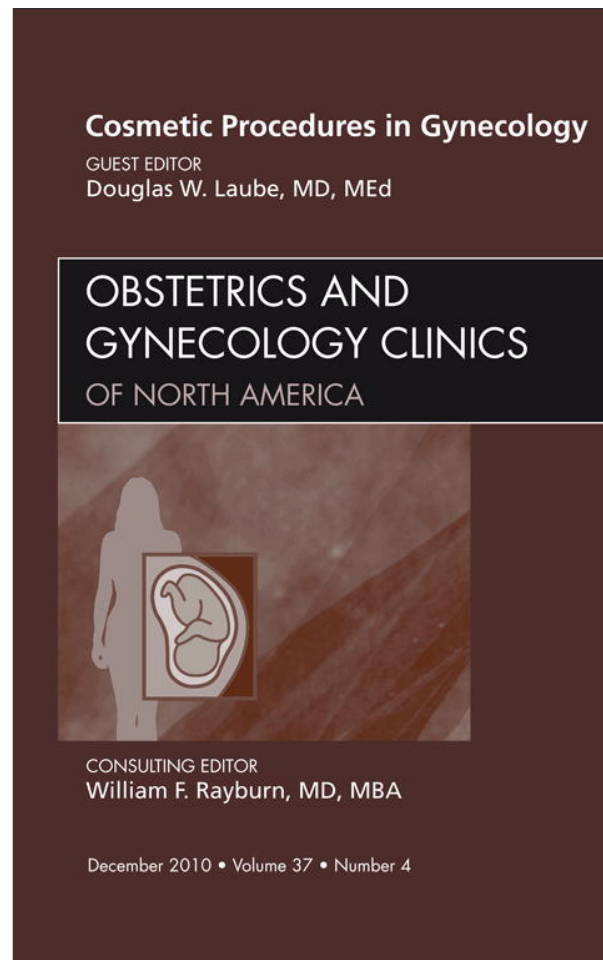


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Liposuction

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KEYWORDS

- Liposuction • Lipoplasty • Suction lipectomy • Aesthetic
- Cosmetic • Body contouring

LIPOSUCTION

The surgical removal of subcutaneous fat using a blunt cannula attached to a suction device is termed *liposuction*. Synonymous terms include *suction lipectomy* and *suction-assisted lipectomy* (SAL). *Lipoplasty*, a broader term, defines any procedure that alters the contours of subcutaneous fat deposits through either removal or addition of fat (liposuction and autologous fat transfer are both examples of lipoplasty). *Lipolysis* reflects the direct ablation of adipocytes using any method.

Liposuction is the most commonly performed cosmetic surgical procedure worldwide. Among North American women, it is second only to breast augmentation in popularity.¹ Currently, indications for liposuction are purely cosmetic, with this procedure having no apparent medical benefit. Frequently treated areas include the torso, extremities, and submandibular regions.

HISTORY

Liposuction evolved from blind sharp excisional procedures. In 1929, Charles Dujarrier, a French surgeon attempted the first contouring procedure of the inner thigh fat deposits, introducing a sharp curette subcutaneously through a small skin incision.² Tragically, hemorrhage ensued and the case ended with amputation. Although blinded sharp excisional procedures were revisited several times in subsequent decades with various devices, they were abandoned uniformly because of bleeding-related complications. Giorgio Fischer, an Italian gynecologist, introduced suction as an adjunct to sharp curettage in the mid-1970s.³

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Ives Gerard Illouz of France introduced the first technique of modern liposuction in the late 1970s.⁴ Unlike his predecessors, Illouz used blunt suction cannulae and high-powered suction to dislodge and remove subcutaneous fat. The technique used 10-mm cannulae and general endotracheal anesthesia. However, it was associated with significant blood loss, which became the limiting factor in the extent of surgery performed. The technique was later termed *dry liposuction*, reflecting the fact that no fluids were injected into the targeted fat layers before suctioning. Subsequent modifications to the technique included the instillation of a small volume of saline, with or without hyaluronidase, into the fat layer as a lubricant to facilitate cannula motion; this became known as *wet liposuction*. Pierre Fournier, a surgeon trained by Illouz, introduced syringe liposuction and syringe transplantation of the extracted fat. He coined the term *liposculpture* to describe his system.⁵ Further refinement of the wet liposuction technique, introduced by Gregory Hetter of Las Vegas in the early 1980s, involved the addition of epinephrine as a vasoconstrictor to the wetting solution.⁶

The mid-1980s marked the modern era of hemostatic liposuction techniques. Central to these methods was the instillation of larger volumes of fluid with epinephrine into the targeted fat layers. Jeffrey Klein, an American dermatologist, introduced a purely local anesthesia technique termed *tumescent liposuction* in 1985.⁷ Klein's technique used lidocaine in larger volumes and higher total doses, and smaller caliber cannulae than were used previously, and continues to have the best safety profile of any method of liposuction surgery. Superwet liposuction, also introduced in the mid-1980s, is a technique using general or regional anesthesia in conjunction with lower volumes and concentrations of lidocaine solution than tumescent liposuction. It displays excellent hemostasis and a degree of postoperative analgesia, but carries the risks associated with general or regional anesthesia.

