group 1: laser and surgery
Mean value of control period 15.5 months Standard deviation 2.46
Group 2: laser only
Mean value of control period 13.75 months Standard deviation 3.34

- Another key point was the manner of administering laser energy to the skin. Stab incisions must be placed at least 4 cm away from the outlined area. Lasering should be stopped at the rim of the target area. If you do not do this, you risk skin necrosis next to the stab incision because of cumulated laser energy next to the incision. The remaining treatment can be administered from the opposite side.

– Laser energy has to be applied only while *retracting* the laser fiber. Applying laser energy while moving the laser fiber forwards can easily cause perforations of the skin. Moreover, as the patient often likes to watch the procedure, she or he must wear special protective glasses, as the risk of injury to patients' eyes is high if they do not wear protective glasses as demonstrated in Fig. 77.16.

Table 77.4 Side effects and complications

	Group1	Group 2
Seroma	1	1
Hematoma more than 25 cm^2	1	1
Small necrosis of the skin	1	3
Restricted mobility of the shoulder for 4 weeks		1
Recurrence of sweating after 1 week		1

There are big differences in the size of the active sweating area that has to be treated. Thus, we measured approximately the size of the "hairy axilla" in square centimeters. Following our experience we decided how much energy per square centimeter should be applied. A simple multiplication of this dose with the number of square centimeters yields the total energy that should be applied. Reliable control of applied energy can only be obtained by using the energy "counter" in the laser control panel.

Less than half of the energy per square centimeter that caused the first skin damage was used in the following cases. Nevertheless we had one partial necrosis of the skin in a Fitzpatrick type 1 patient at 180 W/cm^2.

Safe doses of laser energy per square centimeter should be about 100 J/cm^2 in Fitzpatrick type 1

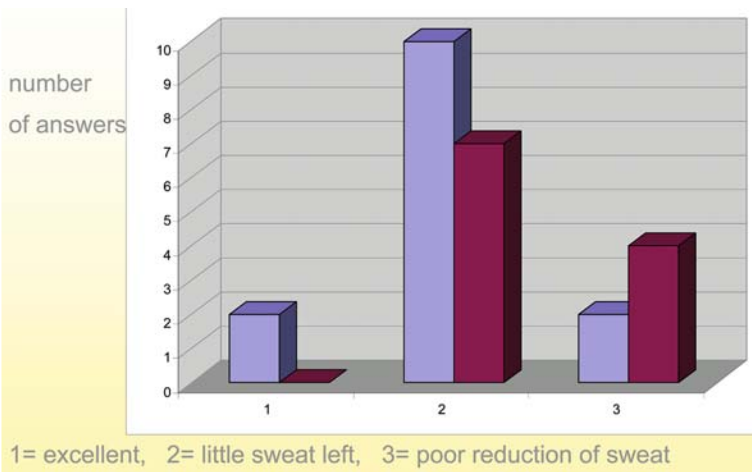

Fig. 77.13. Sweat reduction after 14 months (mean values). Laser and suction, *blue bars*; laser alone, *purple bars*

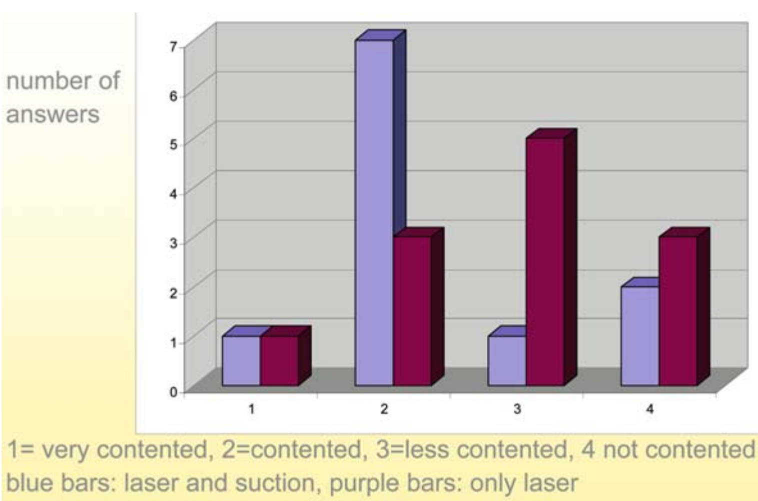

Fig. 77.14. Patient satisfaction postoperatively

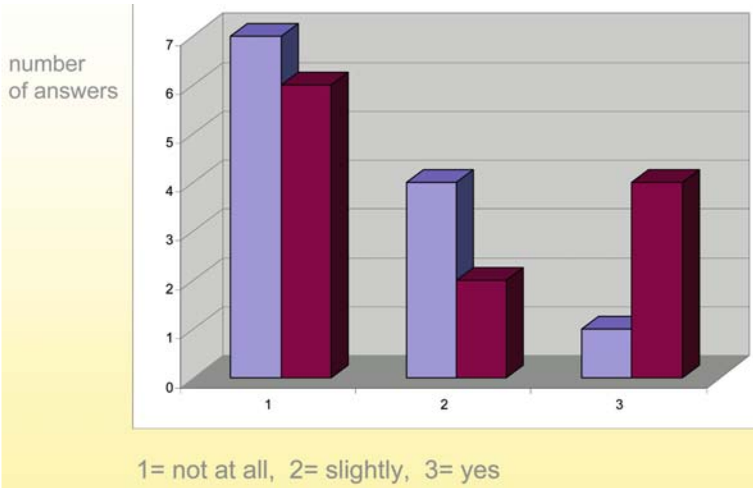

Fig. 77.15. Did surgery bother you? Laser and suction, *blue bars*; laser alone, *purple bars*

Fig. 77.16. Subdermal laser treatment with protected 0-6-mm bare fiber and cooling of the skin

patients and up to 180 J/cm^2 in Fitzpatrick type 4 patients. While the optimal doses are not definitively established, they represent the current state of our knowledge.

77.7 Ectopic Sweat Glands

A very important cause of recurrence of sweat production was revealed when we started to mark 5 cm more of the axillary skin around the "hairy" area with iodine solution. We found that significant numbers of "ectopic" sweat glands may be located outside the presumed area that were not detected in earlier cases with recurrence (Fig. 77.17).

77.8 Epilation

High energy levels resulted in subtotal epilation of the central axilla. Loss of axillary hair is demonstrated and was often reported by patients (Fig. 77.18).

As mentioned before we used a Nd:YAG laser in most cases. Five months ago we started laser treatment with a diode laser with the same settings of energy application. Three patients have been treated to date, and no complaints or side effects have been reported. The results seem to resemble those obtained with the Nd:YAG laser. Further studies will be performed to compare results obtained with these different types of lasers.

77.9 Histologic Observations

To date, 64 histologic specimens of axillary skin have been examined by G.F. The effect of laser energy is power-dependent. The following histologic observations in sweat glands and hair follicles were made (Figs. 77.19–77.22):

- Intracellular edema
- Intracellular vacuoles
- Desquamation
- Cell rupture
- Destruction

77.10 Clinical Results

Patients treated since February 2002 have reported a decrease in sweat production of 80–90% and subtotal

Fig. 77.17. *Blue line*, axillary hair. *Green line*, partly ectopic sweat glands in the case of recurrence outside the hairy axilla

Fig. 77.18. Subtotal epilation of a left axilla 9 months postoperatively

hair removal up to 40 months. These results were verified by examination with sweat tests where possible (n=54) or by a telephone survey (n=58). Six patients were not satisfied with the results of their treatment, perhaps because of the learning curve we had in applying this procedure since February 2002.

77.11 Observed Side Effects and Complications

- Partial skin necrosis in four cases (6%) (Fig. 77.23).
- Seroma in six cases needed puncture and evacuation (9%) (Fig. 77.24).
- Subdermal fibrosis (to be treated successfully with subdermal injections of a mixture of 5-fluorouracil and corticoids) (Fig. 77.25).
- Restricted mobility of the shoulder for 4 weeks in one case.
- Recurrence of sweating after 1 week without explanation.
- Lack of sensitivity of axillary skin postoperatively for 4–6 weeks is normal and cannot be considered to be a side effect.

77.12 Conclusions

- Suction alone with a blunt cannula or a Becker tip cannula is only helpful for a few weeks and can therefore not be recommended. Indeed, it has proven to be less effective than Botox injections.
- Preoperative painting of the axilla should include adjacent areas because sweat glands may be located outside the presumed treatment area.
- The laser energy that is to be applied should be adjusted according to the surface of the axilla to avoid skin necrosis.
- Cooling of the skin is recommended for treatment of the axilla with high laser energy levels.
- Underskin laser treatment with energy levels of at least 140–J/cm^2 or more leads to loss of axillary hair.
- The safety guidelines outlined in the next section should be strictly adhered to.
- Tissue specimens for histological evaluation should be removed no earlier than 1–2 weeks postoperatively.
- Unwanted side effects seem to be more dependent on the applied laser energy than on mechanical stress to the skin.
- Too many unwanted side effects prohibit further increase of the applied energy per square centimeter of skin.

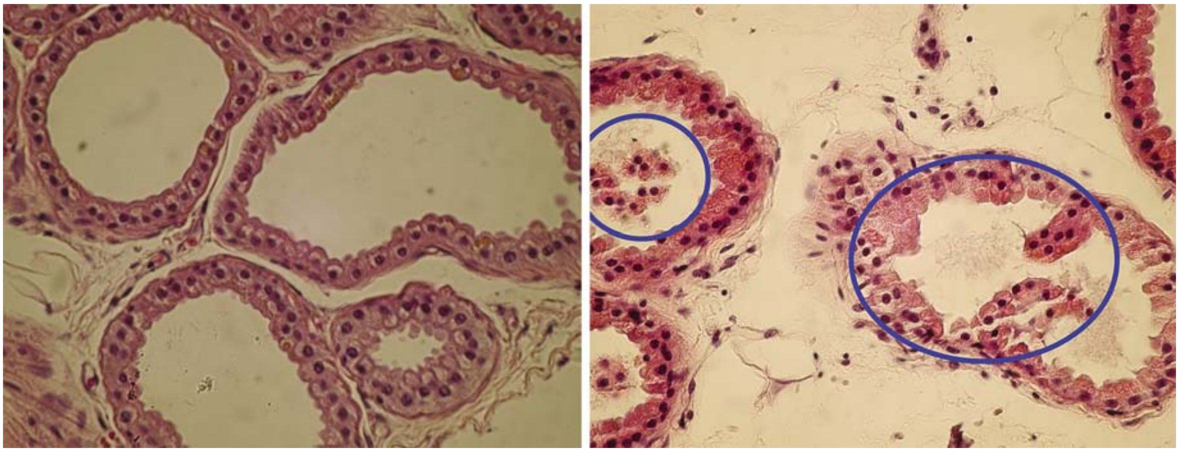

Fig. 77.19. Damage after laser treatment at 15 W. Regular specimen before laser treatment (*left*). Desquamation and rupture of the cellular formation in the gland (100 J/cm^2) (*right*)

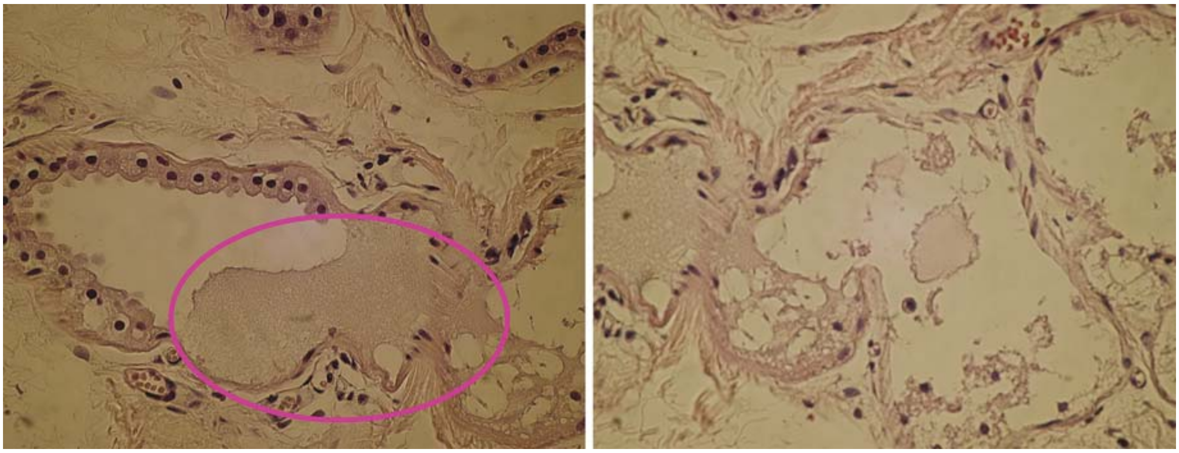

Fig. 77.20. The lower right of the sweat gland is destroyed at 40 W (*left*). Total destruction at 40 W and 150 J/cm^2 (*right*)

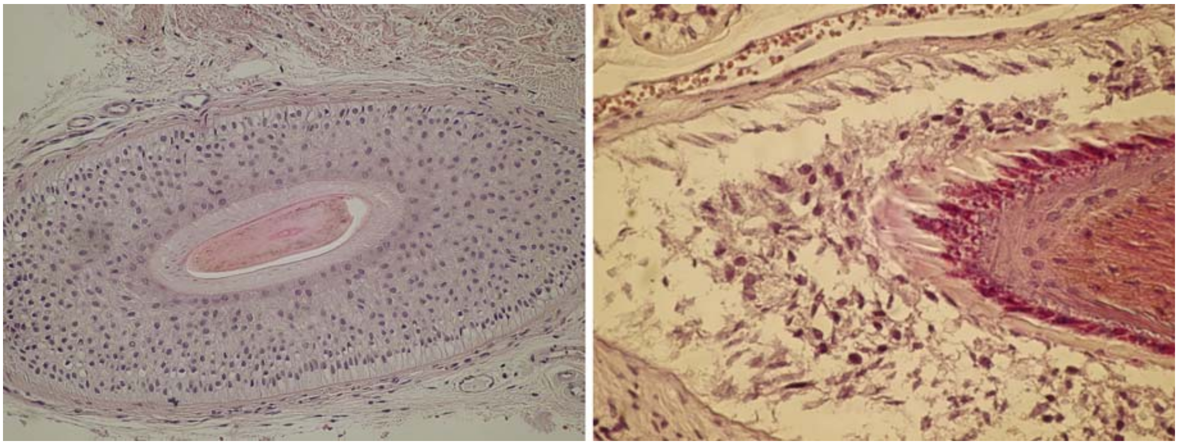

Fig. 77.21. Regular hair follicle (*left*); totally destroyed perifollicular tissue at 40 W (*right*)

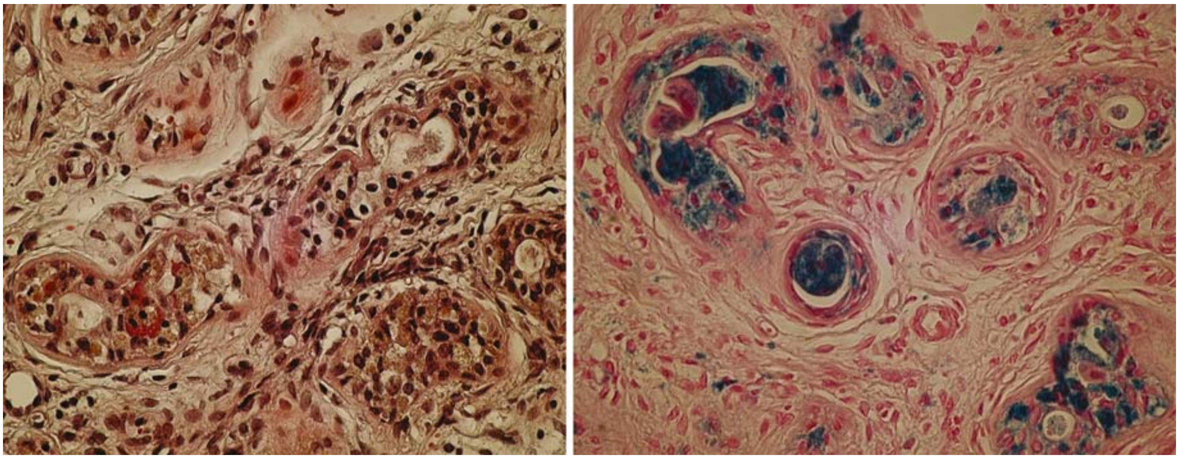

Fig. 77.22. Histological changes at 30 W and 105 J/cm^2 10 days after surgery. Remainder of an acute intraoperative bleeding. Hemosiderin (*left*, *brown*); positive Berlin blue reaction (*right*)

Fig. 77.23. Secondary healing after laser treatment. Note central epilation 2 weeks after surgery

Fig. 77.24. Partial skin necrosis and seroma after laser at 180 J/cm^2 and suction

Fig. 77.25. Subdermal fibrotic "string" 3 months postoperatively

Because of the small number of cases in northern Germany a serious statistical evaluation is not yet reasonable. Our evaluation of this novel method is still in progress; however, a substantial number of successful procedures have been performed.

