Functional and Therapeutic Indications of Liposuction

Personal Experience and Review of the Literature

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Abstract: Liposuction is the most common cosmetic surgical procedure worldwide. It has evolved from being designed primarily for body contouring to becoming essential adjunct to various other aesthetic procedures, greatly enhancing their outcome. Despite its hard clear differentiation between an aesthetic and therapeutic indication for some pathologic conditions, liposuction has been increasingly applied to a gamut of disorders as a therapeutic tool or to improve function. In fact, liposuction has ceased to define a specific procedure and became synonymous to a surgical technique or tool same as the surgical knife, laser, electrocautery, suture material, or even wound-dressing products. At present, there seems to be an enormous potential for the application of the basic liposuction technique in ablative and reconstructive surgery outside the realm of purely aesthetic procedures. The present review contemplates the various nonaesthetic applications of liposuction, displaying the enormous potentials of what should be considered a basic surgical technique rather than a specific aesthetic procedure. Implications of this new definition of liposuction should induce third-party public payers and insurance companies to reconsider their remuneration and reimbursement policies.

Key Words: liposuction, lipodystrophy, dermolipectomy, functional liposuction

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Liposuction is the most commonly performed cosmetic surgical procedure worldwide. Originally designed to correct unaesthetic superficial and deep deposits of subcutaneous fat, it produces highly satisfactory silhouette contouring when performed by appropriately trained operators using properly selected technologies for well-selected patients and anatomical areas.

Modern liposuction can be traced back to lipexeresis, a combination of subcutaneous scissor dissection with curettage and suction of fat. Several variations of the technique have been described since. Its basic principles have been elaborated more recently by Illouz, who was the first to introduce the modern, safe, and widespread method of liposuction with a blunt-tipped cannula as well as subcutaneous infiltration to facilitate adipose breakdown and aspiration.

The fundamental premise of liposuction is aspiration of adipose cells over a large area through small incisions required for the introduction of the aspirating cannula. The procedure preserves neurovascular structures while maintaining fluid balance and minimizing patient discomfort. Surprisingly, the basic principles remain unchanged despite the introduction of modern technologies enabling more efficient fat removal by enhancing liquefaction and disruption of the adipocyte membrane. Suction-assisted liposuction (SAL) is continuously evolving and its indications are rapidly expanding. It has become an essential adjunct technique to improve results of many other aesthetic procedures including cervicoplasty, reduction mammoplasty, abdominoplasty, brachioplasty, thigh lift, and postbariatric body contouring. At present, there seems to be an enormous potential for the application of liposuction techniques in ablative and reconstructive surgery, outside the realm of purely aesthetic procedures. Moreover, with mounting evidence about the role of adipose tissue beyond that of mere storage compartment, and that its dysfunction combined with ensuing insulin resistance, exerts a negative impact on all other tissues, including the heart, by creating a much more lipotoxic environment in peripheral tissues, it is not surprising that in the near future, decreasing the mass of fat tissue would prove to have a therapeutic effect.

Despite the hard clear differentiation between aesthetic and therapeutic indications of liposuction, such as the combination of submental liposuction and orthognatic surgery or for correction of craniofacial malformations, the fundamental principles of the technique have evolved into the method of choice in the treatment of various entities and has been increasingly applied to a gamut of disorders other than pure aesthetic body contouring.

The present review contemplates the various nonaesthetic applications of liposuction, displaying the enormous potentials of what should be considered a basic surgical technique rather than a specific aesthetic procedure. Various conditions and pathologies for which liposuction may be indicated as a primary therapeutic or an ancillary procedure to improve outcome. For some indications, liposuction may confer aesthetic improvement.

MATERIAL AND METHODS

On the basis of personal experience in the treatment of several nonaesthetic conditions with liposuction, a PubMed database search using the keywords “liposuction,” “non aesthetic liposuction,” “non cosmetic liposuction,” and “functional liposuction” was performed to identify all possible recent relevant reports about nonaesthetic indications of liposuction. Retrieved reports were supplemented with papers identified in the reference lists of the selected publications. Additional searches were also performed for each identified indication. No attempt was made to classify studies according to their levels of evidence because the purpose of the review is only to identify conditions in which liposuction techniques have been effectively used as a therapeutic tool to achieve cure or improved function even when some aesthetic improvement may have been achieved as well.

OBESITY AND LOWER LIMB ARTHRITIS

The heterogeneous spectrum of adipose tissue diseases ranges from obesity to lipodystrophy. Large-volume liposuction performed alone for obese patients does not improve obesity and has been originally dismissed as unsafe or unrealistic. Being traditionally labeled as a cosmetic procedure, liposuction is generally not recommended for...
obese patients because poor aesthetic results are the norm without bariatric surgery and major excisional body contouring.\textsuperscript{16}

However, in selected cases for which functional relief of incapacitating symptoms is the aim more than any improvement in aesthetics, liposuction may produce dramatic results. Obesity as such is a major risk factor for osteoarthritis and meniscal tears due to increased joint loading and diminished physical activity with subsequent loss of protective muscle strength.\textsuperscript{17-23} Because weight loss has been shown to reduce the risk of symptomatic lower limb osteoarthritis and to improve significantly the quality of life, daily living, sports activities, and since, in established disease, it reduces symptoms, improves function, and is likely to reduce disease progression,\textsuperscript{18,21,24} liposuction for this group of patients may be indicated for functional and medical reasons and is primarily a debulking procedure. Anecdotally, acute weight loss of 10% of body weight by liposuction in an obese dog with severe bilateral hip osteoarthritis has resulted in rapid improvement of symptoms postoperatively\textsuperscript{25} (Fig. 1).