Patient Selection and Assessment

The best candidates for liposuction are physically fit, weight stable, and nonobese, displaying localized adiposity and minimal skin laxity (**Figs. 1** and **2**). They should be classified as ASA1 or ASA2 according to the American Society of Anesthesiologists Physical Status classification system. The tolerance for morbidity is much lower for cosmetic surgery than for therapeutic procedures. Surgeons must keep in mind that

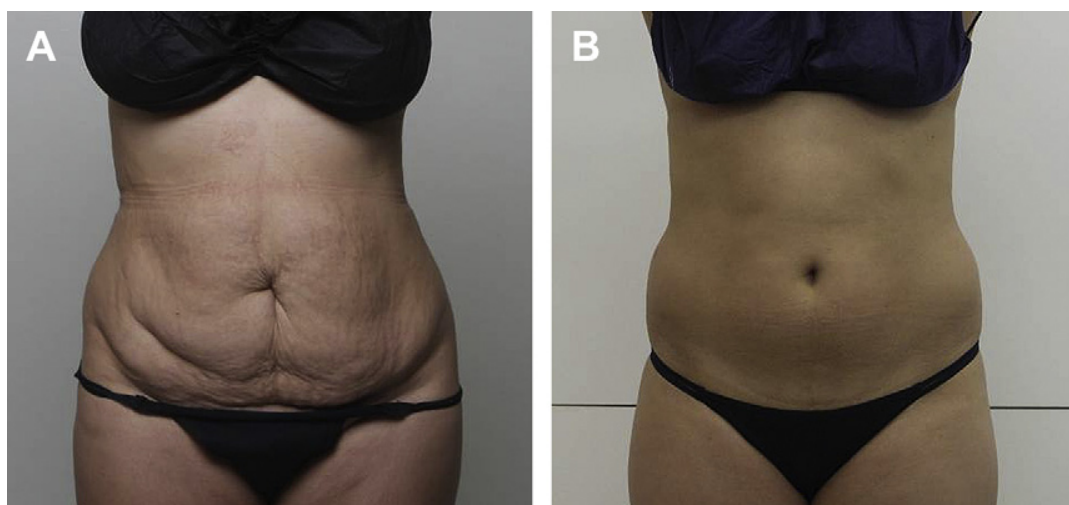


Fig. 1. (A) Patient displaying severe skin laxity, wrinkling, and striae; a poor liposuction candidate. (B) Patient displaying localized abdomen and flanks adiposity with excellent skin tone; an appropriate liposuction candidate.

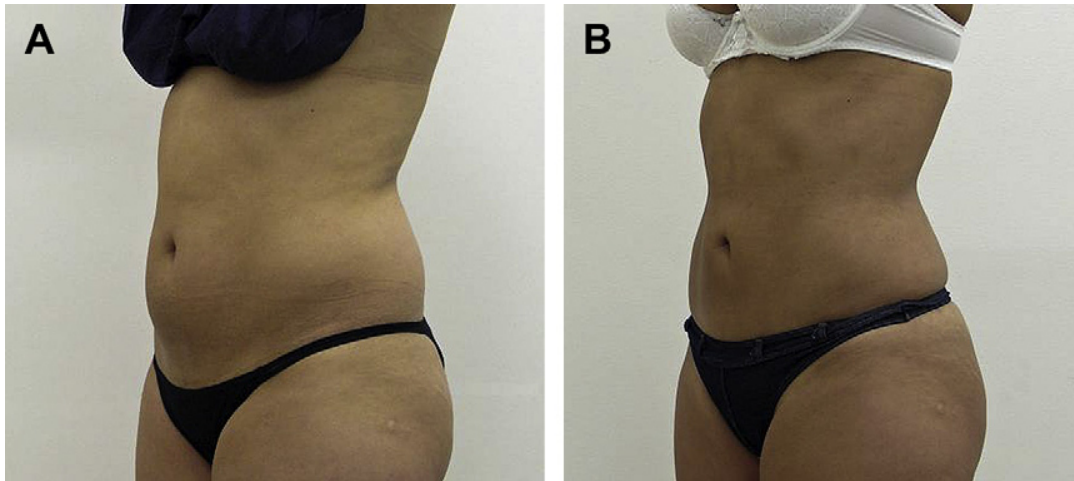


Fig. 2. (A) Patient before and (B) 9 weeks after liposuction of the abdomen and flanks.

the financial burden of any unplanned medical intervention arising from a cosmetic operation typically is not covered by conventional medical insurance. Patients in suboptimal health and those requiring intense perioperative surveillance are not good prospects for this type of surgery.