77.13 Safety Guidelines

- Tumescent solution should also be administered in an area extending 5 cm past the circumference of the "target zone."
- Patient and surgeon should always wear protective glasses during the laser procedure.
- Stop suctioning when you feel the rough holes of the cannula in between your fingers.
- Turn off the laser 4 cm before you reach the stab incision.
- Place the stab incision at least 4 cm outside the target area and never suction or laser outside the target area.
- Only switch on the laser when *retracting* the laser fiber, never when inserting it.
- Retract the laser fiber with a speed of about 1 cm/s.
- Cooling of the skin throughout the procedure is mandatory.

78 Liposuction in Dercum's Disease

Erik Berntorp, Kerstin Berntorp, Håkan Brorson

78.1 Introduction

Adipositas dolorosa or Dercum's disease [1] is predominantly prevalent in young women, 25–40 years of age. The basic sign of the disease is adipositas associated with pain. The disease is named after the neurologist Francis Dercum. The first case was described in 1888. The prevalence is somewhere around one in 1,000 in the general population. There is an indication of a dominant genetic trait and the gender distribution female to male is roughly 20:1 [2]. The pathophysiology behind the pain related to the adipositas is not well substantiated. The symptoms are very therapy resistant and may have a major impact on quality of life. More than half of the patients have been reported to be unable to work.

Hypothetically, the disease could be caused by an autoimmune reaction as the symptoms may start suddenly and a slight increase of inflammatory cells in the adipose tissue has been described [3, 4].

78.2 Diagnosis

The diagnosis can only be made by clinical examination [5]. The pain can be generalized or localized and there is a positive relation between pain and body weight. The basic criterion for diagnosis is pain in the adipose tissue combined with adipositas. The pain is chronic and usually symmetric. The pain is dependent on weather conditions, with a decrease in symptoms during high-pressure situations. The patients are usually overweight, around 50% being above the normal weight for the age.

Dercum's disease may be classified into three subtypes:

1. Type 1: The juxta articular type with pain at the medial sides of the knees and/or around the hips.
2. Type 2: Diffuse, generalized type (Fig. 78.1).
3. Type 3: The nodular type with intensive pain in and around lipomas, sometimes without generalized adipositas. Histologically, some of these have been classified as angiolipoma [6].

Other symptoms associated with Dercum's disease are a tendency of getting edema, especially in the hands, and compression of the median nerve is common. Generalized fatigue, tendency to bruising, stiffness, headache or other non-specific symptoms. The patients can also have problems with depression. Some reports of febris recurrens and susceptibility to infections have been published [7]. A number of associated states, including thyroid dysfunction, have been reported and arterial hypertension and type II diabetes are said to be common.

Regarding laboratory parameters, signs of inflammatory activity can sometimes be seen, such as increased erythrocyte sedimentation rate, and elevations in plasma of alpha-1-antrypsin, orosomukoid, haptoglobin and complementary factors [5].

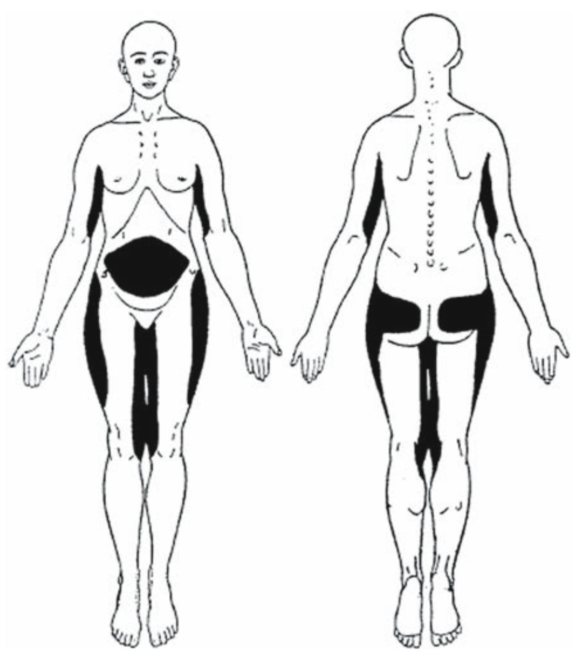

Fig. 78.1. The typical pain distribution in the adipose tissue in generalized adipositas dolorosa

78.3 Therapy

One important therapeutic measure is to inform the patient about the disease. Analgesics do not have much effect, but lidocaine intravenously can give some pain relief [8, 9]; however, owing to side effects it is not possible to administer this as a long-term treatment. Some patients may benefit from treatment with diuretics.

Weight reduction is recommended, but it is very difficult to achieve and gastroplastic surgery has therefore been implemented in some cases. Excision of local lipomas affecting nerves may be of value.

78.4 Liposuction in Dercum's Disease

At Malmö University Hospital some experience of liposuction in Dercum's disease has been acquired. After cosmetic liposuction there is a decreased sensation in the skin for several months. The hypothesis was that this well-known phenomenon might also decrease the pain in patients with Dercum's disease. Postoperatively there was a decreased perception of touch in the skin as well as decreased pain with increased quality of life in a number of patients. The mechanisms behind these findings are probably a denervation of the subcutaneous tissue and skin. However, the effect of the liposuction procedure seems to decrease with time, probably as a result of reinnervation. In a specific research project at our hospital [10], we performed a prospective study of liposuction in 53 patients with Dercum's disease with the objective to study the impact of adipose tissue removal by liposuction on factors associated with increased risk of cardiovascular atherosclerotic disease within the coagulation and fibrinolytic system and glucose metabolism. The study material comprised 53 female patients with Morbus Dercum with a median age of 52 years, range 22–69 years. A group of 50 age-matched, healthy women served as a control. The body mass index (kilograms per square metre) was 34.3 preoperatively in the study group and 28.2 in the control group. The surgical procedure was as follows. Liposuction was performed under general epidural or spinal anaesthesia. A single-lumen bullet-shaped cannula with two to three openings distally and an outer diameter of 5–6 mm was used. All areas of pain were treated through numerous 4-mm skin incisions. The cannula was connected to a vacuum pump giving a negative atmospheric pressure of 0.9. Treated areas were subsequently firmly compressed to arrest bleeding and prevent postoperative edema. This was achieved by using compression garments on the legs, elastic bandages on the arms and an elastic corset. The stockings and corset were used for at least 6 weeks postoperatively.

Body weight was measured and blood samples taken in a fasting state on the day of surgery, and 2 weeks, 4 weeks and 3 months after surgery. The coagulation parameters measured were von Willebrand factor antigen (VWF:Ag), fibrinogen and plasminogen activator inhibitor type 1 (PAI-1) activity. In a subsample of patients, insulin sensitivity was measured using a 2-h euglycemic hyperinsulinemic clamp technique to estimate in vivo insulin sensitivity [11].

78.5 Results

For the whole study the mean weight of aspirate extracted at liposuction was 3,451 g (range 600–9,200 g). The mean preoperative body weight was 90.7 kg and this decreases significantly during the following 3-month period to 86.6 kg. The VWF:Ag level increased, whereas the fibrinogen level remained the same and the PAI-1 activity showed a tendency to increase. In the insulin sensitivity studies the fasting glucose and insulin concentrations were unchanged, but the so-called insulin sensitivity index significantly improved. No complications were recorded which could be related to the liposuction procedure.

78.6 Discussion

The hallmark of Dercum's disease is adiposis associated with pain. The subjects often have decreased quality of life and also the potential to have an increased risk of developing the metabolic syndrome with increased risk of arteriosclerotic disease. Our study indicates that relatively modest weight reduction may facilitate glucose uptake. Increased levels of VWF:Ag and PAI-1 are associated with increased levels of other risk variables contained in the so-called metabolic (or insulin resistance) syndrome of which an increased amount of adipose tissue is a part [12–15]. From a theoretical point of view we would expect a decline of VWF, fibrinogen and PAI-1 when removing adipose tissue, but in our study we saw the opposite [9]. This may be explained by the operative trauma, which causes inflammation in the surgical area and a subsequent increase in the study coagulation parameters as they are known reactive proteins. All these coagulation proteins are increased in the obese [12–15] and in our study it can be speculated that the amount of tissue removed was not great enough to counteract the inflammatory changes or that a change in lifestyle, including eating habits and physical activity, is a prerequisite for improvement.

Liposuction seems to be a logical treatment of the symptoms in Dercum's disease, but according to the experience at our hospital, the improvement of pain has a rather short duration. Removal of adipose tissue using liposuction is probably not a feasible approach to improve risk factors associated with a metabolic syndrome. Diet and physical activities are probably better tools for weight reduction, although it is well known that it is difficult to achieve long-term improvement.

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Treatment of Hematomas with Liposuction

Antonio Ascari-Raccagni

79.1 Introduction

Liposuction is a technique, which was first developed in France in the late 1970s and then introduced in the USA in 1982. Since then, it has increasingly drawn attention and interest owing to the relative ease of performance and the high satisfaction rate of patients.

Liposuction equipment, techniques, and related anesthetic methods are in continuous development to improve the body shape, its aesthetics, and to reduce the hazards during operations. Nevertheless, in order to obtain better aesthetic results the liposuction instruments and machines available nowadays are highly complicated and very expensive.

Liposuction has also recently been employed in a variety of non-cosmetic applications and has increased its appeal to dermatological surgeons and others.

For several of these non-cosmetic applications, even simple, basic liposuction equipment can be used, often to solve real, more strictly medical problems especially for outpatients.

The procedure can be successfully used on many occasions to drain a large post-traumatic hematoma [1] or to manage a postsurgical hematoma, enhancing the post-treatment look of the patient and reducing the recovery time [2].

The observation of both post-traumatic and postsurgical hematomas is nowadays increasing owing to the growing age of the active population and the diffuse prescription of anticoagulants and platelet inhibitors, even though it is obvious that we can try to ward off problem only in a small number of postsurgical patients.

79.2 Post-Traumatic Hematomas

Hematomas of the soft tissues are extremely painful because of the distension of the tissues and may cause necrosis of the overlying skin. Such necrosis may be caused by a thrombus or the lack of flow in dermal and subdermal vessels due to the increasing pressure inside the hematoma, but may also be due to the release of free iron radicals produced by the breakdown of hemoglobin, which is toxic to the skin. There are several techniques for the treatment of hematomas, such as aspiration, irrigation, evacuation, and manual compression.

Aspiration of a hematoma with a big needle and syringe can be performed only after blood liquefaction, with the result of exposing the tissues to the inflammatory melting response and delaying the patient's return to the community. Irrigation, which can be performed with various different solutions, is generally only the second step of an aspiration procedure and, therefore, is subjected to the same inconveniences.

The open evacuation surgical technique is complex, disfiguring, and painful for the patient; especially in the case of persistent coagulated subcutaneous hematomas when open evacuation must be performed with a strong bimanual compression in order to remove all the blood clots, resulting in further damage to the soft tissues.

This is why even large hematomas can be treated with liposuction, a simple and safe technique that reduces the recovery time, avoids skin necrosis, and avoids the necessity of debridement and reconstruction.

Hematomas on the leg [3, 4], the calf [5], the thigh [6, 7], and the outer ear [8] have been reported to have been treated with this technique under local anesthesia (Fig. 79.1).

79.2.1 Materials

The equipment used is affordable and consists of a blunt-tipped liposuction cannula (1.5–4 mm in diameter) with either two opposite rows of aspiration holes or only blunt edge aspiration apertures along the side, mounted with a Luer Lock connection on a 20-ml disposable syringe. The blunt tip allows penetration through the tissues without injury to all but the smallest vessels or nerves.

Expensive high-vacuum liposuction equipment shortens the surgery time, and enhances the possibility to evacuate larger blood volumes [3].

79.2.2 Technique

A solution of 2% lidocaine is injected exclusively in the area of the incision. The tumescent infiltration technique has recently been proposed with the aim to improve safety and allow large areas to be treated under local anesthesia [7].

A small incision is made in the skin using a no. 11 scalpel blade or a trocar. This incision is placed on the lower side of the hematoma to facilitate the drainage. The syringe is firmly held with the right hand, ready to keep the plunger on suction mode after the insertion. The left hand rests on the skin to palpate the borders of the hematoma, which can be outlined with a dermatographic pencil (Fig. 79.2).

The liposuction cannula is inserted through the incision towards the center and then the periphery of the hematoma. It is moved in and out, in a radial fashion to remove all the clots with continuous suction. If high-vacuum equipment is used, the pump must be turned on only after the cannula is introduced, otherwise the vacuum may impede the passage through the subcutaneous tissue. Attention must be paid in keeping the suction holes of the cannula neither facing the skin nor downward against the highly vascular muscle and the fascia in order to prevent further bleeding (Fig. 79.3).

After the procedure, relief from pain is prompt and dramatic. A compression bandage must be applied immediately after the liposuction, eventually using an elastic wrap (Fig. 79.4). The patient must keep the extremity in an elevated position until the edema resolves.

In some cases, after the liposuction of a hematoma, the use of a drain or even of biological glue has been suggested to reduce the virtual cavity present after the procedure [6].

79.2.3 Complications

Potential complications of liposuction in the treatment of hematomas include:

1. Infection, a common hazard in any other surgical treatment of hematomas.
2. Persistent hemorrhage, a possibility reduced by using only blunt-tip cannulas and firm movements.
3. Additional injury to the overlying skin is avoided by placing the suction holes of the cannula away from the skin.

Fig. 79.1. Medium-sized post-traumatic hematoma on the outer surface of the leg in a young woman

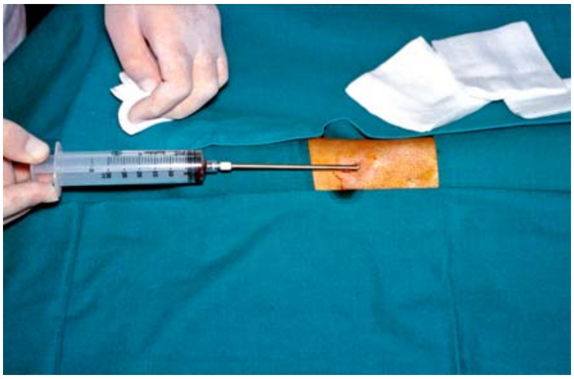

Fig. 79.2. Cannula inserted through the small incision. The right hand starts working with the plunger in suction mode

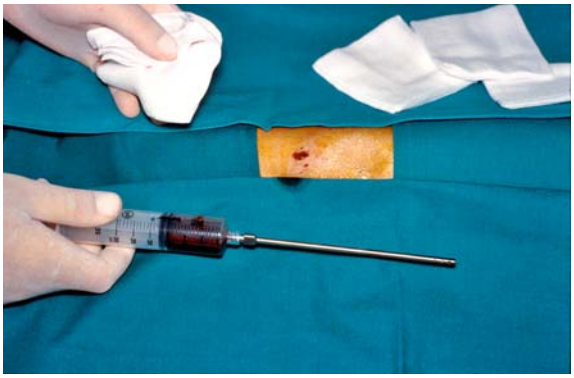

Fig. 79.3. Only a small amount of removed clotted blood in the syringe and a small incision on the skin

4. Injury to tendons or nerves which is theoretical and can be avoided by the use of blunt-tip cannulas. Nevertheless great attention must be paid to avoid a nerve injury at the site of the skin incision, and an unintentional passage of the cannula into

adjacent areas, and can be avoided by performing the liposuction with the right hand while the other one palpates the borders of the hematoma.

79.3 Postsurgical Hematomas

Postsurgical hematomas represent a complication that can usually be prevented by careful hemostasis, good surgical techniques, placements of a drain, and pressure dressings. Nowadays, they occur more frequently, partly owing to the widespread use of anticoagulant and platelet inhibitor drugs in elderly patients. Despite the large number of reference works on this problem there is a lack of agreement on how to manage such patients [9].

There is no evidence of increasing postsurgical hematomas in patients, even with Warfarin therapy, with an international normalized ratio of about 2.5 [10], but the hazard is not well stated in major dermatological surgery employing flaps and grafts [11], and the bleeding time is not clearly established as a major preoperative screening test [12–14]. The risk of a postsurgical hematoma increases with large undermining, the "dead space" after the removal of a large subcutaneous mass, and the placement of flaps or grafts.

Infections, local necrosis of a flap or graft, and increased fibrosis during wound healing may be complications of long-standing postsurgical hematomas.