Major localized fat deposits of the medial aspect of the knees give a clinical picture resembling genu valgum deformity, causing an increased stress on the lateral joint compartments that may progress with time to painful arthritis. In parallel, dermatitis and even skin ulcerations due to friction may also develop. Correction of this deformity certainly has a combined aesthetic value in addition to an undeniable functional indication. With liposuction, 250 to 300 mL of fat may often be removed, leading to realignment of the leg axis in relation to the thigh. Not infrequently, liposuction may be equally useful in anticipation of prosthetic knee replacement (Fig. 2).

\textbf{OBESITY AND METABOLIC SYNDROME}

It is apparent that adipocytes play a key role in the pathogenesis of the metabolic syndrome and have the capability to exert profound effects on whole-body metabolism. Prolonged nutrient excess can promote a state of chronic, low-grade inflammation in adipose

\textbf{FIGURE 1.} A, B, Obese patient with difficulties in ambulation. C, D, Deformity corrected with liposuction with net improvement in gait.
tissue that is associated with the down-regulation of critical adipokines that induces systemic inflammation and insulin resistance.\textsuperscript{8} Liposuction-induced metabolic modulation is now well documented\textsuperscript{26}; however, studies investigating the metabolic effects of liposuction are controversial. Most human studies have reported either no change or improvements in 1 or more cardiovascular risk factors.\textsuperscript{27,28}

Although contested by some, large-volume as well as small-volume liposuction produce a substantial improvement of metabolism with a definite effect on insulin resistance and glucose levels and has been clinically shown to improve insulin sensitivity in obese patients, reducing their risk of developing type 2 diabetes and greatly improving their quality of life.\textsuperscript{15,16,26} A significant reduction in triglyceride level in patients with elevated preoperative levels and a significant decrease in leukocyte count are also favorable metabolic effects of liposuction.\textsuperscript{29} More recently, liposuction and exercise have been proven to equal and directly affect metabolism. Thus, it was suggested that exercise training could exert an additive or even a synergistic effect to liposuction on improving insulin sensitivity as well as the inflammatory balance, resulting in an improvement of cardiovascular risk factors. Moreover, this combination offers an unquestionable aesthetic benefit.\textsuperscript{28}

Pilot animal studies have demonstrated the technical feasibility of relatively noninvasive omental ultrasound-assisted liposuction (UAL).\textsuperscript{30,31} This may have a great therapeutic potential, since in contradistinction to subcutaneous adipose tissue, ectopic fat may contribute to a greater extent to the metabolic syndrome and to the obesity-mediated cardiovascular morbidity and mortality.\textsuperscript{32} In fact, the greater omentum is the largest depot of visceral fat, thus selectively reducing omental fat could be a valid option. However, evidence provided so far did not demonstrate that surgical removal of omental fat improves insulin sensitivity nor cardiovascular risks.\textsuperscript{33,34}

Another underestimated effect and unrecognized therapeutic value of large-volume liposuction in obese patients, although not an effective weight loss procedure, is the fact that for some patients the achieved amount of weight loss cannot be attributable to liposuction alone. Some patients may become more motivated after liposuction and continue to lose weight even 1 year after the procedure.\textsuperscript{35,26} resulting in further improvement in metabolic parameters and quality of life.

LIPEDEMA AND LYPODYSTROPHY SYNDROMES

Lipedema is a generally hereditary clinical condition affecting mostly women, likely to develop at any age between puberty and menopause.\textsuperscript{35–37} Distinct from obesity, lymphedema, and cellulite, lipedema often coexists with obesity and is commonly unrecognized or misdiagnosed.\textsuperscript{35} The deformity ending just above the malleoli in a purse string appearance is characterized by bilateral symmetrical and localized subcutaneous fat deposits of the buttocks and lower limbs. The shape of the knees and the gastrocnemius muscle contour are concealed by the lipodystrophy, resulting in a deformity known as “sausage legs.” In addition to easy-bruising, lipedema causes significant physical disability, fatigability, pain, moderate to severe tenderness disproportionate to pressure applied, and difficulty in putting on footwear and wearing boots.\textsuperscript{35,36} Pain, tenderness, and sensitivity to pressure are expressed in synonyms such as lipalgia, adiposalgia, adipoalgesia, adiposis dolorosa, lipomatosis dolorosa, or painful column leg.\textsuperscript{36} Many synonymous terms have been used in the literature to describe lipedema including lipodosis, lipohypertrophy, painful fat syndrome, and morbid obesity of the legs\textsuperscript{35} (Figs. 3–5).