The localized adiposity to be addressed with surgery should be assessed with the patient standing alongside the surgeon before a full-length mirror, with all relevant areas exposed to allow the patient to explain the cosmetic concerns with precision. Because subcutaneous fat is relatively mobile, the supine position will often yield an inaccurate assessment. Surgeons must point out to patients that cellulite, stretch marks, and significant skin laxity will not be improved with liposuction. Photography is helpful in helping patients view their bodies from multiple perspectives and in defining and explaining the treatment options. Markings are useful in defining the boundaries of proposed treatments and calling attention to preexisting untargeted contour irregularities at both consultation and surgery (**Fig. 3**).

A complete documented medical evaluation should precede any surgery in patients who have not had a recent examination. Any anatomic distortion (eg, hernias) that has the potential to increase the risk for injury should be assessed and managed appropriately before surgery. Blood work analyses include testing for signs of infection,



Fig. 3. Markings made in the standing position define the boundaries of proposed treatments and indicate preexisting and untargeted contour irregularities.

anemia, coagulopathy, and liver disease. Pregnancy testing is performed or repeated on the day of surgery irrespective of history. If the physician performing the medical evaluation is not the surgeon and is unfamiliar with liposuction, basic relevant details of the planned anesthetic agents and surgical interventions should be provided along with the request for medical clearance.

Medications, supplements, herbs, and other substances that can impair coagulation should be discontinued before surgery. Substances that interact negatively with anesthetic agents and perioperative medications should also be withheld. If they cannot be discontinued or substituted, the surgical plan will need to be modified, delayed, or withheld. Cigarette smoking is not a contraindication to liposuction, but smokers typically display an atrophic dermis and less skin elasticity, which increase the likelihood of postoperative skin wrinkling.

Expectations and motivations must be explored in depth with cosmetic patients. Unrealistic expectations will never be fulfilled by surgery even if executed to perfection by any medical or aesthetic standard. The cosmetic surgery “addict,” the “perfectionist,” and the patient expecting cosmetic surgery to remedy interpersonal conflicts are examples of misguided personality types that should be screened out at initial consultation. Similarly, patients seeking weight loss are best served through dietary counseling, the implementation of an appropriate exercise program, and, if necessary, bariatric surgery. Liposuction does not generate long-lasting results or significant weight loss in the presence of poor eating habits and physical inactivity.

ANESTHESIA

Liposuction may be performed with local anesthesia with or without sedation, with epidural anesthesia, or with general anesthesia. Each modality has its advantages, disadvantages, inherent risks, and suitability for the unique demands of each operation and patient. In the United States, most liposuction cases use lidocaine-based instillations into the targeted fat layers as the sole anesthetic (tumescent liposuction) or as an adjunct to general anesthesia (superwet liposuction). In Central and South America, the superwet technique is frequently performed with epidural anesthesia. Regardless of technique, the surgical team should be knowledgeable and prepared, and the facility should be equipped to manage all potential adverse drug effects.

Tumescent local anesthesia, as introduced by Klein and as most commonly prepared, consists of lidocaine hydrochloride, sodium bicarbonate, and epinephrine diluted in normal saline. The target concentration of lidocaine varies depending on the expected sensitivity of the surgical site, but varies little among patients. The target volume of tumescent anesthesia at the surgical site is neither a fixed number nor a fixed ratio of fluid to estimated fat volume; it is determined by the achievement of palpable tumescence (uniform swelling) of the field, which is determined, in turn, by the elasticity, density, and size of the targeted fat deposit. The maximum safe dose of tumescent local anesthesia is based on the amount of lidocaine administered. Most surgeons consider a lidocaine dose of 50 mg/kg to be the toxicity threshold for tumescent anesthesia for liposuction. Lidocaine administered in this fashion displays a peak serum level 12 hours postinfiltration, and complete elimination by 36 hours postinfiltration; it is metabolized through the liver primarily through the cytochrome p450 system.⁸

Superwet liposuction uses an instillation of the same ingredients as tumescent local anesthesia, albeit at a much lower concentration of lidocaine and a much lower volume, because the surgical anesthesia is conducted using general or epidural modalities. The purpose of superwet infiltration of the targeted fat layers is primarily

the hemostasis generated by the epinephrine in the solution, and secondarily the post-operative analgesia produced by the lidocaine. In some instances, no lidocaine is used in the solution.

Both tumescent and superwet liposuction operations begin with the instillation of their respective solutions into the layers of the targeted fat deposit through needle infiltration (**Fig. 4**). The needle may be either a disposable sharp spinal-type needle or a reusable blunt-tipped infusion needle with apertures along the shaft. The infiltration needle may be connected to either a syringe or a pressurized infusion pump system through tubing. The fluid is delivered with a steady fanning motion in horizontal planes, commencing in the deep fat layers and progressing superficially. Because the needle is in constant motion, there is no need to watch for a flashback of blood into the tubing or syringe.