The technique involves making a small skin incision of 3–4 mm on the edge of the wound under local anesthesia using a no. 11 scalpel blade. A liposuction cannula of about 4 mm in diameter mounted with a Luer Lock connection on a disposable syringe is then introduced into the incision towards the center of the hematoma [15] (Fig. 79.5). Sometimes, it is possible to insert the cannula between the sutures of a closed wound or to remove one suture to allow the insertion.

The syringe is then held with the right hand, keeping the plunger on suction and even large amounts of viscous blood can be easily evacuated. However, if a motor-powered device is available, it can be used.

A drain can be inserted and a pressure dressing applied. Use of the liposuction cannula avoids the disruption of the entire suture line and reduces the risk of additional tissue trauma.

In more complex skin surgery, a postsurgical hematoma may occur under a flap or a graft, resulting in large necrosis of the transferred tissues. Liposuction can be performed to reduce the damage and save at least a part of the flap or graft.

The liposuction cannula is inserted with the suction holes placed away from the skin and the deep surface to avoid further damage [2]. If possible, the area of the liposuction is compressed with a pressure dressing immediately after the procedure to prevent recollection.

Fig. 79.4. Results of the procedure 7 days after removing the elastic bandage

Fig. 79.5. Postsurgical hematoma with insertion of the cannula between one knot and another, along the sutured, damaged wound

The liposuction technique is effective for the treatment of a coagulated postsurgical hematomas occurring under a simple, direct suture line. It is less reliable for evacuation of hematomas that occur under large flaps and grafts, but nevertheless it can be performed with the intent to reduce the overlying skin necrosis.

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Syringe Liposuction for Residual Fat in Involuted Hemangioma

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80.1 Introduction

Hemangiomas are the most frequent tumours of infancy [1], affecting almost one out of every ten Caucasian children by 1 year of age with preponderance for girls [2]. Since the commonest location is the head and neck region (60%), many of them are visible and some of them may cause significant aesthetic problems. Following in frequency are the trunk (25%) and the extremities (15%) and some may grow in multiple sites [3]. Superficial hemangiomas manifest as bright-red, raised masses; when they grow deep in the dermis or subcutaneous tissue, they might look bluish with dilated radial veins (Fig. 80.1) [4].

Hemangiomas usually first appear during the first month of life. Their clinical course is very characteristic and is divided into the *proliferative phase*, rapid growth during the first 6–12 months of life, the *involuting phase*, marked by slow regression from 1–7 years, followed by the *involuted phase*, which is usually reached before the age of 10–12 years [4]. Regression of the vascular tumour is completed at this stage. However, around 25% of the lesions may show sequelae, particularly large, voluminous hemangiomas. Some common problems include scarring, skin laxity or atrophy or superficial telangiectasia. Very frequently there is some degree of persistent mass, which is caused by fibrofatty substitution of the original hemangioma as the tumour regresses [2, 5].

The clinical phases of the hemangioma's life cycle correlate with inmunohistochemical markers and radiologic characteristics [6–8]. On MRI the growing hemangioma is bright in T2. After complete involution it becomes isointense and if fatty replacement occurs, it enhances in T1.

Visible hemangiomas often generate a great amount of stress in the patient's family, because they attract attention. Since regression is slow they often feel the need to do something. But most hemangiomas are small and harmless and will disappear spontaneously causing neither functional nor cosmetic problems. In these cases it is advisable to avoid unnecessary or sometimes even harmful treatment.

Only complicated or endangering hemangiomas, depending on the location and the size of the tumour, will need early therapy. Response to corticosteroids is good, showing accelerated involution in 40% of the cases, equivocal in 30% and 30% do not respond. Resection might be indicated during the involuting phase, before schooling, if the lesion causes significant disfiguration. Psychological counselling is also helpful in this circumstance. However, the majority of hemangiomas will be watched as they involute completely and are evaluated for possible sequelae later.

Laser therapy is indicated for superficial residual telangiectasia and surgery often consists of reviewing scars, or trimming redundant skin or residual fibrofatty tissue.

Surgery in the face and neck, the commonest location of hemangiomas, carries a risk of iatrogenic facial nerve damage. Depending on the size, form and location of the residual hemangioma, the resulting scars may be long or lie in an unfavourable direction in regard of the facial lines. Furthermore, hypertrophic scarring is an important adverse effect to be considered in these young patients.

Liposuction is widely introduced in aesthetic surgery of the body outline. It has been proved to be a safe and reliable procedure and its indications continue to expand to different areas of reconstructive surgery [9]. This technique can be applied successfully in most lipodystrophies, but to our knowledge there was only one previous report of its use for the treatment of a facial involuted hemangioma. Fisher et al. [10] published a similar case of a small residual hemangioma of the right cheek treated with ultrasound-assisted liposuction with a good result and no complications.

There are clear advantages of liposuction versus open surgery in these cases, e.g. less bleeding, lower risk of damaging sensitive nerve structures in the area and minimal scars. If skin is redundant as well, it is easier to evaluate the need for cutaneous resection after the underlying fat has been evacuated.

In addition this technique reduces hospital stay and recovery time, requires minimum postoperative treatment and it can be easily repeated to improve results. But we see no advantage of ultrasound-assisted

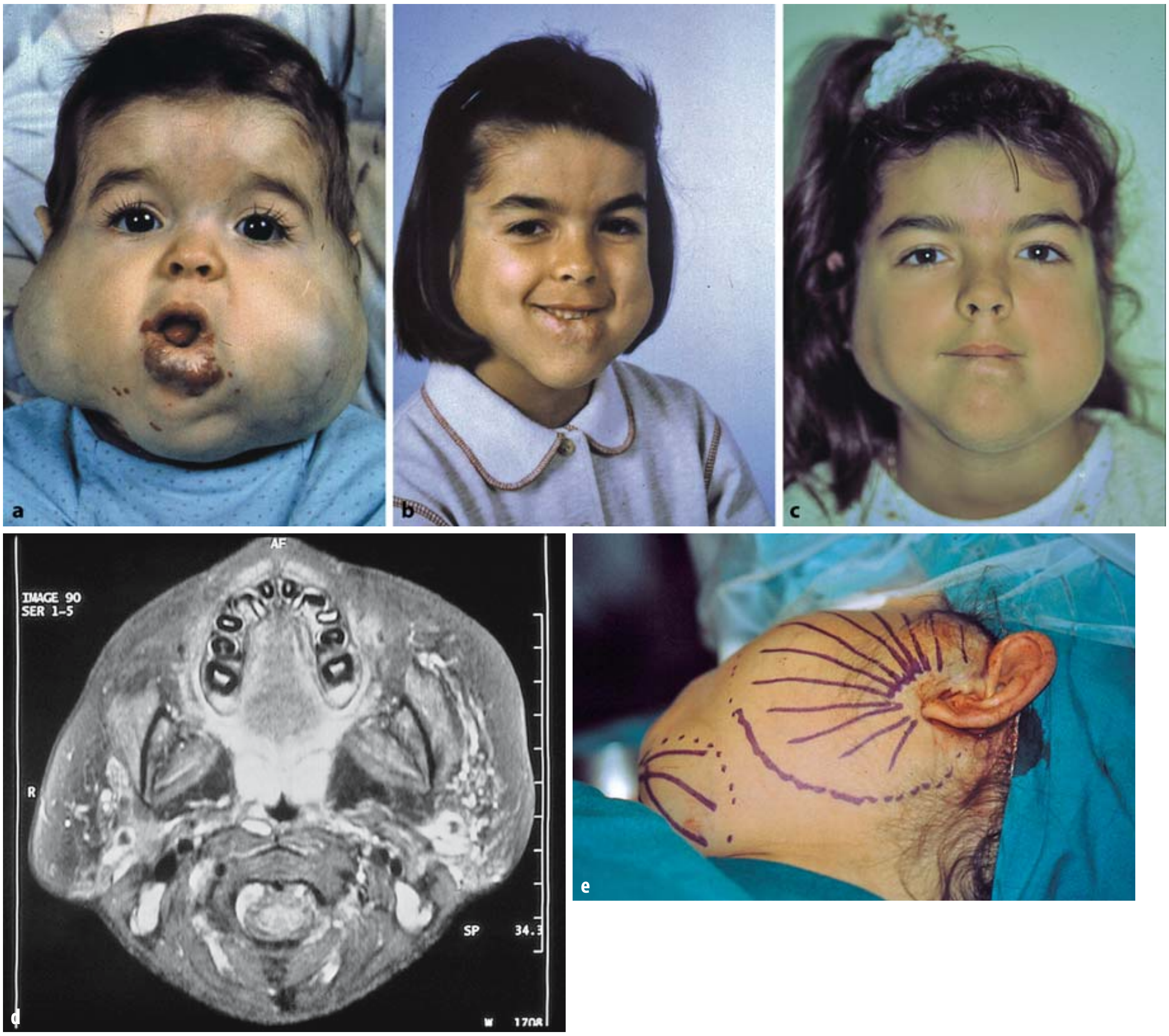

Fig. 80.1. **a** Large cervicofacial hemangioma at age 11 months. The tumour caused congestive heart failure that required urgent embolization. **b** Partial involution at age 6 years, but facial deformity is still noticable. **c** Complete involution reached at age 10. Sequelae include bulky deformities in both cheeks and submental area and scarred and retracted lower lip. **d** MRI in coronal view demonstrates a mass localized in the subcutaneous tissue, superficial to the parotid fascia, showing fat density which is hyperintense in T1 [5] and isointense in T2 [6]. **e** Intraoperative markings of the limits of the fatty prominences and the subcutaneous tunnels for the liposuction. **f** Postoperative view after facial liposuction, excision of lower lip scar, and reconstruction with mucosal eversion. Facial contours are more balanced and the lip is relaxed

liposuction as compared with traditional liposuction. The latter has been refined with the introduction of cannulae of small calibre that, combined with subcutaneous infiltration, reduces mechanical tissue damage, it is less expensive, instrumentation is very simple, and it has no risk of causing burns as could be the case with ultrasound-assisted liposuction in inexperienced hands. We believe that the possibility of a facial burn or thermal injury to neurovascular structures disfavours its use for treating superficial residual fat after involution of hemangioma, particularly in the face.

The authors have successfully treated a variety of residual hemangiomas with syringe liposuction alone or combined with cutaneous trimming.

80.2 Patient Reports

80.2.1 Case 1

A 13-year-old Caucasian female patient was seen in plastic surgery consultation for a large involuted cervicofacial hemangioma. She was born with a pink stain on the lower lip. Two weeks later her cheeks, mental and submental regions grew rapidly in volume and turned bluish in colour. She was diagnosed with a juvenile hemangioma. She required systemic corticosteroid therapy and embolization for life-threatening congestive heart failure during the proliferative phase of the tumour (Fig. 80.1a). Her status improved and the hemangioma then started a slow involution. When she entered school, her facial appearance had improved considerably, but she still had a very noticeable deformity (Fig. 80.1b). In her paediatric follow-up consultations she had been always advised to wait for spontaneous regression, but at age 7 the mass stopped decreasing in size and remained stable for approximately 3 years, when she decided for a plastic surgery consultation (Fig. 80.1c). She was a well-adapted child, but wished to improve her facial image. MRI was ordered to study the nature and extension of the tumour. It demonstrated a mass localized in the subcutaneous tissue with clear fat density, which is hyperintense in T1 and isointense in T2. Facial vascularity was considered normal, with a little increase on the left side (Fig. 80.1d, e).

Since the tumour showed clinical and radiographic signs of complete involution and she had passed the age of 10 by which almost 100% of hemangiomas have totally regressed it was decided to proceed with surgery.

Liposuction was decided as the first choice to avoid possible inadvertent iatrogenic injury to facial nerve branches considering that the normal anatomy might have been altered during hemangioma proliferation and posterior involution with possible fibrosis or scarring. A face-lift incision was considered as the second choice during the same procedure in case the mass could not be evacuated by means of liposuction. The areas to be aspirated as well as the face-lift lines were marked preoperatively (Fig. 80.1f).

Small preauricular stab incisions were performed to introduce the standard tumescent fluid. A total of approximately 60 ml of fat of normal colour and density was aspirated from both cheeks and the submental area with a 3-mm cannula and syringe vacuum. During the same procedure a retracted scar in the lower lip was excised and the mucosa everted to close the defect.

Postoperatively the patient wore an elastic compression garment for 1 month.

The 2-month follow-up showed improvement of the deformity with better definition of her facial contours. She showed no facial nerve deficits. The result was considered excellent by the patient and the surgeons (Fig. 80.1g).

80.2.2 Case 2

A 2-year-old boy was seen in plastic surgery consultation for a large nasal hemangioma (Fig. 80.2a). He had failed to respond to systemic steroid treatment started at age 3 months. The tumour caused such a grotesque deformity that early surgical excision was offered, but the family refused because they feared haemorrhage. Therefore, he was checked periodically until the tumour did not decrease further in size. At age 8 regression was considered complete but there was evident residual volume caused by fibrofatty substitution (Fig. 80.2b). Surgical treatment was decided at this point. The area was prepared and marked in the usual way. Liposuction was performed with a short 3-mm cannula with syringe suction. A small central area was too fibrous to aspirate and had to be removed by a longitudinal incision made along the inferior lateral nasal line. Further liposuction helped to smooth out the transition to the neighbouring healthy tissue and accentuate the nasogenian sulcus. He suffered a postoperative hematoma that was drained through a same incision. Recovery was then fast and at 6-months follow-up he was extremely pleased with the result (Fig. 80.2c).

80.3 Summary

Hemangiomas may develop different complications during their evolution that should be addressed indi-

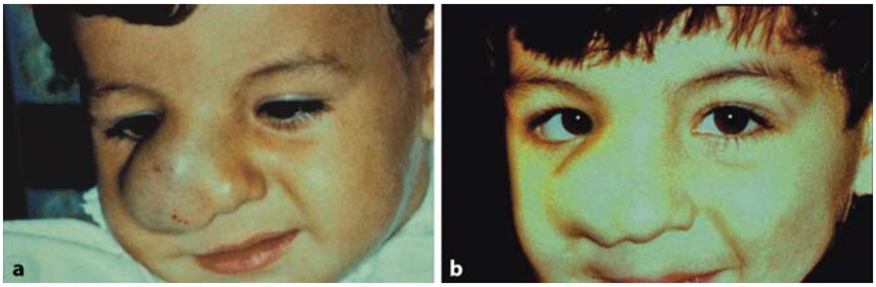

Fig. 80.2. a Two-year old boy with a large nasal hemangioma that causes a grotesque deformity. The parents refused treatment at this stage. **b** Patient at age 8, after spontaneous involution. A residual mass remains. **c** Postoperative appearance after liposuction combined with open resection of residual fibrofatty tissue. Contours are smooth and the scar is inconspicuous

vidually and at the proper time. A «Vascular Anomalies Team» best manages these complicated cases. Traditional liposuction is a safe and effective alternative for the treatment of residual fat after involution of voluminous hemangiomas.

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Aspiration of Breast Cysts with Liposuction

Shridhar Ganpathi Iyer, Thiam Chye Lim, Jane Lim

81.1 Introduction

The clinical and pathological aspects of cystic diseases of the breast were described as far back as 1845 by Reclus [1]. Cooper [2], in his monograph *Illustrations of diseases of the breast*, published in 1929, described in detail cystic disease and many other aspects of benign diseases of the breast. Although the foundations for understanding benign breast diseases were laid early, uncoordinated and sporadic work over several decades has created a confusing array of terminology, including fibrocystic disease, chronic cystic mastitis, cystic mastopathy, hyperplastic cystic disease, and Shimmelbusch's disease. The absence of cancer has often been equated with breast health. The result is that benign breast disorders, which contribute the majority of outpatient visits, receive little emphasis and understanding. Cysts are one of the commonest findings in women presenting to a breast clinic. The precise epidemiology of gross cysts is not known. Most breast cysts are the result of aberration of normal development and involution [3]. There are other less common varieties of breast cysts (Table 81.1).

Table 81.1. Common varieties of breast cysts

1. ANDI	Microcysts Macrocysts
2. Galactocoele	
3. Traumatic	Liquefied hematoma Fat necrosis
4. Infective	Duct ectasia, chronic abscesses, antibioma
5. Neoplastic	Papillary cystadenoma Necrotic phylloides tumor Intracystic papillary carcinoma Cystic degeneration of ductal carcinoma
6. Parasitic	Hydatid cyst
7. Postoperative	Liponecrotic pseudocysts Peri-implant fluid collection

ANDI aberration of normal development and involution

81.2 Etiology

Cyst formation possibly occurs owing to a minor aberration of lobular involution, under the influence of estrogen. This common clinical problem has several etiologic theories but none have ever been proven. It is proposed that unopposed action of estrogen in premenopausal patients maintains the acini in a dilated state. Haagensen [4] regards estrogen administration as a potent cause of cyst formation in menopausal women. Dixon et al. [5, 6] have demonstrated that intravenously administered dihydroepiandrosterone sulfate appears in an apocrine cyst against a concentration gradient. This process seems to be inhibited by Danazol, spironolactone, and evening primrose oil. High concentrations of several hormones are found in breast cysts, including androsterone, epiandrosterone, dehydroepiandrosterone, and estrogen and their conjugates [7, 8].