Dieting or exercise cannot reduce the obvious disproportion between the slim upper half of the body and the large lower extremities. Any attempts at reducing weight results in weight loss from the upper body only. Paradoxically, any weight gain tends to affect the lipedematous regions first.\textsuperscript{35,36} Traditional conservative decongestive lymphatic therapy and manual lymphatic drainage have been shown to be of little benefit and to be only effective against the edema, decreasing tenderness in the affected extremities for only a short period. Despite decongestion, external compression does not reduce the fatty component of lipedema. In addition, subcutaneous tissue accumulation tends to increase and the disease to worsen with time.\textsuperscript{35–38}

Skin and subcutaneous excision significantly improve the size and shape of the limbs; however, it may be associated with severe complications. Suction-assisted lipectomy, although refuted by some,\textsuperscript{35,38} may be a well-suited surgical option given the diffuse nature of lipedema adipose hypertrophy.\textsuperscript{39} If carried out meticulously, using a pneumatic tourniquet, large quantities of fat (approximately 1000 to 1200 mL on each side) can be removed circumferentially. It may be combined with limited skin and subcutaneous tissue excision in cases of persistent redundant skin particularly in older patients.\textsuperscript{35–37,39} Water jet-assisted liposuction and power-assisted liposuction (PAL) have been also described in the treatment of this entity.\textsuperscript{35–37}

When performed properly, liposuction produces aesthetically pleasing resolution of disproportionality between the upper and lower parts of the body and significantly reduces the lipedema symptoms, including reduction of chronic joint pain in the hips and/or knees.
with improved gait and mobility. In a preulcerous leg, liposuction can sometimes improve lower limb circulation and prevent skin ulceration as well. Despite the belief that liposuction cannot completely cure lipedema, recent evidence suggests that the condition can be treated with circumferential SAL and that, in contradistinction to lymphedema, only limited postoperative compression garment use for an average of 4 months may be adequate for successful long-term maintenance of results.

On the other hand, lipodystrophies represent a group of rare diseases characterized by selective body fat loss with altered body fat amount and/or repartition that can be either generalized or partial. Lipodystrophies are usually associated with insulin resistance, type 2 diabetes, dyslipidemia, liver steatosis, polycystic ovaries, acanthosis nigricans, and cardiovascular complications. The main concern with most lipodystrophies is the high prevalence of cardiac (atherosclerosis) and hepatic complications (nonalcoholic steatohepatitis) due to altered fat repartition and insulin resistance. An additional major concern is the presence of signs of premature aging that aggravates some of these diseases.

Etiology of lipodystrophy is generally unknown. It may result from different pathophysiological mechanisms, either genetic or acquired in particular linked to drugs. Genetic forms such as...
Berardinelli-Seip syndrome or partial familial lipodystrophies are uncommon. Acquired forms are much more frequent. Acquired lipodystrophy can be generalized, resembling congenital forms, or partial, as the Barraquer-Simons syndrome, with loss of fat in the upper part of the body contrasting with fat accumulation in the lower part.

There is considerable heterogeneity related to the pattern and extent of fat loss among various types of lipodystrophies. In some patients, fat is lost from small, discrete areas (localized variety); in others from the limbs (partial variety); whereas some have fat loss from nearly the entire body (generalized variety). The extent of fat loss determines the severity of metabolic and other complications.

Treatment of lipodystrophies is difficult. Lifestyle modifications may be helpful but are usually insufficient. Because reversal of the lost adipose tissue is not possible, aesthetic surgery to improve appearance and management of metabolic disorders with insulin sensitizers, insulin, and lipid-lowering drugs are the only therapeutic options. Autologous adipose tissue transplantation or implantation of dermal fillers can improve facial appearance. Unwanted excess adipose tissue from the chin, buffalo hump, and vulvar region can be surgically excised or removed by liposuction.

MULTIPLE SYMMETRIC LIPOMATOSIS (MADELUNG DISEASE OR LAUNOIS-BENSAUDE SYNDROME)

Multiple symmetric lipomatosis is a very rare lipid metabolism disorder more common in the Mediterranean population, mainly affecting middle-aged men. It is characterized by accumulation of multiple, symmetric, nonencapsulated lipomatous masses mainly in the superior part of the body. Due to the peculiar localization of fat bulges, it causes functional more than aesthetic concerns to the patients. Its etiology remains unknown and could be attributable to mutations or deletions of mitochondrial DNA with reduced activity of the cytochrome c oxidase with a decreased activity of mitochondrial respiratory chain; alcohol is a possible cofactor. It seems that the adipose masses are due to hypertrophy of embryonic residues of brown fat caused by an abnormal catecholamine-related synthesis of cAMP. Various metabolic disturbances can be associated with this condition such as insulin resistance, impaired glucose tolerance, elevated uric acid, renal tubular acidosis, alteration in the levels of liver enzymes, abnormal function of thyroid, adrenal glands, hypophysis, and testicles. Patients with multiple symmetric lipomatosis usually experience liver damage and coagulation disorders.