ANATOMY

Subdermal fat throughout the trunk and extremities exists in compartments within a connective tissue matrix termed the superficial fascial system (SFS) that extends from the subdermis to the muscle fascia.⁹ The SFS consists of horizontal sheets of membranous connective tissue connected by vertical and oblique septa. Scarpa's fascia of the lower abdomen is an example of a well-defined horizontal sheet of the SFS. In other areas these sheets may be multiple and less distinct. As adiposity increases, the layers of fat within the SFS increase in thickness.¹⁰

Within each layer, adipose tissue is organized into large visible subunits of varying size, termed *fat pearls*. Fat pearls are composed of smaller ovoid subunits with a pasty consistency known as *fat lobules* and typically are not visible individually without magnification. Fat lobules consist of clusters of adipocytes and are supplied with capillaries and sometimes nerves.¹¹ Microscopic sections of fat tissue show fibroblast-like preadipocytes, mature adipocytes, and adult stem cells; the latter have the capacity to form muscle and bone.¹²

Techniques

Basic techniques of modern liposuction use steel blunt suction cannulas of diameters ranging from 1 to 10 mm (**Fig. 5**). Cannulas 2 mm or narrower are termed *microcannulae*. Cannulas larger than 5 mm are not commonly used when using purely local anesthesia. Narrower cannulas offer more control, whereas wider cannulas offer faster

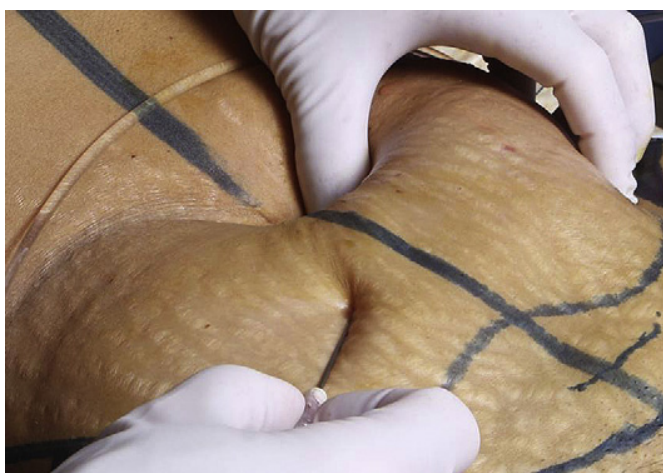


Fig. 4. Infiltration of tumescent anesthesia into the subcutaneous fat performed using a spinal needle.

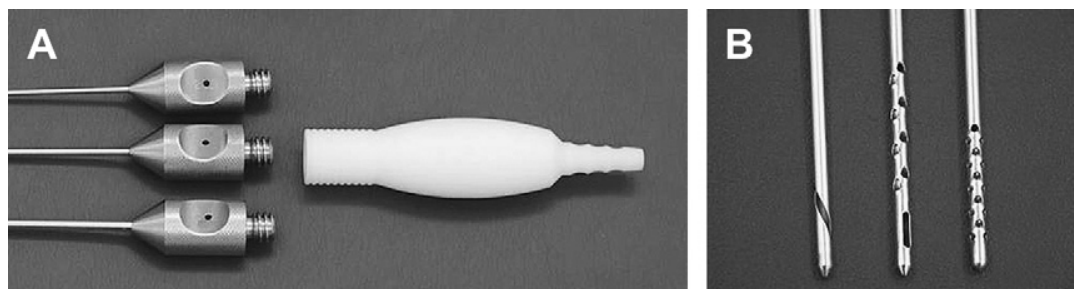


Fig. 5. (A) Vented liposuction cannulae of various diameters and a detachable Teflon handle. (B) Examples of cannula tip and hole patterns.

extraction. Other design variables include tip configuration, aperture configuration, shaft length, and handle design. Handles may be either fused or detachable and may possess a vacuum vent.

Cannulae are designed to be connected to either suction tubing or syringes. Suction tubing is connected to an aspiration pump, which typically is set to operate at a maximum vacuum pressure of -100 kPa (-750 mm Hg). The pressure is greater than that created by conventional operating room general suction devices, and requires semirigid tubing to resist collapse. When syringes are used, various piston locking mechanisms may be used to minimize hand fatigue.

Small skin incisions serve as entry ports for liposuction cannulae. These incisions are most commonly made with either skin punches or a scalpel and whenever possible are hidden within bikini lines, skin folds, scars, or tattoos (**Fig. 6**). Skin punch incisions are preferred when surgeons want the sites to remain open for postoperative drainage.