Fodrin, a cytoskeletal structural protein expressed in normal breast epithelial tissue, is absent in all breast cysts [9]. Whether this is a primary event or a secondary phenomenon remains unclear. All true macrocysts start with an area of apocrine epithelium in the terminal ductal lobular unit. The accumulation of secretion gives rise to progressive dilatation of the terminal ductal lobular unit forming a microcyst. Enlargement of microcysts gives rise to two variants of macrocysts. A type I cyst contains fluid with composition resembling intracellular fluid (high potassium and low sodium) and a type II cyst contains fluid similar to extracellular fluid [3]. The majority of type I cysts are metabolically active with epithelia containing «tight junctions.» Such epithelia generate or maintain a large transepithelial ion concentration or osmotic gradient with secretion by active transport. Type II cysts are metabolically inactive with loose junctions and passive fluid movement. Cysts contain a variety of substances, including lipofuscin products, breakdown products of hemoglobin, steroid hormones, βHCG, relaxin, gross cystic disease protein, growth factors, and tumor markers such as α-fetoprotein and carcinoembryonic antigen [3]. Although there is vast amount of literature concerning cyst fluid biochemistry, the significance of it still is not clear.

Galactocele is an uncommon benign cystic lesion filled with milky fluid usually occurring in pregnant and lactating women. Galactoceles often present as non-tender, smooth and mobile swellings with characteristics of a cyst. Milky fluid of varying viscosity may be obtained on aspiration, which may be diagnostic as well as therapeutic in most cases. Galactoceles have been described in male infants. It appears that three major predisposing factors are required for development of galactocele: (1) present or previous stimulation by prolactin, (2) secretory breast epithelium, and (3) some cause of ductal obstruction [10].

81.3 Clinical Features

Macroscopic cysts are mostly asymptomatic. Distension of the cyst makes it palpable, drawing attention to it. Any pain experienced may be due to the sudden distension of the cyst, and/or leakage of fluid into the surrounding breast tissue, causing chemical irritation. Most cysts occur in women between the ages of 40 and 50 years, disappearing by menopause unless the woman is on hormone replacement therapy. Examination may reveal a variety of findings depending on the number, size, location, and locularity of cysts, the amount of fluid, and the amount of breast tissue. A cyst with lax walls may be impalpable. Very tense cysts may be hard, resembling a carcinoma. Large cysts may displace Coopers ligaments causing what Haagensen [4] described as false skin retraction

The precise incidence of painful gross cystic disease is unknown. A patient presenting with a cyst as a palpable mass or with a cyst discovered on screening, should undergo a routine evaluation with mammography, ultrasound (US) examination, and needle aspiration. The typical ultrasonographic appearance of a cyst is a circumscribed, thin-walled, anechoic structure with increased through transmission of sound [11]. US is 96–100% accurate in the diagnosis of a cyst if the following criteria are applied: round or oval lesions, sharp margins, lack of internal echoes, and posterior acoustic enhancement. Cysts may also show deformability on compression and refractive lateral wall shadowing, which is a non-specific characteristic of benign breast lesions.

Some breast cysts may appear complicated because of proteinaceous material, blood, cellular debris, infection, or cholesterol crystals, and are termed complex cysts. An asymptomatic woman with a typical breast cyst on US examination requires no further evaluation. Most other breast cysts are adequately treated by aspiration, which may be diagnostic as well as therapeutic. A 21-gauge needle with a 10 or 20 ml syringe is used and the cyst is aspirated as completely as possible. The fluid may be discarded unless it is bloodstained. The breast is palpated to exclude a residual mass, which, if present, will require evaluation with fine-needle cytology (if necessary under US guidance). Placement of the fluid on white gauze is a useful technique to assess color. Routine cytology of breast fluid is unnecessary as the incidence of cancer in breast cysts is approximately 1:100,000 [12]. It should be borne in mind that cysts per se are not premalignant and do not require excision but gross cysts may be associated with a small increased risk of subsequent breast cancer [3, 13].

81.4 Indications for Suction Aspiration of Breast Cysts with Liposuction

As most gross cysts can be managed with needle and syringe aspiration, the indications for suction-aspiration with the liposuction apparatus are relative. These include:

1. Symptomatic cysts failing needle aspiration (due to debris or inspissated contents)
2. Congealed galactocele
3. Organizing hematoma
4. Encysted paraffin or silicone
5. Abscesses

81.5 Preoperative Evaluation

Evaluation of the patient for the procedure follows the same recommendations as for any patient for liposuction. A thorough medical history that gives special attention to any history of bleeding diathesis, thromboembolism, infectious diseases, hypertension, and diabetes mellitus is taken. Patients with a medical history of these conditions receive medical clearance before undergoing the procedure. A complete blood cell count with quantitative platelet assessment, prothrombin time, and partial thromboplastin time, chemistry profile including liver function tests, and pregnancy test for women of childbearing age are sufficient for most patients. In selected cases a chest X-ray and an electrocardiogram may be done.

81.5.1 Anesthesia

The procedure is performed under general anesthesia but may also be done under local anesthesia with intravenous sedation. Caution against the use of general anesthesia for tumescent liposuction [14] may not be applicable in this setting as the procedure is done without tumescent solution and involves aspiration of only cysts.

81.5.2 Technique

The technique is simple and differs from the standard liposuction in that it is done without infiltration of the area to be aspirated. The suction pressure is started only when the cannula is in the cyst. No ultrasonic or reciprocating device is needed.

The site of the painful gross cysts is marked preoperatively after an adequate clinical examination in sitting and supine positions (Fig. 81.1). A periareolar stab incision adequate to accommodate the cannula is made (Fig. 81.2). A Mercedes or single port 3–4 mm cannula is used. Although a sharp-tip or open-end cannula can be used for ease of penetration through the cyst wall, the risk of bleeding from the passage is higher. A double Mercedes cannula can be used if the cyst is very large, but there is a risk of aspirating normal breast and fatty tissues by the proximal holes. Larger-bore cannulas can be used but it is more difficult to control the rate suction and too much of the surrounding tissue may be aspirated.

The cannula is advanced towards the cyst without suction, first in the subcutaneous tissues and it is then angled to enter breast tissue to penetrate the cyst, which has been immobilized by the other hand. The resistance of the cyst wall is initially felt and entry into the cavity is felt as a "give-way" or loss of resistance. Suction is commenced only after entering the cyst and after obtaining an aspirate to confirm the position (Fig. 81.3). The suction pressure used is 1 atm. The cyst is aspirated completely by tilting the cannula gently into all the limits of the cyst. Gentle movement of the cannula against the cyst walls may be done to ensure complete emptying. Care is taken to prevent aspiration of the intervening breast tissue, which may result in asymmetry of the breasts. The suction is stopped; the cannula is withdrawn, and then advanced into another cyst. The procedure is repeated till the symptomatic cysts are adequately addressed. A trap bottle along the suction tubing may be used if the contents are to be analyzed or sent for cytology.

A pressure dressing is applied to prevent postoperative hematoma, bruising, seroma, and to reduce pain. Follow-up of the patient will be as indicated by the pathology.

Fig. 81.1. Sites of painful gross cysts marked preoperatively

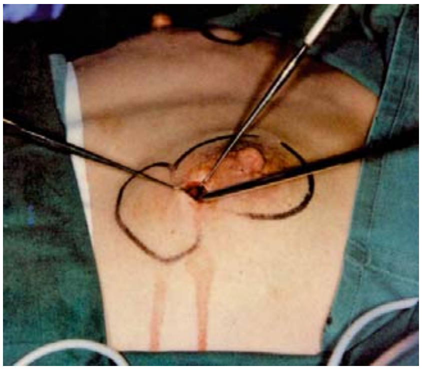

Fig. 81.2. Liposuction cannula guided into the cyst (without applying suction initially), through a periareolar incision

Fig. 81.3. Suction and aspiration commenced after entering the cyst

81.6 Complications

The potential complications may include those related to anesthesia and local complications such as bruising, infection, hematoma, recurrence, and breast asymmetry. Further experience in the procedure will determine the long-term outcomes and complications.

81.7 Discussion

The use of liposuction has evolved considerably over the last decade. The indications are expanding with increasing experience in the technique. Liposuction has been used since 1985 as an adjunct to breast reduction by Teimourian et al. [15] and Avelar and Illouz [16]. Originally it was used to address the difficult surgical area of the tail of breast during reduction mammoplasty. In 1991, Matarasso and Courtiss [17] recommended suction mammoplasty for patients with an optimally well located nipple-areolar complex.

Initially it was thought that liposuction might be used only on fatty breasts. Experience with treating gynecomastia has shown that the glandular breast can also be aspirated. Improved liposuction instrumentation and experience has led to increasing applications. Suction-assisted lipectomy has also been used successfully to treat a variety of medical conditions, including extraction of lipomas, axillary hyperhidrosis, benign symmetric lipomatosis (Madelung's disease), congenital body asymmetry, congenital or acquired lymphedema, flap defatting, traumatic or postoperative hematomas, and fat necrosis [18–24].

The majority of symptomatic breast cysts can be treated by aspiration alone. The consistency of breast cyst fluid may vary from serous to heavily turbid and occasionally may contain inspissated secretions. Some patients may present with painful breasts riddled with cysts containing thick fluid, which can be aspirated only with difficulty. Suction-aspiration of breast cysts was first described in a 28-year-old patient presenting with painful contour-distorting cysts containing thick inspissated secretion in both breasts [25]. It was effective in relieving the pain and distortion. Locker et al. [26] showed a reduction of cysts requiring aspiration after a course of 100 mg Danazol three times a day for 3 months. It should be stressed to the patient that this treatment is not innocuous in that it involves considerable alterations of hormone levels and that recurrence of symptoms such as breast pain, discomfort, and recurrence of the cyst is not uncommon after cessation of therapy.

The technique of suction-aspiration of breast cysts may be useful for patients with painful breasts riddled with cysts full of debris or who are symptomatic with a congealed galactocele which cannot be decompressed with a 14G needle with the aspiration pressure of a 10 or 20-ml syringe. It may decrease the number of repeat aspirations and visits to the outpatient clinic. It is emphasized that the procedure should be used judiciously in selected patients with the same care exercised as in any patient undergoing the liposuction procedure.

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82 Blunt Liposuction Cannula Dissection in Reconstructive Surgery

Lawrence M. Field

82.1 Introduction

Utilization of blunt liposuction cannulae for reconstructive procedures originated almost 2 decades ago, evolving from techniques learned in cosmetic surgery. Utilization of this extremely safe dissection technique precludes sharp cutting injuries to subdermal tissues, and allows extremely rapid determination of safe undermining planes. All procedures were carried out with local anesthesia, and more recently with bilevel tumescent anesthesia. Both office and hospital surgeries have been the sites for surgical intervention. No undue injuries to underlying structures have occurred in many hundreds of procedures. Bilevel anesthesia and blunt instrumentation, when combined with nerve blocks, have resulted in virtually painless and bloodless surgery. When the surgeon adopts the techniques and tenets contained herein, he will have adopted the safest, rapidest, and most satisfying surgical approach available to date.

In the continuing effort to provide the surgeon with safer and rapider means of intervention, the past 2 decades have seen an ever-expanding usage of liposuction techniques adopted to reconstructive surgery [1]. The major impetus to this phenomenon has been the evolution of blunt liposuction dissection techniques for flaps and for graft harvesting [2–15, 16], and subsequently the addition of tumescent surgical anesthesia (in higher concentrations than that used in liposuction procedures) administered both subcutaneously and intraepidermally. These more recent concepts of bilevel anesthesia [16–21] have allowed virtually bloodless intervention in cutaneous surgery.

82.2 Technique

Application of blunt cannula dissection techniques in reconstructive surgery requires the presence of subcutaneous tissue which has been adequately and appropriately hydrodissected with a more concentrated tumescent infiltration solution than Klein's original formula of 35 mg Xylocaine/kg body weight [22]. This author utilizes 0.2–0.3% Xylocaine HCl in lactate Ringer's solution or normal saline solution with sodium bicarbonate, combined with freshly mixed 1:250,000–1:500,000 epinephrine HCl. The quantity of tumescent solution required varies, and the concentration of epinephrine is dependent upon the vascularity and the safety of epinephrine in respective anatomic sites. For surgical tumescent anesthesia in reconstructive surgery, the addition of steroids is not indicated.

An ice-pick-like Pocar (Tulip Medical Co., San Diego, CA, USA) is used to enter one or more previously anesthetized loci obliquely into the subcutaneous space, discontinuing all forward motion when entrance into that plane is felt by the surgeon by lack of resistance to passage of the instrument – a most important tactile end-point. A blunt multiport infiltrator (Tulip 2.1–2.3-mm infiltrator, 35-ml syringe injection system for head and neck work, or a 60-ml syringe system for body and extremity work; Tulip Medical Co., San Diego, CA, USA) is then also introduced obliquely paralleling the anesthesia passage, the infiltrator tip immediately entering the proper plane to be hydrodissected.

For infiltration in surgical procedures, a second, uppermost level of standard 0.5–2.0% Xylocaine with 1:1,000 epinephrine is administered into the supradermal integument in the design of the pending dissection parameters. Installation discomfort at this level is lessened by the previously instilled tumescent solution below, and the hydrostatic pressure from the lower level decreases bleeding both directly by pressure and by the pre-existing, albeit dilute, epinephrine effects.

The tumesced plane can be entered at the safest level (tumesced) by a forward movement of a blunt, slightly curved spatula cannula tip (Fig. 82.1) which attaches to the same anesthetic syringe system (35 or 60 ml), a blunt-tipped needle holder, or any similar undermining instrument of the surgeon's choice, including a finger [23]. Forward movements of the undermining liposuction cannula instrument allows gliding through the hydrodissected plane, while gentle upward pressure on the cannula positions the instrument at an immediate subdermal level (Fig. 82.2). *This assures a position anatomically above any and all threatened vessels, nerves, or ducts!* Passage of a blunt instrument further allows preservation of multiple neurovascular trabeculae. The minimal number of these surviving trabeculae (containing intact nerves and vessels) should be sacrificed to accomplish adequate tissue movement for the reconstruction.

The only exception to this approach is in the presence of tumor where deeper penetration may exist. In this circumstance, the tumescent anesthetic is injected while the infiltrator used is moving *forward* toward the tumor area. Careful observation of the subdermal flow of the anesthetic will frequently determine if the tumor is fixed. If not fixed, expansion of the subdermal space should allow the tumor to float upward, easing the difficulty and danger of the dissection [24]. If and when sharp dissection is necessary as an ancillary procedure, passage of a blunt cannula will lessen the amount of scalpel or scissors surgery necessary, will lessen bleeding, and will diminish the possibility of surgical trauma to nerves.

When moving flaps with adipose tissue for superficial reconstruction, it may be necessary and appropriate to thin the reconstructive flap itself [25]. For cutaneous surgeons, this may be done preliminarily, thinning to accomplish peridefect surface apposition of the moving flap to the surrounding tissue around the defect. One may also immediately debulk a thicker flap by lipoaspiration, again to evolve surface apposition. Flap thinning with liposuction cannulae may proceed pre-, post-, and intraoperatively when indicated (Fig. 82.3). It has been clinically demonstrated that cannula dissection proceeds rapidly above a cicatricial plane, with even less bleeding than expected or previously experienced. However, bleeding is less controlled within cicatrix, in previous radiation sites, and in deeper planes, especially of the nose.

Defects in virtually any body area have been closed by tumesced adjacent tissue transfer, including neck, temple, cheek, preauricular area, infra-auricular neck, upper midback, infravermilion chin, upper arm, suprasternal area, upper chest, abdomen, and thigh. Both the defect area and the donor site are appropriate for tumescent infiltration, bilevel anesthesia and blunt dissection. Further adaptations have included submental fat removal for harvesting of full-thickness grafts [16], and submental adipose removal with evolution of a submental flap for scar revision, excision, and the repositioning of remaining scars under the prominence of the mandible, thus lessening their visibility [26].