The current treatment of the richly vascularized lipomatous deposits is only palliative surgical ablation; the main effective therapeutic options are surgical lipectomy and/or lipoaspiration. Both options have advantages and disadvantages. Open-roof surgical resection is probably the first choice for anterior cervical fat accumulation. Limitations include high recurrence rates secondary to incomplete excision due to difficult distinction of pathologic from normal fat, hematomas, infections, lymphatic fistulas, and pathologic scarring. Despite its limited effectiveness for large masses, liposuction is a valid option because of its ease, simplicity, and low morbidity (Fig. 6). Liposuction, however, is not suitable for nonprimary excisions of fibrotic adipose tissue. Nevertheless, UAL may achieve good results. Moreover, combined lipectomy and liposuction is possible and may yield satisfactory results; preliminary SAL reduces fat volume and renders the dissection and consecutive skin resection easier. This, however, may be associated with a nonnegligible risk of skin necrosis or poor healing. Advantages and drawbacks of each of the 2 techniques should be equally considered before surgery.

INSULIN-INDUCED LIPOHYPERTROPHY AND HIV-ASSOCIATED CERVICODORSAL LIPODYSTROPHY

Lipodystrophy secondary to insulin therapy injection sites in diabetic patients is a known entity causing functional and aesthetic disorders including pain, reduction of treatment efficiency, hematomas, and edema. It is probably due to an inflammatory process characterized by lymphocytic infiltration caused by impurities present in the insulin preparations. This complication was seen in 25% to 55% of patients before the production of highly purified insulin and has currently dropped tremendously. The condition may be
effectively managed with SAL. In addition to net aesthetic improvement, significant reduction of insulin dose necessary to obtain normoglycemia and better control of pain may also be achieved.48

Cervicodorsal lipodystrophy resulting in both aesthetic and functional concerns is a well-recognized adverse effect of certain human immunodeficiency virus (HIV) medications, in particular indinavir, a protease inhibitor, well known to induce fat metabolic disorders. Although recommended cessation of associated medications may halt further progression of the deformity, abnormal fat collections do not resolve without further intervention. Numerous conservative treatment modalities have been suggested, however, none has been demonstrated to safely and effectively correct the broad changes of HIV-associated lipodystrophy.49

Contrary to prominent scarring and associated morbidity and complications of standard surgical excision, SAL is a less invasive approach that may be highly successful. However, unlike non-HIV-affected adipose tissue, the cervicodorsal fat in these patients is characteristically very fibrous in nature. The use of UAL has proven to be a helpful adjuvant for the removal of these deposits and has shown major advantages over open excision and conventional liposuction technique. Nevertheless, multiple sessions may be necessary to achieve satisfactory results.49

LIPOMA

Lipomas are the most common soft tissue benign tumors, often presenting as soft, painless, well-circumscribed mobile subcutaneous masses of mature fat cells surrounded by thin, fibrous capsules. Lipomas can vary in size from small lesions to large tumors over 15 cm in size.50,51 Most lipomas pose no diagnostic dilemmas.52 These lesions are primarily removed for cosmetic reasons. Simple surgical excision remains the main and most effective treatment, however, removal of large or multiple lesions may be problematic and result in significant objectionable scars.51,52 The role of liposuction, a less invasive treatment modality, in the treatment of lipomas or multiple lipomatosis has been reported.50,53 However, because of the fibrous nature of the capsule, liposuction has limitations; incomplete resection is frequent, possibly leading to recurrence; moreover, it does not allow histopathological analysis.52,53 It has been stressed that pulling out the capsular wall through the small liposuction incision is necessary to avoid recurrence51,53 but this does not seem to be a practical nor feasible technique in most cases. On the other hand, laser lipolysis, performed alone or before liposuction, has been reported to further facilitate removal of these lesions and can be a highly effective minimally invasive method for removal of large lipomas.51 We have successfully treated simple polylipomatosis of the upper limbs by SAL.

Liposuction has been also described in the treatment of some forms of noninfiltrating angiolipomas.54 It has been reported as well that deflation and shrinkage of relatively large adrenal myelolipomas with retroperitoneal laparoscopic liposuction can make laparoscopic en bloc tumor resection safer and easier without affecting its pathological diagnosis.55 The concept of liposuction deflation is very appealing and may potentially be extended to minimally invasive ablation for other conditions.

GYNECOMASTIA, MACROMASTIA, AND GIGANTOMASTIA

Gynecomastia is a benign, excessive development of the male breast that occurs at an overall incidence of 32% to 36%.56 The increase in breast volume may be due to glandular tissue, fat (pseudogynecomastia), or a combination of both.57,58

Current treatment combines subcutaneous fat and breast tissue excision.57 Suction-assisted lipectomy, UAL, and PAL have been used for primary treatment of gynecomastia. However, all have limitations in terms of removing rubbery and firm glandular tissues that may need to be resected under direct vision through a Webster periareolar or transareolar incision.56,57 In addition to treating excess fatty deposits, beforehand liposuction facilitates glandular resection and may also result in skin retraction for better contouring.57

It has been also proposed that the combined use of PAL or UAL with an arthroscopic cartilage shaver for the treatment of gynecomastia allows effective removal of both fat and glandular tissue through a minimal incision. This technique can achieve excellent aesthetic results with inconspicuous scarring.56,59 Liposuction in

**FIGURE 6.** A, Patient with Madelung disease. B, Shoulder lipomatous mass corrected with liposuction.
combination with vacuum-assisted biopsy device (mammotome) has been also reported and may provide the same outcome. As for female macromastia and gigantomastia frequently associated with significant symptoms such as neck and back pain, growing of the shoulders from bras straps, and inframammary fold irritation and dermatitis, the standard treatment is surgical breast resection. Liposuction combined with traditional resection mammaplasty has been exploited for many years, allowing volume reduction before excision in addition to refining the results after excision as popularized by Lejour.