The process of liposuction necessitates a back and forth motion of the cannula as suction simultaneously holds fat tissue in the lateral apertures of the cannula shaft. This action results in the avulsion of small parcels of fat from its connective tissue attachments, creating tunnels through this matrix along the paths taken by the instrument. Tunneling creates narrow channels devoid of fat that collapse under the weight of the overlying tissue and is the mechanism through which contouring is achieved. The process typically does not damage blood vessels and nerves because they offer greater resistance to avulsion and because the cannula apertures do not have sharpened edges. The combination of fat and fluid removed as a result of this process is

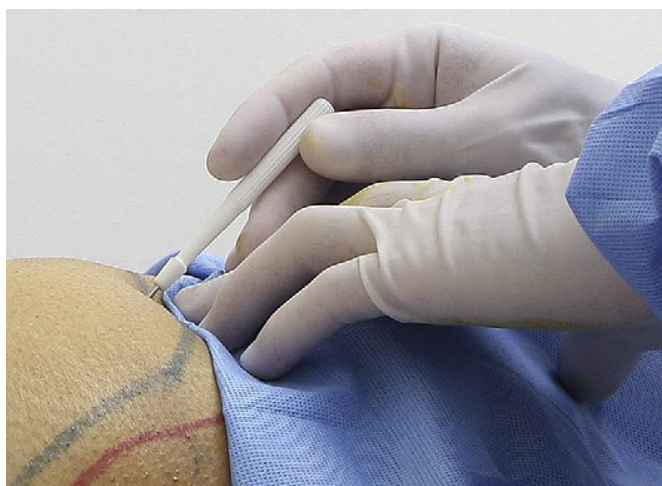


Fig. 6. Access incisions made with small skin punches remain patent for several days, facilitating passive drainage of tissue fluids and minimizing edema.

termed the *lipoaspirate*, and over time it can be observed in the collection canister to separate into a yellow supernatant fat layer and a blood-tinged infranatant fluid layer (**Fig. 7**). When the back and forth cannula action is generated exclusively by the motion of the surgeon's hand, the process is called *manual liposuction*. When the cannula action is generated by a motorized handle, the process is known as *power-assisted liposuction* (PAL).

Control over the direction of the liposuction cannula is the cornerstone of both safety and an adequate cosmetic result. The nondominant hand plays a central role in this process through continuously confirming depth and direction, and detecting and protecting vital local anatomy. Under most circumstances, the motion of the cannula is parallel to the underlying muscle fascia and the process proceeds in horizontal planes starting in the deeper fat layers (**Fig. 8**).

The end point of the liposuction process is variable and determined by a combination of the patient's wishes, the nature of the skin and fat layers, underlying musculo-skeletal architecture, and the need to develop symmetry. For example, when treating the inner or outer thigh fat deposits, a relatively large amount of fat intentionally is left behind to preserve the characteristic female contours, whereas when treating the abdomen, very little fat is preserved to enhance the definition of muscle lines. Total extirpation of the subcutaneous fat is never the goal of the procedure, and if pursued is likely to produce irreversible and unsightly injury to the overlying skin. It is prudent to leave the first 5 mm of superficial subdermal fat intact as a way to protect the delicate subdermal vascular plexus and minimize the risk of dermal trauma, which most frequently manifests as skin wrinkling. At surgery, the thickness of the subcutaneous fat layers is determined by pinching them between the fingertips as the fat deposits are gradually debulked.

The upper limit of fat volume that may safely be removed in a single liposuction session has not yet been defined by science, but in some instances has been constrained by law. For example, in California, extracting more than 5000 mL total aspirate volume per procedure outside of an acute care hospital is deemed unprofessional (SB 450 Speier Bill, adopted August 31, 1999), and in Florida, exceeding 4000 mL total fat aspirate volume in tumescent liposuction procedures is prohibited in an office surgical facility (64B89-9.009, Standard of Care for Office



Fig. 7. The lipoaspirate separates into a supernatant layer of fat and an infranatant layer of blood-tinged fluid.



Fig. 8. Control of the liposuction cannula is achieved with the nondominant hand, which defines depth, direction and the boundaries of local anatomy. Cannula motion is parallel to the underlying muscle fascia.

Surgery, adopted February 17, 2000). In practical terms, purely tumescent liposuction is limited inherently by lidocaine dosing constraints. Nonetheless, it would be difficult to assert that the removal of a fixed volume of fat produces the same degree of surgical trauma in people of vastly different size and whether removed from a single area or multiple sites.

Perioperative Care

Because liposuction involves extensive manipulation of skin structures, broad-spectrum antibiotic prophylaxis targeting common skin pathogens is used either orally or parenterally immediately before surgery. The skin is cleansed with the same agents used for conventional therapeutic surgery. When surgery is performed totally using local anesthesia, noninvasive monitoring of blood pressure, electrocardiogram, and pulse oximetry parameters is routine.

After surgery, absorbent dressings are placed over all incision sites; drainage of serosanguineous fluid from unsutured incision sites typically ceases in 2 to 3 days. Compression garments are applied over the wound dressings and over the complete span of each surgical site. High-compression (ie, “phase one”) garments are worn continuously until drainage from the incision sites ceases. Lower-compression (ie, “phase two”) garments are worn continuously thereafter for 4 to 6 weeks. Rarely is postoperative discomfort severe. Most patients describe varying degrees of a burning soreness over the muscle layer at the treatment sites that responds well to nonsteroidal anti-inflammatory medications. Massage of the treatment sites frequently expedites resolution of varying degrees of soft tissue swelling common after this type of surgery. No established standards exist for postliposuction massage, but most regimens begin a minimum of 2 weeks after surgery, when the patient’s discomfort level from this type of therapy is low. Complete healing and tissue remodeling require approximately 6 months. Within this timeframe, induration of the treatment sites develops and resolves.