This author has not used larger myocutaneous flaps for reconstruction, but certainly the same principles exist and apply to them. There are now surgeons reporting the use of tumescent anesthesia with blunt dissection techniques in breast augmentation, reduc-

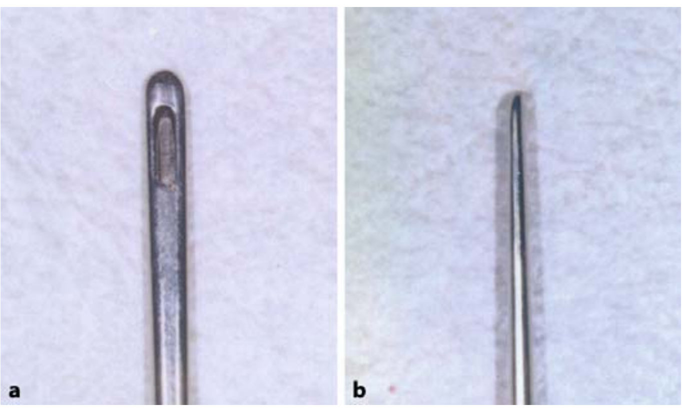

Fig. 82.1. Tulip cutaneous flap dissecting cannula. **a** Dorsal, **b** oblique, **c** lateral

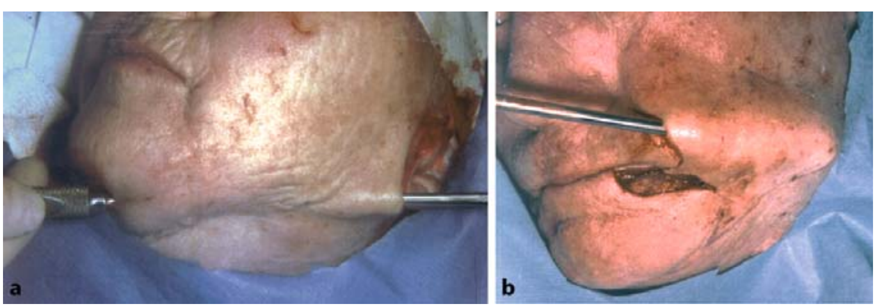

Fig. 82.2. Undermining with liposuction cannulae

Fig. 82.3. **a** Flap undermined. **b** Flap "set." **c** Result 1 year later

tion, and reconstruction, though this author again has no experience with such.

Once the surgeon has acquainted himself or herself with the instrumentation, techniques, and pharmacology of the procedures and medications involved, he or she will embark on a wondrous new voyage of rapid, safe, virtually bloodless surgery.

82.3 Conclusions

1. Epidermal anesthesia with small needle and 0.5% lidocaine without epinephrine for painless instillation of tumescent infiltrator entrance point/s and premarked incision lines.
2. Small stab incision/s at infiltrator entrance point/s.
3. First-level anesthetic injection to accomplish *tumescence with hydrodissection* into entire areas to be removed and to be moved, i.e., excisional site and potential undermining sites. All vital nerves and vessels lie *beneath* this level unless tumor infiltrates and fixes tissue. The second level is intraepidermal with 0.5–1% Xylocaine with 1:1,000 epinephrine HCl. There is rapidity of anesthetic delivery – a large volume in minimal time.
4. Scalpel incision along premarked lines *only* to the depth of the dermis. A manual spreading maneuver along both sides of the incision will give visible control of depth. Do not penetrate fat unless it was preplanned to do so by necessity of resection.
5. A blunt dissector penetrates at selected loci along already incised lines to make entrance point/s for undermining. The author's preference is a blunt spatula cannula assisted by a blunt-tipped needle holder.
6. Penetration assisted by repeatedly opening needle-holder jaws, slightly increasing pressure and forward motion until resistance of the dermis is no longer felt.
7. With a blunt undermining instrument of one's choice (blunt spatula cannula, needle holder, blunt-edged scissor, periosteal elevator, etc.) enter through the aperture to the area of least resistance, i.e., the hydrodissected area of infiltration, change the angle of the instrument (usually 90°) to allow appropriate undermining beneath the area to be excised, and continue to extend undermining *past that area at the same level as the excisional bed*. This establishes symmetry in thickness of one or both sides of future closure with the depth of the excision.
8. Complete the removal of the excisional specimen. A scalpel is used only for the epidermis, a scissoris used to cut the remaining dermis. The crushing action of the scissor blades lessens fine bleeding.
9. Further blunt undermining in hydrodissected plane as necessary to accomplish desired tissue movement. No additional sharp cutting.
10. Closure technique of your choice (sutures, staples, glue, etc).

Addendum: Intraoperative expansion, pulley traction systems, etc. may be utilized at proper times in sequence. Surgery can be completed in the least possible time by this method with maximal safety of any surgical system known.

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83 Cellulite Syndromes

Pier Antonio Bacci

83.1 Introduction

The cosmetic surgeon dreams of body improvement since he cannot prevent the aging process. All of his efforts have to deal with scars, which are the unavoidable traces of the knife. Adipose tissue, as well as its variety of distribution, represents the main structure for the silhouette definition and body harmony.

The attempt to reduce or to remove excessive fat or fat that is poorly located has always been limited by scars.

In September 1976 the first revolutionary operation allowing removal of fat tissue while limiting trauma and scars was published [1, 2]. Liposuction was born. This method had a variety of evolutions [3–6] and it became possible to use liposuction for different pathologic entities [7–9] or in unaesthetic disorder such as lymphedema, lipoedema, or lipolymphedema [10, 11].

83.2 Cellulite

The silhouette is characterized by the particular localization of the subcutaneous adipose tissue over the osteomuscular structure. The human body is characterized by the presence of rigid fasciae, and especially deep muscular fasciae which, starting from the cranium base and without continuity, extend to the ankles and metatarsus promoting various physiological functions including vascular, neurophysiologic, and orthopedic.

Cellulite is classically a degenerative and evolutionary disorder of the subcutaneous tissue with growths on a constitutional substrate linked to a whole series of predisposed and releasing factors. Cellulite has been described from a histomorphologic point of view and defined as a panniculopatia edematofibrosclerotica (PEFS) or "edemato-fibro-sclerotic panniculopathy" [12, 13]. Cellulite is considered as a series of events characterized by interstitial edema, secondary connective fibrosis, and consequent sclerotic evolution. Recent clinical observations demonstrated that if PEFS is a true part of cellulite, it does not represent all the various clinical aspects of cellulite. In fact there are often particular forms of connective tissue, interstitial damage, or diffuse syndromes characterized by lipoedema associated with lymphedema and/or lipodystrophy. Such pathologies are mainly observed over the gluteal muscles and on the lower limbs of women.

Cellulite can be described by stages as scored by Nurnberger and Muller [14]:

- Stage 0: Regular when standing and reclining. Pinching creates folds without the characteristic dimpling.
- Stage 1: Regular when standing and reclining. Pinching creates a *peau d'orange* appearance.
- Stage 2: Regular when reclining. "Mattresslike" skin when standing.
- Stage 3: "Mattresslike" appearance while standing and reclining.

83.3 Lipoedema and lipolymphedema

Lymphedema is described [15] as a pathology characterized by a tumescent state of soft tissues, usually superficial, and related to the accumulation of lymph containing a high level of proteins from stasis in the interstitial space. It is determined by primary and/or secondary damage of the transport vessels.

Lipoedema is a particular syndrome, the etiology of which is not well known, and is characterized by fat and water deposition in the subcutaneous tissue (particularly in lower limbs and over the gluteal muscles) associated with lymphedema and/or lipodystrophy. Lipoedema was first described as an accumulation of subcutaneous fat with hard leg edema excluding the feet. In the various descriptions there is foot hypothermia with a localized gradient of temperature [16].

The pathology, often superficially defined as lymphedema, venous insufficiency, or cellulite, is observed in more than 65% of women between the age of 14 and 35 years and becomes lipodystrophic lipolymphedema after the age of 40. The common characteristics of a lipolymphedema are the absence of venous insufficiency (eventually secondary) and the close relationship with fat tissue metabolism.

The syndrome is characterized by fat deposition in subcutaneous tissue, associated with orthostatic and recurrent edema in legs and gluteal muscle that induces the impression of increased limb volume. Lipoedema always begins in the legs, excluding ankle and foot, making this different from lipolymphedema. It is not always related to weight increase and it is frequently independent of it. It is often related to familial factors.

The characteristic of this extremely frequent disease is that edema is always followed by fat deposition. The fat deposition is secondary to an endocrine-metabolic disorder of the interstitial matrix and is not accompanied by obesity or overweight. The edema is not caused by structural changes of venolymphatic vessels but by the modified ratio of the distance from adiposity and connective structure with a loss of support. It is edema of recurrent severity, principally constituted by free water. The edema becomes worse with walking and standing, in contrast to phlebolymphedema, for example. Another difference with lymphedema is its softness and the possibility to form a skin fold, which is not obstructed by the viscosity. Thus, it is different from lipolymphedema, phlebolymphedema, Barraquer–Simmonds disease (characterized by upper body thinness) or Dercum's syndrome, which is clinically similar, has an etiology related to the toxicity of the autonomous nervous system, and is associated with an intestinal dysbiosis.

83.4 Lymphedema

Lymphedema is a chronic and progressive disorder that is very difficult to cure. The aim of the treatment, followed by physicians and physiotherapists, is to keep the disease stable in order for the patient to live normally and thus consider him "cured." In this type of pathology, the first component is edema and the second one is fibrosis. The increase of protein levels in the tissues contributes to the development of edema and probably causes chronic inflammation and consecutively fibrosis.

The basis of the clinical signs of lymphatic problems, either mechanical or dynamic, is a cold and pale swelling, initially viscous then becoming hard but not painful in most cases. With the increase of edema severity, there is an increase of limb volume. At this point, it is not sufficient to hold the limb in an elevated position in order to reduce edema because fibrosis has already occurred.

83.4.1 Dercum's Syndrome

The word "lipodystrophy" means a pathology characterized by structural and functional damage of adipose tissue. Lipodystrophy can be associated with some forms of lipolymphedema, the more typical being Dercum's lipodystrophy or painful lipodystrophy.

The female gender is affected early with recurrent lipoedema. Typical painful fat nodules often precede the appearance of lipoedema and are associated with asthenia, neuropsychic troubles (depression or anxiety), adynemia, and intestinal dysbiosis. Limb pain is different from the pain of lipolymphedema or from superficial hypoxia where pain is induced by pinching the subcutaneous tissue and is associated with tissue viscosity with interstitial hyperpressure of toxic lymph.

The pathogenesis of Dercum's syndrome is not endocrine nor metabolic (as in recurrent lipoedema) but of nervous origin (nervous damage of the neurovegetative system, either the hypothalamic or the peripheral). Inflammation has been demonstrated to be related to the nervous network linked to the adipose tissue in the environment of the extracellular matrix. In this context, bacteria of intestinal origin have also been found. This disease is associated with changes in the interstitial mesenchymal with increased lipogenesis (slowdown of the microcirculatory flux and damage of the two tissues) due to the damage of the peripheral neurovegetative regulatory system. Dercum's syndrome could be the "classical cellulite".

83.4.2 "Big Leg"

"Big leg" [17] means a lower limb in which the volume increase is measurable and palpable. A total or partial big leg can be observed but there can be different causes of a big leg, such as venous, varicosis, postphlebitic, posttraumatic, angiodysplasic, lymphatic, adipose, or cellulitic."

The main characteristic of a big leg is edema consisting of systemic, lymphatic, venous, or interstitial edema.

83.5 Discussion

Considering that lymphatics run in the interstitial subcutaneous tissue, it is easy to think that the increase of lymphatic edema or of adipose tissue could induce a lymph slowdown. Neoangiogenesis occurs, stimulated by collagen production and adipocyte rupture. The collagen also stimulates fibrinogenesis and vascular cell formation. There is a difference between localized adiposity and lipodystrophy or angiolipodystrophy. Localized adiposity means physiological or pathological accumulation of fat tissue in a determined body area, without a dystrophic process, at least in the beginning.

Lipodystrophy means a pathologic disorder of both supporting tissue and subcutaneous adipose tissue characterized by a variety of circulatory and metabolic damage.

Cellulite is the result of multiple processes and not simply excess fat in a particular area. Degenerative and evolutionary processes take place [18-19].

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Liposuction Treatment of Cellulite

Clara Lieberman, Jose A. Cohen, Rashi Rosenstock

84.1 Introduction

Cellulite consists of skin that has the appearance of an orange peel and is very common in women. It is frequently associated with multiple depressions that make the appearance of the affected area aesthetically unpleasant. Cellulite is seen primarily in women after puberty, and is rarely seen in men.

In an in vitro study by Rosenbaum et al. [1], biopsies were taken of areas affected by cellulite. These biopsies showed a diffuse pattern of extrusion in the adipose layer of the reticular dermis that was not present in areas free of cellulite in other individuals. This finding was corroborated by in vivo ultrasound. Rosenbaum et al. [1] also observed that, in women, there is a diffuse and irregular pattern with no continuity of the connective tissue immediately underneath the dermis. This connective tissue is more irregular and discontinuous in patients with cellulite.

No difference was found in the subcutaneous adipose tissue with regard to lipolytic reactions or blood flow between cellulite-affected areas and unaffected areas [1]. There was a discrepancy concerning the importance of blood flow. Leibaschoff [2] and Curri [3, 4] mention that there is an alteration in the microvascular system with venous and lymphatic ecstasias, resulting in edema. Biochemically, glucoaminoglycans are increased in cellulite interstitial spaces, producing an increase in the viscosity of these regions. This makes drainage of the adipose tissue difficult, and, as a consequence, hypertrophy is produced in these tissues.

The pathophysiological cause of cellulite is produced by alterations in connective tissue. «Bridges» are formed that originate as fat extrusions, thus causing a separation between the zones, producing irregularities on the skin.

84.2 Technique

The treatment of cellulite requires the separation of the fibrosis of connective tissue from the dermis using liposuction cannulas, producing a homogenous tissue by breaking the bridges.

Local anesthesia with the tumescent technique is administered. Two-millimeter liposuction cannulas are used for the anterior thigh and knees, and a three-millimeter cannula is used for the outer and inner thigh. Overweight patients should undergo fat liposuctioning as well as separation of the multiple bridges from the anterior area of the thigh. Patients who are not obese should have only separation of the bridges, without any fat aspiration. For all patients, aspiration is used to mold the inner and outer thighs.

All patients use compression garments for 5 weeks after the procedure, and all receive a 1-h massage, once in the first week, and then three times a week for 4 weeks. Patients are instructed to walk for 1 h a day. Follow-ups should be done at 8 days, 5 weeks, and 6 months.

84.3 Discussion

Of the 20 patients treated by the authors, 14 exhibited clinical disappearance of the visible irregularities of cellulite (Figs. 84.1, 84.2). In four patients, visible but insufficient improvement was seen, and in the obese patients, improvement was minimal. For the six patients with less than satisfactory results, it was necessary to repeat the treatment after 4 months, with removal of more fat, which resulted in optimal improvement.

Measurements showed 4–8-cm decreases in circumference at the trochanteric level, and 2–5-cm decreases in the knees. The complications that occurred in the 20 patients were ecchymosis in the treated zones, which disappeared in the second and third weeks, and a small-to-moderate edema in the lower legs that disappeared with the use of elastic garments.

Surgical treatment using liposuction and the release of the fibrous tissue bridges with blunt, thin cannulas resolve cellulite, with results that were satisfactory to both physician and patients. The cannulas break the

Fig. 84.1. **a** Circumferential cellulite and obesity of thighs. **b** Six months postoperatively after 6,300 ml of fat had been extracted

Fig. 84.2. **a** Cellulite of the anterior aspect of the thighs prior to treatment. **b** Six weeks after treatment. The anterior areas of both thighs were aspirated and 1,900 ml of fat was extracted

fibrous bridges that originate from the herniation of subcutaneous fat. The uniformity of the skin that is seen postoperatively is the result of uniform distribution of the fat in the affected area. All the deformed and bulging areas are sculpted with liposculpture of the area. This treatment is in accordance with knowledge of the pathophysiological causes of cellulite. Previous treatments performed conservatively have never produced optimal visible results.

In obese patients, the amount of fat in these areas is obviously greater than in patients of normal weight; thus, it is important to aspirate fat. In patients of normal weight, it is only necessary to break the fibrous bridges and fat aspiration is unnecessary.

The treatment of cellulite with liposuction cannulas using local tumescent anesthesia is, in our view, the treatment of choice. It is safe and causes no harm.

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85 Vibro-Assisted Liposuction and Endermologie for Lipolymphedema

Pier Antonio Bacci, Serena Leonardi

85.1 Cellulite

The silhouette is characterized by the particular localization of the subcutaneous adipose tissue over the osteomuscular structure. The human body is characterized by the presence of rigid fasciae, and especially deep muscular fasciae which, starting from the cranium base and without continuity, extend to the ankles and metatarsus, promoting various physiological functions including vascular, neurophysiologic, and orthopedic.