Although adequate volume reduction can be obtained by breast liposuction alone, it has remained controversial ever since its first introduction and has failed to gain widespread acceptance. Despite the technical possibility of removing large volumes with liposuction, essential reshaping of the breast in most cases is not possible without excisional surgery. Aesthetic results are always inferior to those of traditional resection techniques. Liposuction alone has significantly fewer complications than traditional incisional approaches and results in less scarring. In addition to the short down period, patients maintain nipple sensation and the ability to breastfeed. It may be primarily indicated for patients requesting bulk reduction without aesthetic concerns provided they realize the limitations of the technique.

Widespread controversy still exists regarding the benefits and limitations of liposuction in a cancer-prone organ such as the breast with particular concerns about potential spread of cancer cells. Surprisingly, the same concerns are not expressed regarding the multitude of described surgical mammaplasty techniques. Available data, although limited, suggest that liposuction-only breast reduction is oncologically safe. Increased glandular density essentially without internal calcification has been demonstrated by mammography, which is apparently significantly easier to interpret than after traditional surgical reduction.

MELKERSSON-ROSENTHAL SYNDROME

Melkersson-Rosenthal syndrome (MRS) is a rare granulomatous disease characterized by a triad, including orofacial swelling, facial palsy, and lingua plicata with mostly recurrent or progressive course. Correction of orofacial swelling, the most common sign of MRS, is aimed primarily at symptomatic relief of discomfort. Despite the myriad of nonsurgical therapies available for the treatment of MRS, none has proved uniformly and predictably successful to date. Surgical management of MRS has often yielded disappointing results. It is suitable only in severe disfigurement or when the orofacial swelling has become permanent. To achieve facial symmetry, subcutaneous fat hypertrophy can be reduced by SAL. Acceptable results may be achieved in combination with mucosa, submucosa, and tangential muscle resection, as well as crescent shaped commissuroplasty whenever indicated.

DERCUM DISEASE

Dercum disease, also known as Morbus Dercum, adiposis dolorosa, adiposagia, lipomatosis dolorosa, and adipose tissue rheumatism is a rare condition of unknown etiology characterized primarily by generalized overweight or obesity and pronounced (>3 months), symmetrical, often disabling pain in the adipose tissue resistant to traditional analgesics, associated with several systemic and psychologic symptoms. The extremities, trunk, pelvic area, and buttocks are the common locations of painful fat deposits. Only few convincing large studies on the treatment of Dercum disease have been conducted. Surgical lipectomy has been described and found to be only temporarily effective in relieving pain. In contrast, SAL could be considered a valid treatment option. It is more effective and may alleviate pain for at least 5 years, although pain relief tends to diminish over time. The clinical significance of this improvement and whether pain alleviation after liposuction is attributed to the actual procedure or to other factors remain controversial.

Nevertheless, with careful monitoring, the procedure is safe even for patients with advanced stages, old age, and with comorbidities.

LYMPHANGIOMA AND CYSTIC LYMPHANGIOMA

Lymphangiomas are fibrolipomatous lesions containing dense fibrous connective tissue with abundant lymphatic and vascular components. Several techniques have been proposed for the treatment of these lesions, such as cryotherapy, sclerotherapy, and radiotherapy.
Although en bock surgical excision is the best choice of treatment, debulking by liposuction may be highly effective in certain cases. Treatment of specific lymphangioma forms such as lymphangioma circumscriptum with SAL has also been described and could be the best modality to resect selectively the deep cisterns associated with this type of malformation.

Cystic lymphangioma is a congenital benign malformation occurring most frequently in the necks of infants and young children. The lesion can extend deep into the tissues, making surgical treatment and complete excision often difficult. Combining liposuction, which aimed to rupture the cystic walls, to established treatments like OK-432 (penicillin-killed Streptococcus pyogenes) sclerotherapy, mainly in polycystic lymphangiomas, is thought to be very useful. Other sclerotherapy agents may also be used but none have so far been reported in combination with liposuction.

**LIMB GIGANTISM AND MACRODACYLY**

Excessive overgrowth of the fibroadipose tissue with unusually large fatty lobules fixed by a mesh of dense fibrous tissue is a

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**FIGURE 7.** Patient with lipodystrophy and multiple lipomatosis of the left lower extremity. Magnetic resonance imaging demonstrating subcutaneous fatty tissue thickening with diffuse muscular involvement. Only partial contour improvement could be achieved by aspirating 1400 from the subcutaneous tissue. Multiple large well-encapsulated lipomas were aspirated then remaining capsules as well as other small lipomas were excised through a small skin incision. Postoperative figures not available.
usual finding in limb gigantism of various syndromes or conditions such as macrodystrophia lipomatosa or fibrolipomatous hamartoma, a rare congenital disorder characterized by an abnormal overgrowth of the mesenchymal elements resulting in hamartomatous enlargement of the soft tissues, leading to localized or generalized gigantism of a limb. Although exact diagnosis of unilateral limb soft tissue enlargement in newborns may be often unclear, surgical treatment is indicated depending upon patient’s symptoms, age, and extent and severity of the deformity and must be designed to reduce the length, width, and height of the affected limb. En bock resection, whenever indicated, is the standard procedure for soft tissue debulking. Liposuction probably produces equivalent outcome with less complications and minimal scarring. We have successfully treated hereditary hypertrophy of the leg in children and congenital hemihypertrophy in adults by liposuction (Figs. 7 and 8).