Complications

Complications may relate to either anesthesia or surgery. Anesthetic complications of general and regional anesthesia are no different for liposuction than for other types of surgery. However, the addition of large volumes of superwet or tumescent fluids into

the fat layers creates the potential added risk of fluid overload if the patient is receiving significant amounts of intravenous fluid simultaneously. When liposuction is performed totally using local tumescent anesthesia, intravenous access is established only for the purpose of administering medications; fluids are administered orally, intermittently, and in small volumes.

Lidocaine overdose is rare with tumescent liposuction when toxicity thresholds are assessed and respected, but patients taking medications that interfere with lidocaine metabolism are at increased risk. Allergic reactions to the components of tumescent and superwet solutions have been described in their undiluted states and are most commonly attributed to preservatives such as sodium metabisulfite. Allergies to lidocaine hydrochloride, an amide anesthetic, are rare.¹³

Visceral and vascular perforation injuries from either infusion needles or liposuction cannulae are rare. They have been reported in association with surgery in the presence of an abdominal scar or hernia and with large-volume cases under general anesthesia.^{14,15}

Surgically related thromboembolism is a function of venous stasis, endothelial injury, and hypercoagulability. These conditions are more characteristic of prolonged procedures performed under general anesthesia or deep sedation than tumescent local anesthesia, but nonsurgical factors such as oral contraceptive use, inherited coagulation disorders, a history of smoking, or a long trip spent sitting in a car or an airplane perioperatively should alert the surgeon to the need for mechanical or pharmacologic prophylaxis irrespective of the type of anesthesia used.

Fat embolism, which occurs asymptotically in most cases of orthopedic trauma, is distinct from fat embolism syndrome (FES) which is relatively rare and rarer still in relation to liposuction.^{14,15} FES is a delayed biochemical inflammatory condition which, when severe, is marked by respiratory distress, cerebral dysfunction, and a petechial rash 24 to 48 hours after surgery. Emboli of fat may also provoke mechanical blockage of the pulmonary capillaries, resulting in tachycardia, tachypnea, elevated temperature, hypoxemia, hypocapnia, thrombocytopenia, and mild neurologic symptoms.¹⁶

Hemorrhage from direct vascular injury within the surgical field is not typically seen with either tumescent or superwet liposuction because of the vasoconstriction that both of these modalities produce. Low-level intraoperative bleeding is sometimes provoked by venturing beyond the zone of vasoconstriction, from either inadvertently venturing into fat outside the treatment zone or grazing the underlying superficial layers of muscle and fascia with the cannula. The latter respond well to compression and targeted infiltrations of dilute epinephrine. Case reports of significant bleeding necessitating blood transfusion during liposuction indicate deep tissue lacerations and perforations under general anesthesia or deep sedation.

Bruising, typically mild, is common after liposuction, but less so when small-caliber cannulae, pure tumescent techniques, and drainage are used (**Fig. 9**). Not infrequently, bruising will appear in areas dependent to the surgical field. More extensive bruising accompanies the use of systemic anesthesia, larger instrumentation, and the treatment of highly vascular regions, such as the submandibular fat pad and the breast. Hypertensive patients are at higher risk for bruising.

Hematomas and seromas are uncommon in liposuction, but when seen are usually related to the treatment of richly vascularized areas, such as the breast or the submental fat pad, and may be associated with extensive bruising. Sonography is a useful assessment tool for these conditions. Primary treatment in both instances is drainage and compression. Hematomas left undrained subcutaneously provoke wrinkling of the overlying skin.

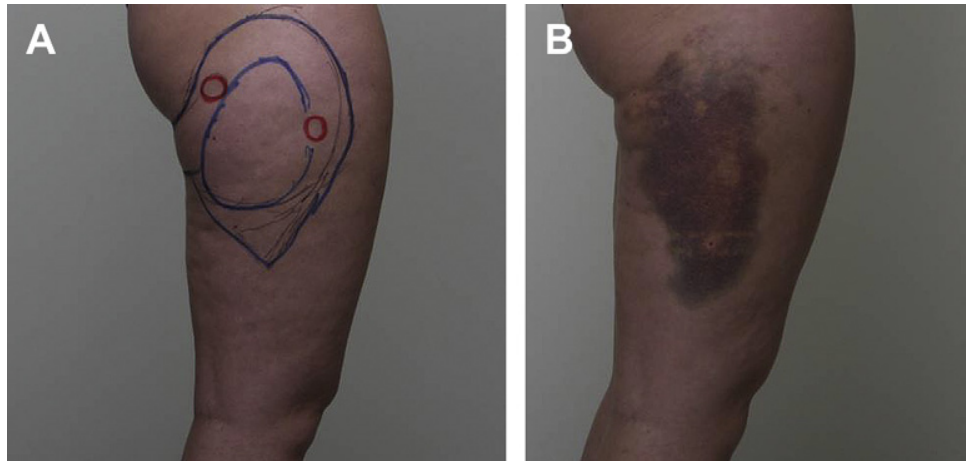


Fig. 9. (A) The right outer thigh of a 26-year-old patient is shown before and (B) 11 days after liposuction showing moderate bruising. She noted no particular discomfort.