Cellulite is classically a degenerative and evolutionary disorder of the subcutaneous tissue with growths on a constitutional substrate linked to a whole series of predisposed and releasing factors. Cellulite has been described from a histomorphologic point of view and defined as a panniculopathia edematofibrosclerotica (PEFS) or "edemato-fibro-sclerotic panniculopathy." [1, 2] Cellulite is considered as a series of events characterized by interstitial edema, secondary connective fibrosis, and consequent sclerotic evolution. Recent clinical observations demonstrated that if PEFS is a true part of cellulite, it does not represent all the various clinical aspects of cellulite. In fact there are often particular forms of connective tissue, interstitial damage, or diffuse syndromes characterized by lipoedema associated with lymphedema and/or lipodystrophy. Such pathologies are mainly observed over the gluteal muscles and on the lower limbs of women.

85.2 Lipoplasty

Liposculpture or lipoplasty means a surgical strategy of body contouring removing localized adiposity and improving the angiolipodystrophic (cellulite) areas. With this therapeutic strategy, the body can be shaped in a valid and quick way and, particularly with the decrease of adipose and toxic material, the vicious cycle induced by this disease is broken. At the same time, if surgery is performed well, microcirculation is enhanced, allowing a better venous and lymphatic return, improving metabolism, decreasing interstitial toxicity, and improving venous and lymphatic drainage. Lipoplasty uses various methods of liposuction and lipolymphosuction.

85.3 Lipolymphosuction

The use of the lymphosuction method has already been adopted with success [3] in the traditional method with the utilization of 3–4-mm cannulas linked to a mechanical suction pressure. Surgery can be performed under local or general anesthesia suctioning even slight quantities of adipose tissue by the way of a blunt-pointed cannula (type Mercedes) with one or two holes at the top. The cannulas are connected to a device using a pressure of 0.8 atm.

In particular areas, such as ankle or knee, the channelization technique can be used with the creation of channels under the skin using small cannulas (diameter 2, 3, 4 mm). This is performed under local anaesthesia and with 2- or 3-mm incisions. Cannulas are not connected to a suction device and only the back and forth movement of the cannula induces the cellular disruption and channel formation. The created channels will help, in the healing phase, the adhesion of subcutaneous tissue to skin and also angioneogenesis. The adipocyte contains collagen. Its disruption leads to collagen exposure in the extracellular matrix that is very useful in the postoperative healing phase.

With the introduction of ultrasound-assisted liposculpture and the patented vibro-assisted method of Microaire®, the possibilities have been multiplied [4, 5]. The benefits obtained from the reduction of the interstitial pressure due to the adiposity decrease are characterized by microcirculation (arterial and lymphovenular) and tissue metabolism improvement. The reduction in the number and the size of adipocytes prevents hormone action and thus the evolution of adipose and lipodystrophic pathology. As a consequence in the reduction of adipocytes, there is systemic slimming and the improvement of systemic metabolism related to improvement of insulin-peripheral metabolism.

All this is now intensified by the use of Endermologie® in the rehabilitation postsurgery phase.

An important application for liposuction is also the treatment of lymphedema and particularly, lipolymphedema. Lipolymphosuction allows the reduction of lymphedema in the ankle, knee, and calf.

85.4 The Vibro-Assisted Method

The vibratory pneumo-assisted liposculpture by Bacci (1997) or the reciprocal automatic liposculpture by Scuderi (1999), according to the Microaire method, is a method which consists of a 300-g device linked to compressed air from the surgery room or to a nitrogen bottle and the other part to a 2–3-mm, small, light cannula connected to a small vacuum device. The system, defined in this version as PAD100-MicroAire, allows vibrations of the cannula tip, 2 mm transversely and 4 mm vertically, inducing the rupture and homogenization of the fat tissue, while simultaneously aspirating the fat.

Heat production and venolymphatic tissue trauma are avoided because the backward–forward motions are not necessary as in traditional liposuction. Slight movement is sufficient, similar to using a violin bow. Such a method, with a 1.8–2.4-mm cannula, is now used in the treatment of lymphedema and lipolymphedema, particularly at level of the ankle, calf, or arm. Such a method, owing to its easy use and its rare side effects even for unskilled users, is an extremely useful remedy [6, 7].

85.5 Endermologie® and LPG Technique

Endermologie is a non-invasive technique for the mechanical treatment of skin, subcutaneous, and connective tissues [8–11]. The technique, using the Cellu-M6® (LPG Systems) consists of two motorized rollers that mobilize the skin by folding and unfolding through vacuum power generated between the rollers. The technique of LPG was initially used to soften burn and traumatic scars.

Numerous studies have been performed in order to explore the mechanism of the action of Endermologie and its effects on tissues. These show a dramatic increase in skin blood perfusion, venous return, and lymphatic flow as well as the creation of thick, longitudinal bands of collagen in the deep subdermal layer and changes in both the interstitial structure and tissue vascularization. The results have improved with the use of this technique in a protocol developed by the authors from 1997 to 2000 (BIM.ED protocol) [12].

85.6 Clinical Study

Despite clinical results confirming the usefulness of this method in the conservative treatment of lipolymphedema and lymphedema of the lower limbs as well as the rapid recovery from or the rare occurrence of complications, a clinical trial was started to underline the side effects and to evaluate the benefits.

85.7 Materials and Methods

Objective evaluations were performed using videocapillaroscopy with an optical probe (VCOP), laser Doppler flowmetry (LDF), transcutaneous oximetry (tcpO2), lymphoscintigraphy [1, 2, 13] and measurement of body parameters.

The subjects were seven female patients, 18–28 years old (mean 20.7), who underwent surgery for malleolar and calf lipolymphedema. The patients were enrolled after signing a consent form. All the subjects were studied for exclusion of vascular and/or systemic pathologies, which could have an effect on the objective evaluations (macrovascular and/or microvascular troubles, renal/hepatic pathologies). All the subjects were non-smokers and did not take estrogens or progestrogens.

The protocol included:

– Experimental evaluations before and 30 days after surgery with VCOP, LDF, and tcpO2.
– Eight Endermologie sessions (LPG Systems), twice a week in the postoperative period with the patient wearing an elastic garment during the day (Solidea 14 mmHg).
– Lymphoscintigraphy 30 days after surgery.

The design followed was:

– Day 0: VCOP, LDF, tcpO2, body parameter followed by surgery
– Day 30: VCOP, LDF, tcpO2, body parameter – lymphoscintigraphy

VCOP was performed at magnifications ×100 and ×200. VCOP parameters were:

– Red blood cell velocity (chosen in the most significant field)
– Capillary density changes

85.8 Results

The VCOP results are shown in Fig. 85.1 and Table 85.1 and the LDF and tcpO2 results are shown in Fig. 85.2 and Table 85.2.

Circumferences were measured with a tape before surgery and 60 days after at the malleolar level, superior area of the thigh, and Boyd's and solear perforating area [14] (Fig. 85.3, Table 85.3).

All the values obtained at the end of this study showed a decrease in the circumferences with a decreased thickness of the lymphoadipose tissue and improved lymphovenous reflux. In the case of the lymphatic vessel lesions, there was progressive increase in the circumferences.

Lipolymphedema is a chronic pathology, so it requires an integrated medical and physiotherapeutic treatment in addition to elastic stocking therapy, to maintain the results for a long period of time.

Lymphoscintigraphy (Fig. 85.4)was done before and after the treatment in eight cases of leg lipolymphedema treated by vibro-assisted liposculpture (MicroAire system). All the examinations were made in the Nuclear Medicine Center by the radioisotope test using Tc-99m with less than 0.5 ml using the traditional methods. Each study was repeated after 60 days from the surgery. No lymphatic vessel lesions were noted in the surgically treated areas and a reduction in the foot–thigh was shown.

This examination shows that vibro-assisted surgery provides a reduction in the complications of the lymphatic vessel system and subcutaneous tissue. At times, an improvement of the lymphatic stasis, a reduction of the epidermal fibrosis, and a reduction of the rate of evolution of this pathology were noted. The evolution of epidermal fibrosis and hard lipolymphedema is a common complication of the lymphatic stasis.

Table 85.1. Videocapillaroscopy with an optical probe

Average values in basal conditions
Basal flux 1.67
Capillary density 0.70
Average values after 30 days
Flux 1.93 (+0.26)
Capillary density 2.01 (+1.31)

Table 85.2. Laser Doppler flowmetry and transcutaneous oximetry (*tcpO2*)

Perfusion and tcp02 basal values
PU=10.04
tcpO2=60.02
Values after 30 days
PU=16.12 (+6.08)
tcpO2=81.09 (+2.,07)

Table 85.3. Circumferential values after 60 days

Average basal values
Malleolar level 25.8 cm
Solear perforating 36.4 cm
Boyd's perforating 35.3
Thigh 62.1 cm
Average values at 60 days
Malleolar level 23.9 cm
Solear perforating 35.1 cm
Boyd's perforating 34.9
Thigh 58.1 cm

85.9 Discussion

In this clinical study, an important and significant increase of the measured values was observed, showing improvement in the microcirculation of the cutaneous oxygenation and of the interstitial metabolism.

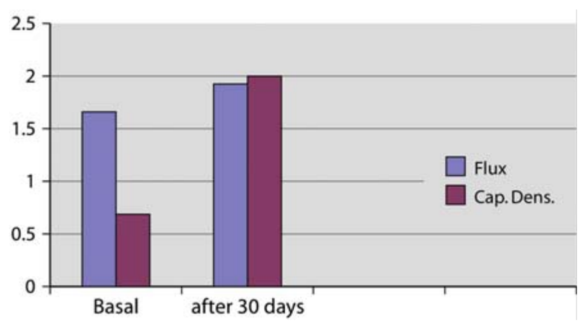

Fig. 85.1. Videocapillaroscopy with an optical probe ($P<0.05$)

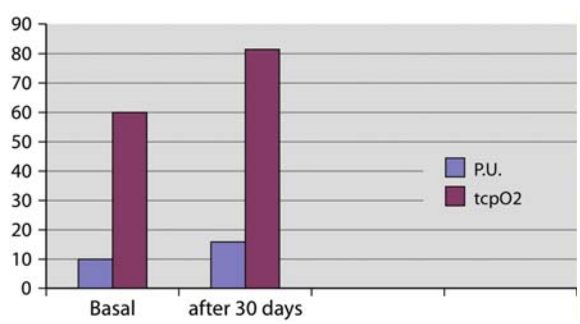

Fig. 85.2. Laser Doppler flowmetry and transcutaneous oximetry (*tcp02*). Mean values on baseline and after 30 days ($P<0.05$)

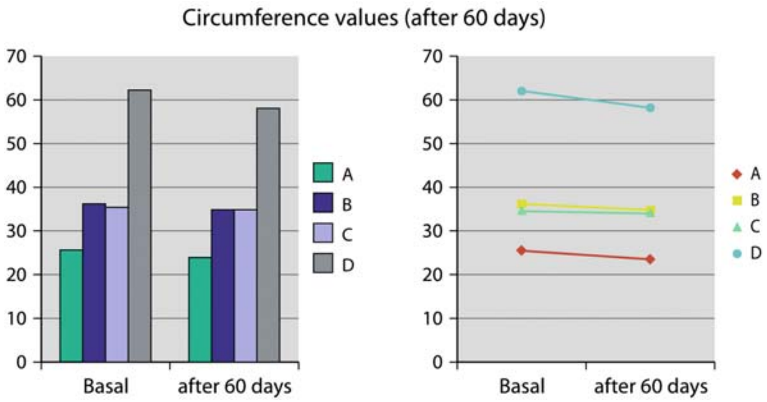

Fig. 85.3. Circumference values (after 60 days)

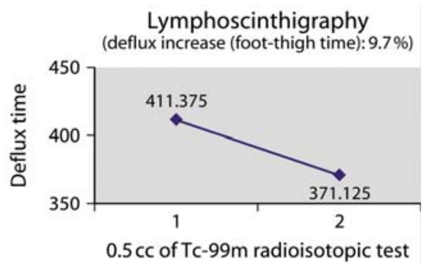

Fig. 85.4. Lymphoscintigraphy

This improvement is obtained by decreasing the interstitial pressure and tension caused by the presence of fat and lymph in the tissues. This result is detectable clinically as well after lower limb liposculpture or lipolymphosuction surgery using a very small cannula, atraumatically with the MicroAire method. The metabolic and microcirculatory improvement has already been observed in other clinical trials using the LPG Systems patented device and the LPG technique [15-18].

Every liposculpture or lipolymphosuction surgery must be completed by physiotherapeutic sessions between the surgery and the Endermologie sessions. The circumference decrease also showed how the proposed physiotherapy/surgery therapeutic protocol gave good results by decreasing edema and adipose tissue, thus leading to a clinical, functional, and aesthetic improvement (Fig. 85.5).

Improvement can also be evaluated by the delay of the typical evolution of these pathologies towards fibrosis and phlebolymphoarthrosis with articular rigidity. The lymphoscintigraphy, performed after 60 days, demonstrated the absence of lymphatic drainage and the value of the MicroAire surgical technique.

85.10 Conclusions

There were clinical observations of slight surgical trauma and synergy with Endermologie in the treatment of lower limb lipolymphedema and lymphedema. This treatment is conservative and should always be associated with elastocompressive treatment and physiotherapeutic maintenance.

When the present methods are not able to guarantee real success and a long-term effect the author believes that a protocol of conservative surgery with both a vibro-assisted lipolymphosuction and Endermologie is justified.

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Fig. 85.5. **a** Preoperative 29-year-old female patient. **b** Postoperatively following liposculpture with MicroAire and Endermologie

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Liposuction of Lipedema

Manuel E. Cornely

86.1 Introduction

For years there has been a controversial discussion whether the liposuction of lipedema can be carried out without damaging the lymphatic system of the patient.

Some authors keep claiming that the liposuction of lipedema is an obsolete method of treatment but this is not true.

A prerequisite for liposuction of lipedema of the arms or legs carried out *lege artis* is an adequate presurgical diagnosis, as is always the case with surgical and dermatologic surgical operations. The following has been recommended as the gold standard for a long time:

1. Unambiguous clinical findings
2. Complete clarification of the vascular situation of the extremities by
   (a) Representation of phlebologic disease
   (b) Exclusion of arterial illness
   (c) Function-lymphoscintigraphy
   (d) Indirect lymphangiography
3. Duplex examination of the adipose tissue
4. Exclusion of lymphedema

86.2 Technique

If the diagnosis of lipedema is undoubted, liposuction with tumescence anesthesia is carried out according to the method described by Klein [1]. Owing to the huge amount of adipose tissue the operation of the extremities will have to be done fractionally. The security standards have to be adhered to. Never infiltrate more than 10 l of tumescence local anesthesia per liposuction. However, these amounts are very seldom needed. Do not suction more than 5 l of tissue. However, frequently several sessions will be necessary to achieve the desired reduction of circumference of the extremities. Since this can only happen with several sessions, one can remain under the limits of the tumescence local anesthesia per session. In liposuction of lipedema usually microvibration cannulas are utilized.

For the outer thighs the positioning is done on the side with stretched leg; for the inner thighs on the side with bent leg. Always try to perform liposuction according to the axes. This especially serves the protection of vulnerable vessels.

Microcannulas are used beyond the articular limits in the best possible positioning. At the special anatomic regions (inner knee and inguinal) a crisscross should be clearly avoided. Here, lymphatic vessels run parallel to blood vessels and are very close to each other. An injury has to be avoided here and this applies to liposuctions in these areas of the extremities in general. The operating surgeon should be able to suction the whole extremity from the ankle to the hip and from the wrist to the shoulder, respectively. This can be achieved more easily with the new vibration cannulas. Lipedema liposuction should be performed symmetrically.

The concluding compression in the region of the suctioned areas is of decisive importance for the remodeling after the liposuction. The inner thigh and the “banana fold” are taped across the lying garment but also across the ventral thigh in order to achieve a better contour. In the extreme, the compression dressing should be worn up to 16 weeks. This achieves better remodeling. As the patients are used to wearing compression trousers anyway owing to their lymphologic history, this part of surgery is the easiest to explain and the compliance is good.

Follow-up liposuction in an area already treated should be postponed for 8 months. The wound healing is completed not earlier than that and a further remodeling cannot be expected.

According to the “lipedema standard” the following is recommended:

1. Not more than 10 l of tumescence solution per session
2. Not more than 5 l of aspirate per session
3. No cross-over
4. Strict suction according to the axes suprafascially

Fig. 86.1. a Preoperative patient with lipedema. **b** Two years postoperatively after six procedures

5. Use of long instruments
6. Sufficient number of surgical sessions up to the definite redevelopment of the lipedema on arms and legs

86.3 Discussion

In principle, the legs are affected symmetrically and not, as sometimes presented, asymmetrically. First one leg is involved completely and after that the other one.

Presurgical and postsurgical manual lymph drainage is indispensable. The postsurgical manual lymph drainage results in rapider healing and mobilization of the remaining tumescence solution out of the areas operated upon.