**SCAR REVISION**

Hypertrophic scars are certainly disfiguring, however, they may also be the source for itching and pain. To date, there is no surgical or nonsurgical effective scar treatment modality. Regardless, scar revision or reduction in scar surface area can have both an aesthetic and functional outcome. Invariably, recruitment and mobilization of surrounding normal skin is required. If not enough skin is available for safe wound closure with minimal tension, scar revision may be performed in stages or tissue expansion may be indicated.

For hypertrophic scars at sites rich in subcutaneous fat such as trunk and thigh for which simple excision and closure is not feasible, scar revision could be performed in 1 stage aided by easy, safe, effective, and economic liposuction. Instead of standard undermining of skin flaps, SAL achieves discontinuous undermining similar to what has been described for lipoabdominoplasty, creating mobile sliding flaps that can be easily approximated with minimal suture line tension while maintaining vascular perforators and preserving flap perfusion. Liposuction achieves additional reverse tissue expansion by deflation; by complete aspiration of underlying subcutaneous fat, facilitating excision of the scar proper while minimizing bleeding (Fig. 9). Liposuction sliding flaps provide skin of similar texture and color to the defect area without the need for labor-intensive, time-consuming, and expensive tissue expansion. It minimizes also dead space that invariably results after wide standard surgical undermining. However, the indications of liposuction-assisted scar revision are strict. Only sites with subcutaneous fat accumulation or patients with high body mass index are suitable for this technique. In addition, the size of scar that can be revised with liposuction sliding flaps in 1 stage is finite. When scars are too large to be reconstructed in 1 stage, other procedures should be combined.

Liposuction is also useful to correct the appearance of retracted scars seen after laparotomy or cesarean section. Bilaterally bulging tissues may be simply reduced by SAL and tight adherences underneath the scar may be released using a forked cannula to achieve a flat and more uniform contour. We have reported release of severe neck contracture with a large full-thickness skin graft harvested with the aid of reverse tissue expansion by liposuction deflation and primary closure of the donor site.

**FLAP MOBILIZATION FOR SINGLE-STAGE CLOSURE AFTER WIDE EXCISION OF SKIN LESIONS**

The repair of skin defects resulting from the excision of large skin disorders is always challenging. Although primary linear closure is mostly favored, undermining of defect edges does not completely eliminate wound tension, which consequently results in a linear but wide and hypertrophic scar. Other options such as skin grafts and local or distant flaps are not without major drawbacks and complications. Similar to what has been described for scar revision, liposuction sliding flaps may overcome these problems; thus for a variety of skin lesions located at sites rich in subcutaneous fat, surgical excision in combination with liposuction may be easily effected without high wound tension and donor-site morbidity. Elevation and mobilization of cutaneous transposition flaps by blunt liposuction cannula dissection may also be performed easily without

![FIGURE 8. A, Unilateral congenital lower limb gigantism. B, Soft tissue hypertrophy is adequately managed with liposuction.](image-url)
jeopardizing flap vascularity. If indications are correctly selected, the technique is easy, safe, effective, and economic.

**CONTOUR REFINEMENT OF FLAPS**

Musculocutaneous and fasciocutaneous flap reconstruction of a variety of defects, free or pedicled, has become a standard technique associated with an excellent success rate. However, harvested flaps are generally oversized to provide ample tissue for reconstruction. Although successful reconstruction remains the primary goal, after convalescence and functional recovery, a bulky flap appearance is one of the major patient complaints becoming increasingly important with regard to quality of life. Flap revision and contouring to fit adequately over certain anatomical areas such as the foot, ankle, and pretibial area or even the breasts and the face greatly improves functional results.

Recommended serial multiple debulking procedures with staged excision require a long time before an adequately thinned flap is achieved and may result in vascular pedicle injury. Although this possibility of vascular compromise dictates caution particularly with respect to free flaps, late recontouring of bulky cutaneous flaps by liposuction is now an established and well-accepted method; it allows thinning the subcutaneous tissue usually without the risk of flap necrosis and reduces the number of revision procedures required to achieve optimal aesthetic and functional results. Appropriate timing for debulking and flap refinement requires, however, a delay period. Although the ideal timing usually is directed by the patients as they regain function, several weeks are needed before considering flap contouring to achieve optimal outcomes.

for the edema and inflammation to subside before proper evaluation of flap size becomes possible.\textsuperscript{6,100,104}