Infection is rare with this type of surgery, probably because of the selection of exclusively healthy patients, the common use of dedicated clean operating rooms, antibiotic prophylaxis, and the routine use of postoperative drainage. The common method of postliposuction drainage is through the egress of fluid from unsutured cannula sites rather than by the placement of indwelling drains. Necrotizing fasciitis, the most dangerous type of tissue infection, has been reported with liposuction, is most commonly caused by streptococcus pyogenes, and is extremely rare.¹⁷

Partial- or full-thickness skin necrosis **Fig. 10** can occur when the vascular supply to the skin is injured through various means. Damage may be provoked by excessively superficial liposuction, pressure from improperly worn compression garments, ice packs, infection, and dermal atrophy, which is common with obesity, advancing age, and chronic cigarette smoking. Prompt and regular debridement with either sharp instrumentation or hydrogen peroxide and appropriate antibiotic coverage until healthy granulation tissue develops are the mainstays of management. Lesser degrees of vascular injury to the dermis manifest as areas of erythematous skin discoloration.

Contour irregularities subsequent to liposuction may range from mild to severe. Proper positioning and surgical technique minimize these defects, but when they occur they can be managed with either autologous fat transfer (sometimes referred to as *lipofilling*) or liposhifting. Autologous fat transfer involves the harvest of fat through liposuction from areas usually remote from the intended recipient site, separation of the fat from the anesthetic fluids, and fine incremental injection of the purified fat in layers into the targeted region using small syringes and blunt-tipped fat transfer cannulae. Numerous techniques are available for separating and preparing the harvested fat, but are beyond the scope of this article. With liposhifting, the fat peripheral



Fig. 10. Full-thickness dermal necrosis associated with abdominoplasty at (A) 6 days, (B) 13 days, and (C) 12 weeks.

to an iatrogenic concavity is loosened through mechanical disruption using specialized cannulae and then massaged vigorously into the target area.¹⁸

Technology

Liposuction is most commonly performed manually and generally produces excellent results in properly selected patients. Nonetheless, the process is tedious and requires prolonged repetitive motion by surgeon. Consequently, one of the major stimuli for technological innovation has been to facilitate the liposuction process.

Liposuction has been found to require less time and effort when the integrity of the targeted fat layers has been partially disrupted, especially in the presence of fibrous tissue, scar tissue, or a previously liposuctioned field. Three methods are approved by the U.S. Food and Drug Association to achieve this goal: mechanical disruption, internal ultrasound, and external laser therapy. All require preliminary tumescent or superwet infiltration of the fat layers.

Slow mechanical disruption of the fat layers using smooth cannulae without suction was originally described as a way to soften the transition between the treatment site and the surrounding tissues during wet liposuction, and was termed *mesh undermining* in the early 1980s.¹⁹ The process was subsequently adopted as a pretreatment of the targeted fat during wet liposuction and found to facilitate both cannula motion and the achievement of smooth contours, and dubbed *pretunneling*.²⁰ Pretunneling reemerged as “fat disruption” in 2003, a pretreatment to tumescent liposuction with the goal of speeding the surgical process.²¹ Unlike its predecessor, fat disruption uses cannulae with flared apertures originally designed for liposhifting, which are more effective at softening the tissues of the SFS than are smooth cannulae.

Internal ultrasonic emulsification of the targeted fat layers was introduced in 1987.²² Termed *ultrasound-assisted liposuction* (UAL), this technology uses metallic probes to deliver mechanical vibrations at frequencies ranging from 20 to 60 kHz, which interact with the targeted tissues through direct thermal effects, cavitation, and direct mechanical effects. The emulsified fat is then removed through conventional liposuction. Burn injuries continue to plague this modality because ultrasonic energy can easily turn into heat energy (ie, the widely used harmonic scalpel uses the same basic principles exclusively for their thermal effects). An external version of this technology using skin paddles and a gel interface was introduced in the 1990s, but no device is currently on the market.²³ Other adaptations of external ultrasound technology that bypass the need to use liposuction are marketed outside the United States, but remain a topic of continued investigation.²⁴

A technique of external laser-assisted liposuction was introduced in 2000.²⁵ The procedure, termed *low-level laser-assisted lipoplasty*, used a 635-nm, 10 mW diode laser applied in conjunction with tumescent anesthesia before conventional liposuction. The authors showed microscopically that the laser action caused transient pores to open in the adipocytes cell membrane, allowing its contents to move into the interstitial space. They commented that the latter effect resulted in easier fat extraction and less surgical trauma and bruising. An attempt to duplicate these microscopic findings by another group using superwet rather than tumescent solution was unsuccessful.²⁶

Powered liposuction cannulae offer a more direct alternative for reducing surgical fatigue but do not reduce operating time to any perceivable degree. Power-assisted liposuction (PAL) devices became available in 2000.²⁷ Various designs include electric motors, pneumatic motors, axial motion, rotational motion, and oscillation. Patients typically perceive less discomfort with PAL cannulae because of their inherent vibration when activated. PAL is sometimes referred to as *vibroliposuction*.