Consistent wearing of a compression dressing for at least 8 weeks is recommended. If the compression dressing was worn for up to 16 weeks, clearly better results could be achieved compared with results from the usual short wearing periods of only 4 weeks.

Definitive assessment of the areas operated on, at the earliest, is possible after 6–8 months (Fig. 86.1).

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87 Liposuction in Treatment of Plexiform Neurofibromas

Srdan Babovic, Dusica Babovic-Vuksanovic

87.1 Neurofibromatosis Type 1 and Plexiform Neurofibromas

Neurofibromatosis type 1 (NF1), also known as Recklighausen's disease, is a common autosomal dominant disorder with an incidence of 1:3000 (more than 80,000 persons affected in the USA). NF1 is characterized by variable cutaneous, neurological, skeletal and neoplastic manifestations as well as a progressive course. Patients with NF1 have an increased risk of developing tumors of the central and peripheral nervous systems, including plexiform neurofibromas (27%), optic gliomas (15–20%), pheochromocytomas (1%), malignant peripheral nerve sheath tumors (5%) and neurofibrosarcomas (6%) [1, 2].

The hallmark of NF1 is the development of multiple types of neurofibromas, including localized cutaneous neurofibromas, localized intraneuronal neurofibromas, diffuse neurofibromas, massive soft tissue neurofibromas and plexiform neurofibromas. Plexiform neurofibromas and paraspinal neurofibromas cause major morbidity and mortality in NF1 [1, 3]. Plexiform neurofibromas are benign nerve sheath tumors that grow along the length of nerves and involve multiple branches of a nerve and often infiltrate surrounding tissues. These tumors are usually diagnosed early in childhood, may be multiple and might develop throughout one's life. Early childhood, puberty and childbearing ages in women are considered to be the periods of greatest risk for disease progression [4]. Plexiform neurofibromas may be seen as isolated tumors, but the majority of these lesions develop in the context of underlying neurofibromatosis; approximately 20–44% of individuals with NF1 develop plexiform neurofibromas [5]. In contrast to other types of neurofibromas, plexiform neurofibromas are at an increased risk for malignant degeneration resulting in a malignant peripheral nerve sheath tumor. Such an event occurs in about 5–13% of NF1 patients [2, 6]. Early recognition of malignant degeneration of plexiform neurofibromas is essential for successful therapy, since these tumors are known to be highly malignant with an early metastatic potential. However, diagnosis may be challenging especially owing to the fact that the malignant degeneration usually affects only part of the tumor, such that biopsies may be unreliable. Clinical signs suggestive of malignant transformation of a tumor include new onset of pain within the tumor, rapid enlargement of the tumor as well as radiological evidence of tumor necrosis and hemorrhage [7].

Plexiform neurofibromas may cause significant disfigurement as well as compression of vital structures. For example, they may infiltrate the orbit, displace the globe and compromise vision; paraspinal tumors (also referred to as dumbbell lesions) can compress the spinal cord and cause paralysis; tumors in the mediastinum may compress the trachea or great vessels; and tumors of the extremities can cause local nerve infiltration, progressive neurologic deficit and, often, unremitting pain [4]. Plexiform neurofibromas may be visible from the surface of the body or may be internal with no evident superficial extension. Involvement of the skin gives rise to a thickening of the dermis, irregular hyperpigmentation [8] and/or increased vascular markings and palpable cordlike masses. Cutaneous plexiform neurofibromas may arise from superficial peripheral nerves, in which case there is no deep involvement, or can represent the superficial extension of a deeper, more massive plexiform tumor [1].

87.2 Treatment of Plexiform Neurofibromas

Plexiform neurofibromas rarely regress spontaneously, and in many patients their growth is relentless. The rate of growth of this histologically benign neoplasm is commonly unpredictable and often episodic [2]. There is no currently accepted effective drug therapy for plexiform neurofibromas. Management of plexiform neurofibromas is generally surgical but is difficult owing to the infiltrating nature of tumors. Up to 44% of tumors progress after the first surgery, most commonly in patients younger than 10 years of age with head and neck tumors that could not be completely resected [4]. Therefore, repetitive surgical procedures are often necessary, resulting in scarring and functional deficits.

Different surgical techniques have been advocated in the surgical treatment of plexiform neurofibromas, including carbon dioxide laser removal [9–11]. Direct electrocautery desiccation is advocated for the management of multiple, small superficial neurofibromas. A tumescent technique has been successfully used as an adjunct in the resection of large neurofibromas [12]. A vacuum-assisted wound closure system has been reported in reconstruction of massive defects and for bleeding control in very difficult cases [13].

87.3 Use of Liposuction for Treatment of Plexiform Neurofibromas

Liposuction is one of the most frequently performed aesthetic surgery operations. Since its introduction in the late 1970s, it has evolved into a safe, reliable and effective procedure. The introduction of the tumescent technique, new instruments and technologies have all improved results and also widened the applications of liposuction for the treatment of problems previously managed by excision only. The treatment of choice for gynecomastia was glandular excision until Teimouran and Perlman [14] reported their experience with liposuction. Today, liposuction is an integral part of gynecomastia management, with or without glandular or skin resection. Treatment of the "buffalo hump" deformity further expanded the scope of the liposuction application for treatment of abnormal localized lipomatous masses. The idea to utilize liposuction to treat lipomatous tumors dates back to the early 1990s. Sharma et al. [15] treated a giant lipoma using liposuction. It was not until 2001 that liposuction was introduced as a common technique in the treatment of benign tumors [16–18]. The literature is consistent in stating that for the large tumors, or unusual presentation, computed tomography and/or MRI should be performed [19, 20].

Just recently, liposuction was added in surgical armamentarium for the debulking of superficial plexiform neurofibromas [21]. We used liposuction as a main means of plexiform neurofibroma debulking in two patients without complications. The outcome in both cases was favorable, with good aesthetic results and no tumor regrowth within the 2 years of follow-up (Figs. 87.1, 87.2).

The superwet technique was used with modified Klein's solution. A power-assisted liposuction system, with Mercedes-type cannulas, 6 and 4.5 mm in diameter for debulking of the gluteal plexiform neurofibroma, and 3.7-and 2.1-mm liposuction cannulas was used for the head and neck case [21]. Significant volumes of aspirate were removed (2,540 ml in gluteal neurofibroma) with no difficulties. The usual application of the postliposuction compressive garments was advised. Skin redraping was not complete after 6 months and additional skin remodeling was performed in order to achieve optimal contour improvement. No complications were observed in our two cases. Resulting scarring was minimal. Significant improvement in contour was obtained in both cases [21].

87.4 Risks of Procedure

As in any other procedure, liposuction should follow general precautions for bleeding diathesis and increased risk for infection. This is of crucial importance to assure that the tumor does not involve vital structures or large arteries where an injury could result in significant bleeding or damage to internal organs or nerves. Preoperatively, an imaging study should be carried out for patients (preferably MRI) to determine the extent of the tumor and to define surgical planes. Also, one should assure that liposuction treatment is not applied to patients with possible malignancy where liposuction may result in tumor dissemination. Prior to liposuction, true-cut or excisional biopsies should be obtained and pathological diagnosis confirmed with intraoperative frozen section. Rapidly enlarging lesions and very painful tumors should be carefully evaluated to exclude malignant processes where the use of liposuction would be contraindicated [19].

87.5 Conclusions

If the advantages of liposuction regarding short post-surgical recovery and minimal scaring are taken into account, this method may be preferable in selected patients with superficial plexiform neurofibromas. Similar to conventional surgical treatment, the risk of tumor regrowth and recurrence should be considered. Patient preoperative workup should include an MRI scan to define surgical planes and rule out the involvement of vital structures. Rapid growth of lesions, significant pain and tumor necrosis or bleeding seen on an MRI scan could indicate malignant degeneration of the tumor and liposuction should be avoided in such patients. Prior to liposuction, pathological diagnosis should be confirmed with intraoperative frozen section. One should keep in mind that our experience in treatment of plexiform neurofibromas with liposuction is limited, based on just a few cases.

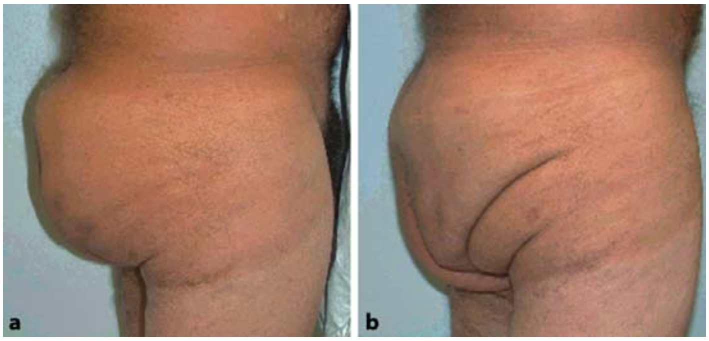

Fig. 87.1. **a** Preoperative side view. **b** Six months postoperative side view. Note a significant reduction of soft tissue. Two 5-mm access incisions are the only surgical scars1

Fig. 87.2. **a** Preoperative oblique view. **b** Six months postoperative oblique view. Note the decreased bulk of the tumor and the satisfactory cosmetic outcome

More experience with a larger number of patients and longer postprocedure follow-up will certainly shed better light on the usefulness of this method in treatment of plexiform neurofibromas.

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88 HIV Lipodystrophy Treatment (Buffalo Hump) with VASER Ultrasound-Assisted Lipoplasty

Alberto Di Giuseppe, Marianne Wolters, Herman Lampe, Guido Zanetti

88.1 Introduction

HIV lipodystrophy is an heterogenous syndrome, which has yet to be objectively defined, comprising peripheral lipoatrophy, central fat accumulation, and lipoma, along with hyperlipidemia, insulin resistance, and lactic acidemia [1]. Along with the issues of cosmesis and stigmatization, a principal clinical concern that arises with lipodystrophy is a possible increased risk of accelerated atherosclerosis [2]. A variety of therapeutic interventions, designed to limit these risks, have been proposed, but none has been conclusively shown to be of value [3].

The authors propose the surgical elimination of the pathological lipodystrophy with ultrasound-assisted lipoplasty (VASER), which selectively emulsifies the fat compartment, thus inducing skin retraction and remodeling of the treated areas. Good clinical results and no long-term recurrence (4 years follow-up) clearly indicates this method as the most promising treatment for HIV lipodystrophy.

88.2 HIV-Associated Lipodystrophy

The HIV-associated lipodystrophy syndrome has only recently been recognized; nevertheless, there have been numerous reports describing the changes in body image and associated metabolic disturbances [4]. The condition is characterized by fat loss and/or redistribution, insulin resistance, and proatherogenic hyperlipidemia. Psychological and social consequences of the body shape changes are as important as the increased risk of premature atheroscleroses. Recent studies have shown an increase in cardiovascular mortality in HIV-infected patient [5].

The role of protease inhibitor based therapy has been clearly established, as the metabolic changes induced increased carotid intima-media thickness changes [6]. The protease inhibitor associated lipodystrophy involves metabolic changes, body composition assessment, and psychological assessment [7].

88.3 Metabolic Changes

HIV infection is associated with a number of metabolic abnormalities, including lipodystrophy, a difficult-to-define disorder whose characteristics include hyperlipidemia, insulin resistance, and fat redistribution. Current data suggest that lipodystrophy is caused by multiple factors. Dual-nucleoside reverse transcriptase inhibitor therapy combined with protease inhibitor therapy has been shown to increase the risk of metabolic abnormalities, but susceptibility independent of drug effects has also been shown.

While many of the treatments for the broad range of signs and symptoms of lipodystrophy bring about improvement in patient status, none have been demonstrated to bring about a return to baseline levels. A baseline fasting blood test for lipids (cholesterol – triglycerides and high-density lipoprotein cholesterol) and tests for fasting glucose, thyroid function, liver function and lactate level should be carried out for diagnoses, for all affected patients.

88.4 Body Composition Assessment

The patient's data, including height, weight, body mass index, and body cell mass, should be evaluated. A dietician should assess nutritional status and caloric intake.

88.5 Psychological Assessment

A psychological and social assessment using a quality-of-life questionnaire should be considered.

88.6 Assessing Body Composition

Numerous tests have been proposed to evaluate body changes and fat accumulation or loss after highly active antiretroviral therapy (HAART): clinical assessment, anthopometric measurements, magnetic resonance tomography (can visualize body fat), computed tomography scanning, and bioelectrical impendance assessment for measuring body cell mass.

In conjunction with the Infection Diseases Department of our regional hospital, the authors we have started treating patients with dorsal (hump) accumulation of fat (the so-called buffalo hump) or associated with other body lipodystrophies (arm, back, dorsum, flanks, abdomen, neck).

Besides the changes-in-lifestyle measures (diet and exercise) proposed by the dietician and the physiotherapist, psychological support through the hospital staff has been given to all patients suffering from HIV-associated lipodystrophy syndrome. Lipid lowering therapy has frequently been associated with these patients.

The syndrome is a major cause for concern, as the alteration in appearance has a huge impact on these individuals' lives, especially now that more successful HIV treatment has reduced the anxiety associated with living with HIV. Carr [8] showed that 64% of patients receiving protease inhibitor therapy developed the syndrome, starting 10 months after beginning therapy. Those taking nucleoside reverse transcriptase inhibitors more often develop facial lipoatrophy.

Insulin-sensitizing agents may have a role in managing glucose abnormalities and adverse body fat changes but currently experience is limited. These agents include metformin (a biguanide antidiabetic drug) and glitazone (a thiazolinedione which acts as a ligand for peroxisome prolifetaror activated receptor-J).

88.7 Surgical Treatment

Ponce-de-Leon et al. [9] and Wolfort [10] proposed liposuction as a technique for protease-inhibitor-associated lipodystrophy. The results have been unsatisfactory with a high risk (60%) of early (3–6 months) recurrence. The authors have introduced ultrasound-assisted lipoplasty with VASER [11] (by Sound Surgical Technologies, Denver, CO, USA) to treat buffalo hump or lipodystrophies related to HAART. The VASER pulsed ultrasound device (Sound Surgical, CO, USA) represents the third-generation ultrasound-assisted liposuction (UAL) device, which optimizes ultrasound energy and efficiency to emulsify body fat.

In the last 2 years, the authors have treated 15 patients affected by HAART-associated lipodystrophies (mainly buffalo hump, but also Madelung's disease). Four of these patients had early recurrence of lipodystrophies previously treated with liposuction.

88.8 Materials and Methods

Fifteen patients affected by lipodystrophies associated with HAART therapy have been treated in the last 2 years (January 2002–2004) (Table 88.1). Twelve patients (age range from 28 to 55) presented with buffalo hump lipodystrophies (ten men, five women). One patient presented with multiregional lipodystrophy (Madelung's disease) including dorsum, trunk, flanks, abdomen, arms, and neck. Two patients presented recurrence of buffalo hump after treatment with standard liposuction. The recurrence appeared after 2–3 months of previously established surgery, or even 6 months after surgery.

The operations were performed under modified tumescent anesthesia with the technique of Klein [12] and sedation or general anesthesia, depending on the extent of the lipodystrophy.

Buffalo hump was mostly treated under tumescent anaesthesia and mild intravenous sedation. The modified tumescent anesthesia included 1,000 ml Ringer's lactate/1 ml adrenaline/500–750 mg lidocaine (Table 88.2). Different concentrations of lidocaine in the modified tumescence solution were adopted depending on the site of infusion.

Table 88.1. Lipodystrophies assoviated with highly active antiretroviral therapy between January 2002 and January 2004

Men	Women	Total patients	Age range
10 Buffalo hump 12	5 Madelung's disease liposuction 1	15 Recurrence after 2	28–55

Table 88.2. Buffalo hump was mostly treated under tumescent anaesthesia and mild intravenous sedation

		Infiltration of tumescence	
General anaesthesia	+	Lidocaine (200 mg) Adrenaline (1 ml)	In 1 l normal saline
Intravenous sedation	+	Lidocaine (500–700 mg) Adrenaline (1 ml)	In 1 l Ringer's lactate

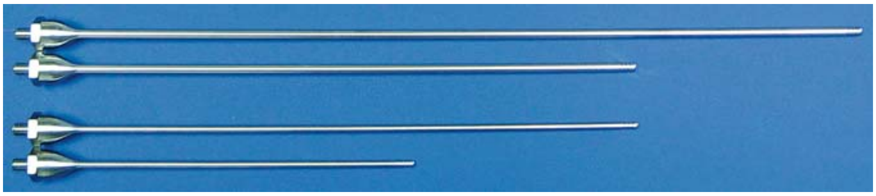

Fig. 88.1. 2.2-, 2.9-, and 3.7-mm solid titanium probes

Buffalo hump lipodystrophy presented as a very fibrotic fat pad. Total infusion in the buffalo hump never exceeded 1,500 ml (total lidocaine ranged from 500 to 1,500 mg.). Total doses of lidocaine ranged from 11 to 22 mg for body weight, and never reached the threshold of 35–40 mg/kg of body weight, as indicated by Klein and by the guidelines of the American Academy of Cosmetic Surgery (2001, 2002, 2003) as safe total doses of lidocaine for tumescent anaesthesia. Intravenous sedation could be utilized along with surgery, depending on the patient's attitude.