Standard SAL has been performed on cutaneous flaps for many years. Suction-assisted liposuction or PAL procedures are safe and simple; they may be combined with skin excision whenever required to improve appearance and function.\textsuperscript{5,103} To enhance fibrous fat fragmentation, UAL can be performed in addition to flap advancement and excision if necessary.\textsuperscript{103} Interestingly, flap prefabrication by thinning may also be performed before transfer without affecting flap survival. Ultrasound-assisted liposuction has been described for the thinning of abdominal flaps elevated to cover finger avulsion stumps achieving, as claimed, good functional range of motion of the interphalangeal joints.\textsuperscript{105}

**EXTRACTION OF PERMANENT FILLERS**

Injection, capsule formation, and migration are the most common complications of injectable permanent fillers used for enhancement of contour or correction of deformities.\textsuperscript{106} For all these complications, a direct surgical approach with strict aseptic technique is primarily indicated.\textsuperscript{106} Direct surgical excision, however, can be demanding and results in unacceptable scarring. Liposuction can be a safe and effective alternative.\textsuperscript{106} Liposuction has also been reported in the successful management of a case involving chronic infection from contaminated Vicryl sutures.\textsuperscript{7}

**EXTRAVASATION INJURIES**

Extravasation injury is a common complication of neonatal intensive care and can result in serious cosmetic and functional sequelae.\textsuperscript{107} Many agents when extravasated during intravenous administration can result in severe necrosis of the skin and subcutaneous tissue. The mechanism of damage is thought to include direct cellular toxicity of the drug, vasoconstriction, and extrinsic mechanical compression of large extravasated volumes producing ischemic damage. However, hyperosmotic edema and local electrolyte imbalance with subsequent ischemia are considered to be the major factors inducing tissue damage.\textsuperscript{108–110,111}

Local swelling, erythema, blistering, and pain are the initial symptoms. Unfortunately, true extent of the injury is usually difficult to determine from these superficial signs. Moreover, progressive tissue necrosis may continue up to 3 weeks after the initial injury.\textsuperscript{109,110} In most cases, tissue necrosis is initially underestimated.\textsuperscript{109} Early diagnosis is critical and immediate management includes stopping the infusion with possible injection of specific antidotes for some agents. Subcutaneous irrigation with saline (with or without hyaluronidase) has been recommended;\textsuperscript{107,109}; this, however, may lead to further fluid increase in tissue pressure and ischemia. In contradistinction, early emergency subcutaneous “wash-out” with subsequent liposuction has been claimed to be the treatment of choice to minimize tissue injury and avoid extensive necrosis.\textsuperscript{108,110}

**LIPOSUCTION FOR TRACHEOSTOMY, COLOSTOMY, AND UROSTOMY**

Suction-assisted liposuction has been reported for the treatment of patients with severe obstructive sleep apnea who require tracheostomy.\textsuperscript{13} Such morbidly obese patients frequently have their tracheostomies occluded by excess fatty tissues in the neck and submentum area. Suction-assisted liposuction can be performed as a second procedure or simultaneously with tracheostomy. The procedure is rapid and effective and can be performed with little morbidity.\textsuperscript{13}

Similarly, in selected patients, leakage of colostomies and urinary stomas may be successfully managed with simple syringe-assisted liposuction above or around the stoma under local anesthesia.\textsuperscript{112–114}

**SUPERFICIALIZATION OF ARTERIOVENOUS ACCESSSES FOR HEMODIALYSIS**

The number of obese end-stage renal disease patients, who frequently have type 2 diabetes, is continuously increasing. This group of patients has an increased risk of arteriovenous fistula (AVF) failure due to advanced arteriosclerosis but mostly due to reduced accessibility of forearm vessels because of excessive overlying fat tissue that causes miscanulation and needing difficulties resulting in local infiltration, infection, and aneurysmatic vein dilatation.\textsuperscript{115,116} Superficial AVF is necessary for successful dialysis access. Surgical techniques, using vein elevation/stretching/transposition and repositioning are indicated for deeply located or tortuous veins. Alternative techniques such as lipoectomy are useful to solve cannulation inability in obese patients.\textsuperscript{115,116} Surgical excision of the fat pad overlying deeply located forearm veins at the time of AVF construction has been shown to be a safe, effective, and durable approach.\textsuperscript{117,118} Liposuction may also be performed as a secondary revision procedure whenever required. However, AVF superficialization with a standard surgical procedure necessitates a large incision and requires an extended healing time before the fistula may be accessed. Suction-assisted lipoectomy may be an alternative technique to remove excess fat through limited incisions. Ultrasound guidance is, however, necessary to reduce the risk of fistula injury.\textsuperscript{118} Alternatively, an endoscopic vein-harvesting device may be used to shield the vein and the fistula during liposuction.\textsuperscript{119}

**GENITAL AREA AND SEXUAL DYSFUNCTION**

Obesity and massive weight loss are not infrequently associated with genital area problems and sexual dysfunction. Weight gain causes significant alternations in the appearance of both male and female genitalia with large fat deposition in the pubic areas along with ptosis of the fat pad and skin. These deformities often persist despite weight loss.\textsuperscript{120} In obese men, while standing, the pubic fat and ptotic skin commonly obscure all or part of the penis, decreasing its visible length and the partially visible penis may become completely burried as the patient bends or sits.\textsuperscript{120} This condition is named “buried,” “hidden,” or “concealed” penis and invariably results in serious secondary sexual dysfunction, hygiene issues, discomfort, and aesthetic concerns.\textsuperscript{120,121} In the female obese patients, ptotic skin and fat of the mons pubis is usually combined with fatty infiltration of the labia majora and subsequent ptosis of the anterior labial commissure. Poor hygiene with difficulty in wearing clothes and in sexual intercourse may result.\textsuperscript{120}

Removing excess suprapubic fat is one of the suggested surgical options for penile lengthening.\textsuperscript{123} Although liposuction may not be the ideal lipoectomy procedure in certain pathologic conditions requiring pubic and penoscrotal tacking or sectioning of the tethering dartos bands that are all better achieved with open lipoectomy, suction lipoectomy of the suprapubic area particularly in obese adults can invariably increase the visible length of the penis.\textsuperscript{120,121} In the female patient, liposuction of the mons pubis may be all that is necessary, but skin excision and tacking may be indicated if the patient has significant mons ptosis. Additional labia majora reduction is usually performed only if the patient complains of excessive size.\textsuperscript{120}

**AXILLARY LYMPHADENECTOMY—SUZANNE PROCEDURE**

Axillary lymphadenectomy is a standard oncological technique for the management of breast cancer; however, it may be associated with significant morbidity. Minimally invasive techniques have been applied to a growing number of surgical procedures
now including exploration of the axilla. To reduce postsurgical morbidity, a new technique combining liposuction and endoscopic dissection for axillary lymphadenectomy in breast cancer has been described. Liposuction seems to facilitate a better anatomical dissection and a better preservation of the nervous and vascular structures without altering the pathological features of the lymph nodes. It may result also in a lower incidence of seroma formation in obese patients and in patients undergoing radical mastectomy. It probably reduces the incidence of limb edema as well. The cosmetic result is also certainly better than after conventional axillary clearance.

More recently, experimental studies have demonstrated that lymph node identification and precise dissection in pelvic laparoscopic lymphadenectomy could be facilitated by UAL particularly in obese subjects. It has been suggested that UAL may strengthen the value of laparoscopic cancer staging, especially in obese patients. It may offer a precision of dissection that could rival the expectations for robotically performed oncologic surgery. Ultrasound-assisted liposuction does not seem to damage lymph node architecture; however, dissemination of neoplastic cells remains an unanswered question and needs further investigation.

AXILLARY HYPERHIDROSIS AND OSMIDROSIS (BROMhidrosis)

Hyperhidrosis is excessive sweating due to overstimulation of eccrine glands. Osmidrosis, malodorous sweating due to interaction of apocrine secretions with microorganisms in the axilla, often associated with hyperhidrosis, is primarily due to an abnormal increase of apocrine sweat glands both in quantity and secretory activity. Axillary hyperhidrosis and osmidrosis result in distressing social problems to the affected patients.

So far, results of conservative measures used such as antibacterial soap, topical antiperspirants, deodorants and perfumes, physical therapy iontophoresis, and anticholinergic agents seem to be disappointing; botulinum A toxin injections, on the other hand, need to be repeated frequently. Complete removal and destruction of the axillary sweat glands is needed for cure. However, surgical axillary skin excision, undermining and/or skin reconstruction may cause secondary functional and cosmetic problems and are associated with high morbidities and many complications and might result in obvious surgical scars.

Subdermal suction with curettage has been proposed as a safe, effective, minimally invasive procedure, and a valid alternative for axillary hyperhidrosis and osmidrosis treatment. It produces a longer lasting effect than botulinum A toxin and may have lower complication rates than surgical skin undermining and excision. It is worth mentioning that simple SAL alone is not adequate as it may not be highly effective in eliminating the sweat glands tightly attached to the dermis in the dermo-subcutaneous junction. Moreover, liposuction with curettage is still controversial with a reported high rate of residual malodor and dissatisfaction. To overcome this deficiency, several modifications have been proposed. After completing the aspiration of deep subcutaneous adipose tissue along with sweat glands in this layer, subcutaneous pruning with scissors to remove the residual apocrine sweat glands located superficially may be performed until the skin flap thickness approximates that of a full-thickness skin graft. This technique has been reported to result in a high satisfactory rate for malodor elimination and a low complications rate. Alternatively, a combined approach using liposuction and subcutaneous tissue shaving with a cartilage shaver has been reported to be highly successful.

Ultrasound-assisted liposuction in the very superficial plane is another proposed modification and is claimed to have a high success rate with rapid recovery and minimal complications. Skin burns remain, however, a feared complication with this technique.

CONCLUSIONS

Previously, liposuction was seen as a “cosmetic” procedure with no real therapeutic value. At present, the term “liposuction” needs to be demystified and redefined. In fact, liposuction has evolved to define a specific technique that could be advantageously used in greatly diverse pathologies and conditions for treatment. Although some of the described indications of the various liposuction technologies are still not completely validated and standardized, they undoubtedly open new horizons for liposuction far from its original aesthetic indication.

Liposuction nowadays can be equated to “closed surgical de-bulking,” a reconstructive therapeutic procedure or an adjunct facilitating other indicated procedures. Implications of this new definition should induce third-party public payers and insurance companies to reconsider their remuneration and reimbursement policies.

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