The VASER pulsed UAL device utilizes solid titanium probes to emulsify fat. The solid probes are 2.2, 2.9, and 3.7 mm in diameter, have different lengths, and present one, two, or three grooves on the tip of the probe (Figs. 88.1, 88.2). The tip grooves are expressively designed to enhance efficiency of the system and to optimize emulsification, thus utilizing lower ultrasound energy in comparison with previous UAL systems [13] (Figs. 88.3, 88.4). One groove probe is utilized for harder, more fibrotic fat. The three-groove probe is used in softer tissue.

HAART lipodystrophy typically presents fibrotic dense fat localized at the dorsum of the trunk (suboccipital and interscapular region). This may extend to dorsum, neck, and submental regions. Standard liposuction, with mechanical destruction and simultaneous aspiration of destroyed tissue presented three main problems:

1. Difficulties in breaking very fibrotic fat tissue
2. A high percentage of blood in the aspirate
3. A high rate of recurrence of lipodystrophy

Ultrasound assisted lipoplasty with VASER resolves all these problems.

88.9 Operative Technique

An ultrasound wave is selective for adipose tissue, thus emulsifying only the adipocity, thus sparing the fibrotic dense structures of the dorsum. The authors have utilized the 3.7-mm large solid probe, with one groove, and the power of the device was set at 80% of the total. After infiltration of the modified Klein solution with blunt needles, it is always advisable to

Fig. 88.2. New design of the tip to increase efficacy: one, two, three rings

wait 10–15 min to allow adrenaline to obtain good hemostasis. Typically, the area infiltrated will soon become nearly white in comparison to the surrounding tissue.

An expressively designed skin port (protector) (Fig. 88.5) with a special introductor (Fig. 88.6) is placed at the site of entrance to avoid friction injuries. The ultrasound solid probe gently moves together fibrotic fat compartments. The emulsified solution starts rapidly to flow back to the entrance site. Application of ultrasound energy for 10–15 min can be necessary to emulsify tissue in this fibrotic dense region.

At the beginning the superficial layers are treated, to free all the adhesions from underlying tissue. Then, the deeper layers are addressed until no resistance is found when the probe is progressing. This reveals the emulsification has been completed. The emulsified fat is removed using the special eight-hole cannula of the VentX System (by VASER) (Fig. 88.7), which is a low power but efficient suction system that removes the emulsified fat, combined with the infiltrated solution.

The authors tend to leave a drain (Jackson-Pratt with close aspiration system) in place for 48–72 h. The postoperative leakage is, as a rule, part solution and part blood. Compression with a foam pad (Epifoam, Biodermis, Las Vegas NV, USA) (Fig. 88.8) is maintained for 1 week. The patients can shower as soon as the drain is removed, then the foam pad is repositioned. A pressure garment is maintained for 1 month after surgery.

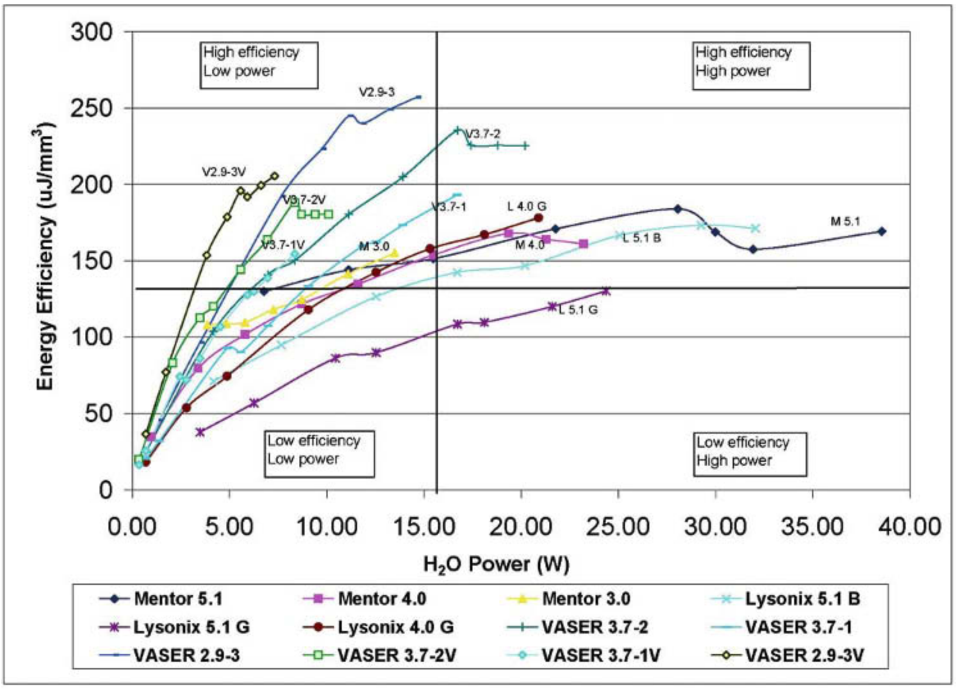

Fig. 88.3. Energy efficiency versus power (W) with different probes

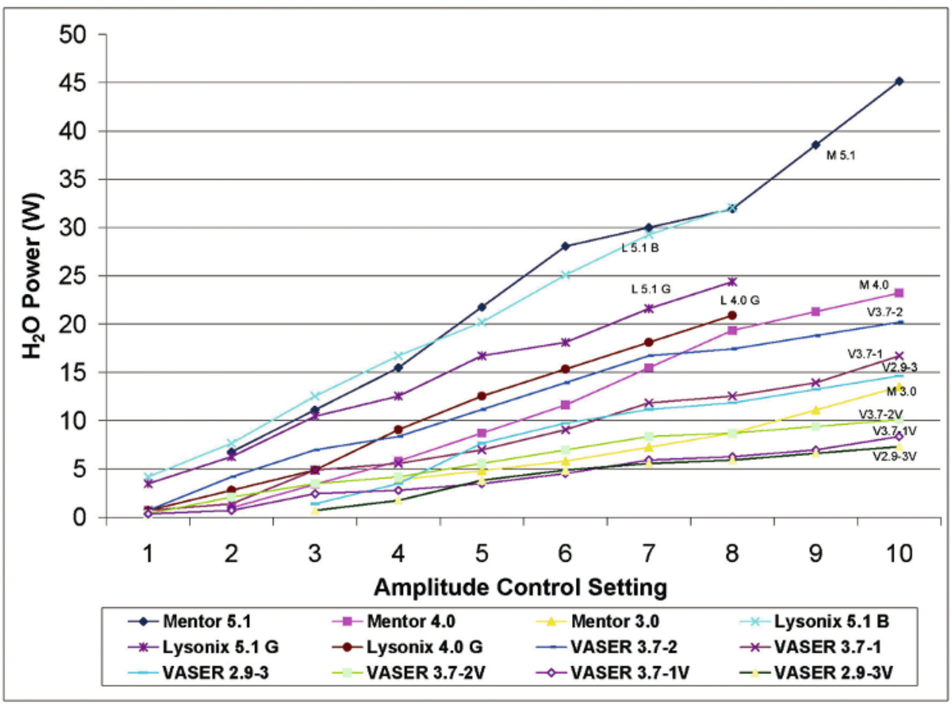

Fig. 88.4. Power (W) versus amplitude control settings with different probes

Ten days after surgery, a lymphatic massage with Endermologie (LPG Endermologie) (Fig. 88.9) is started (twice a week, for 6–8 weeks to reduce swelling and soften the area). The procedure is absolutely painless, which makes VASER clearly distinguishable from standard liposuction. This is due to the delicate action of the ultrasound energy, which emulsifies the fat deposit with a gentle continuous mode, without trauma, as in standard liposuction. Fat is not broken mechanically, but is emulsified efficiently and progressively by the action of the ultrasonic wave.

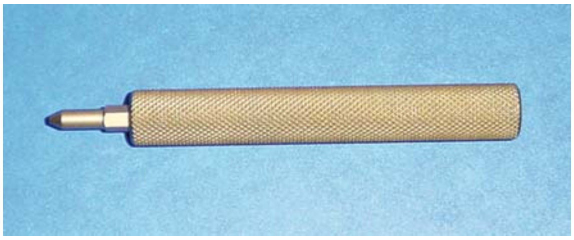

Fig. 88.5. Skin ports to prevent skin friction injuries

Fig. 88.6. VentX cannualae

Fig. 88.7. Foam pads, for compression dressing

Fig. 88.8. LPG Endermologie

88.10 Clinical Results

Clinical results with 2 years follow-up are presented in Figs. 88.10 and 88.11. There were two cases of lipodystrophy recurrence (Fig. 88.12) (already treated with standard liposuction elsewhere) that were successfully treated with VASER UAL. In their particular cases, the aspirate was bloodier than in standard cases (Fig. 88.13), and UAL energy had to be supplied for longer to emulsify the body fat and treat the area. The authors suppose that the higher percentage of blood in the aspirate was because of the even more fibrotic tissue encountered. The total aspirate varied from 300 to 1,200 ml in buffalo hump removal. A case of multiregional lipodystrophy (called Madelung's disease) (Fig. 88.14) was treated with total aspirate of 12,700 ml in a single stage. The patient is actually considering the benefit of a second stage.

The recurrence of lipodystrophy occurring in HAART may be due to the mechanism of liposuction, which mechanically destroys the encountered fat, in a blind manner. If a few adiposities of the lipodystrophy still remain, by continuing the HAART therapy, they are pushed to grow back again. In contrast, VASER UAL selectively destroys all the fat of the lipodystrophy, leaving no spare fat behind. This is why VASER proved to be the elective therapy for this peculiar pathology.

VASER pulsed ultrasound is a recently redeveloped technique which utilizes ultrasound energy to emulsify the fatty tissue. The main differences with previous ultrasound techniques concern safety issues. Owing to the excessive ultrasound energy delivered

Fig. 88.9. a Preoperative 43-year-old male patient with buffalo hump. **b** Two years postoperatively following 350-ml aspiration

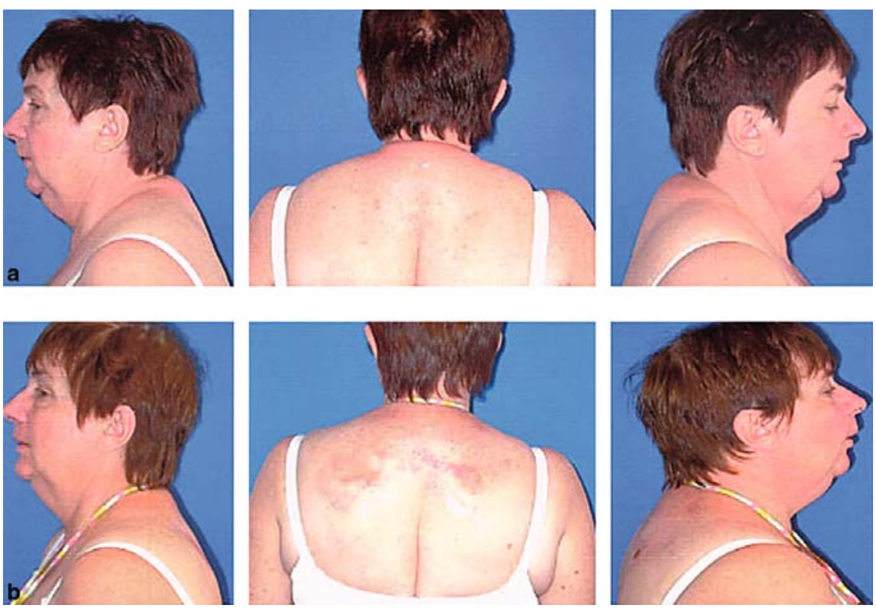

Fig. 88.10. a Preoperative 40-year-old female patient with buffalo hump. **b** Two years postoperatively following 400-ml aspiration

by first- and second-generation UAL devices (Sculpture, Smei, Mentor Contour Genesis, and Lysonics, Inamed), a series of complications were described following UAL between 1995 and 2000 (seroma, burn, skin necrosis, dysesthesia). The initial enthusiasm for UAL decreased owing to the high complication rate and cost of equipment. In 2001 VASER was introduced as the third-generation device. The shape and design of the new solid titanium probes increases the efficiency of the system and reduces the power of the device, which together with the pulsed mode, reduces complications.

Superficial UAL allows (through minimal skin incisions) the utilization of 2.2-mm solid titanium

Fig. 88.11. **a–c** Preoperative 38-year-old female patient with buffalo hump. **d** Recurrence of lipodystrophy 3 months after liposuction. **e, f** One year postoperatively without evidence of recurrence

probes to fully undermine the subcutaneous tissue, thus allowing excellent skin retraction. Deeper planes are treated with 2.9- or 3.7-mm probes for faster emulsification. Grooved probes increase the efficiency of the system. Cimino [13] showed that the rings (one to three) applied on the tip of the solid titanium probe increase the specificity of the system, allowing greater emulsification with less energy (thus less heat): less heat means fewer complications. With the pulsed mode, the same amount of energy is delivered in a longer time, allowing a further decrease of energy.

Three alarms control the system and prevent mistakes. The first stops the device in case of electric failure or bad connections. The second stops the device if the surgeon utilizes a probe which is not correct for the type of tissue to be treated. The third stops the device if the surgeon does not use the probe correctly (UAL is a dynamic technique) and suddenly the temperature of the probe rises too much (risking a burn). These alarms greatly reduce risks for the patients. This explains why the complication rate dropped to virtually zero with the present device.

88.11 Surgical Risk

There is some risk to healthcare workers during surgical procedures, but HIV is not the greatest risk. The risk of viral infection from needlestick injuries is 0.3% for HIV, 3% for hepatitis C, and 30% for hepatitis B. The risk of becoming infected with HIV may be even lower when the patient is known to be HIV positive, as healthcare professionals use more care when handling the patient and have immediate access to prophylaxis, should exposure occur. In addition, many of these individuals are on treatment and therefore have low or undetectable viral levels.

Fig. 88.12. a1, a2 42 y.o. male patient with recurrence of buffalo hump after previous treatment with liposuction. **b** See previous scars (arrows). **c** See drawing of surgical plan

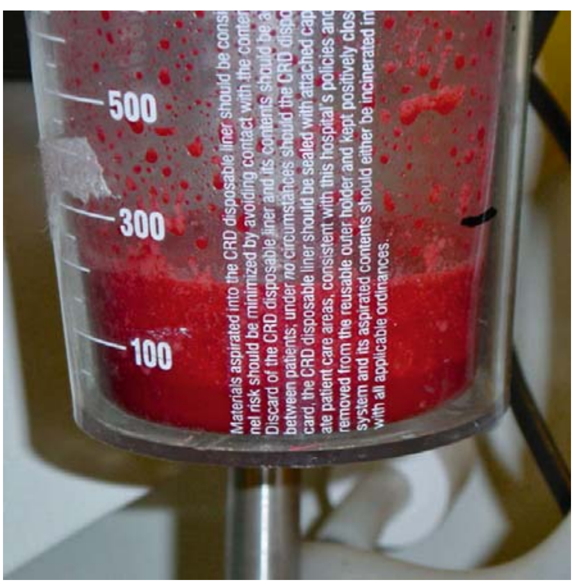

Fig. 88.13. Typical aspirate from buffalo hump lipodystrophy. Note the bloodier content of the aspirate

Strict injection control procedures are utilized for all these patients, including admission to a special unit for infections disease. Universal precautions recommend that blood and body fluid safety measures be used for all patients. Face shields or goggles are routinely utilized.

88.12 Conclusions

Lipodystrophy syndrome, characterized by fat redistribution and accumulation, hyperlipidemia, and insulin resistance are frequently seen in HIV-infected individuals. It seems to be related to protease inhibitor therapy. Patients with lipodystrophy must weigh the impact the syndrome has on their lives against the complications of HIV and improved survival.

Management of HIV-associated lipodystrophy must be specific for each patient. Central fat accumulation (buffalo hump) or multiregional fat accumulation (Madelung's disease) can be treated safely with

Fig. 88.14. **a** Preoperative 62-year-old male patient with Madelung's disease. **b** Two years postoperatively after 12,700-ml aspiration

UAL with VASER. The technique seems to offer good clinical results, and high patient satisfaction. No recurrences have been seen at 2 years follow-up. Recurrences of four cases previously treated with standard liposuction were successfully treated with UAL. The technique is safe: no burns or seroma or skin necrosis was observed in this small series of patients.

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