Aside from facilitating the liposuction process, various technologies have focused on augmenting the benefits of the procedure. Internal laser devices for assisting conventional liposuction surgery were first described in 1992,²⁸ with the implication that laser-mediated coagulation of blood vessels, collagen, and adipocytes would result in less blood loss, bruising, and tissue reorganization. First-generation devices were low-energy 1065-nm neodymium:yttrium-aluminum-garnet lasers and were heavily marketed in South America and subsequently in North America, but clinical studies, including a prospective randomized trial comparing it to standard liposuction, failed to find any major cosmetic or convalescent differences.²⁹ Lasers continue to flood the liposuction market, touting “unique” combinations of wavelengths and watt-ages, each promising the ultimate cosmetic results with little more than the anecdotal blessing of a handful of industry-friendly surgeons. Water-assisted liposuction was introduced in Europe in 2005, with the promise of less tissue trauma, using a powered cannula that delivers a pulsatile flow of fluid and aspirates simultaneously,^{30–32} but data are insufficient to substantiate whether the procedure offers any advantages over existing methods in terms of complications or cosmesis.

SUMMARY

Liposuction provides effective contouring of the torso, extremities, and submental areas in properly selected patients. Effective techniques have been established for performing liposuction under local anesthesia and general anesthesia. Both methods share many similarities regarding the surgical craft of fat removal, but have distinct elements of anesthetic precaution that must be respected to optimize safety. No technology seems to give superior results over conventional methods.

REFERENCES

1. Cosmetic Surgery National Data Bank. 2008 Statistics. New York (NY): American Society for Aesthetic Plastic Surgery; 2009. p. 3.
2. Comiskey C. Cosmetic surgery in Paris in 1926: the case of the amputated leg. *J Wom Hist* 2004;16(3):30–54.
3. Fischer A, Fischer GM. Revised technique for cellulitis fat reduction in riding breeches deformity. *Bull Int Acad Cosmetic Surg* 1977;2:40.
4. Illouz YG. Une nouvelle technique pour les lipodystrophies localisées. *La Revue de Chirurgie Esthétique de Langue Française* 1980;6(19):10–2.
5. Fournier P. *Liposculpture: ma technique*. Paris: Librairie Arnette; 1990.
6. Hetter GP. The effect of low-dose epinephrine on the hematocrit drop following lipolysis. *Aesthetic Plast Surg* 1984;8(1):19–21.
7. Klein JA. Tumescent technique for liposuction surgery. *Am J Cosm Surg* 1987;4:263–7.
8. Klein JA. Tumescent technique for regional anesthesia permits lidocaine doses of 35 mg/kg for liposuction. *J Dermatol Surg Oncol* 1990;16:248–63.
9. Lockwood TE. Superficial fascial system (SFS) of the trunk and extremities: a new concept. *Plast Reconstr Surg* 1991;87(6):1009–18.
10. Avelar J. Regional distribution and behavior of the subcutaneous tissue concerning selection and indication for liposuction. *Aesthetic Plast Surg* 1989;13(3):155–65.
11. Klein JA. Subcutaneous fat: anatomy and histology. Tumescent technique: tumescent anesthesia and microcannular liposuction. Philadelphia: Mosby; 2000. p. 213–21.

12. Kaminski M, Lopez deVaughn RM. The anatomy and physiology metabolism/nutrition of subcutaneous fat. In: Shiffman MA, DiGiuseppe A, editors. Liposuction: principles and practice. Berlin: Springer; 2006. p. 17–25.
13. Gonzalez-Delgado P, Antón R, Soriano V, et al. Cross-reactivity among amide-type local anesthetics in a case of allergy to mepivacaine. *J Investig Allergol Clin Immunol* 2006;16:311–3.
14. Talmor M, Hoffman IA, Lieberman M. Intestinal perforation after suction lipoplasty: a case report and review of the literature. *Aesthetic Plast Surg* 1997;38:169–72.
15. Shiffman MA. Prevention and treatment of liposuction complications. In: Shiffman MA, DiGiuseppe A, editors. Liposuction: principles and practice. Berlin: Springer; 2006. p. 333–41.
16. Levy D. The fat embolism syndrome: a review. *Clin Orthop* 1990;261:281–6.
17. Wang HD, Zheng JH, Deng CL, et al. Fat embolism syndromes following liposuction. *Aesthetic Plast Surg* 2008;32:731–6.
18. Haeck PC, Swanson JA, Gutowski KA, et al. Evidence-based patient safety advisory: liposuction. *Plast Reconstr Surg* 2009;124:28S–44S.
19. Heitman C, Czermak C, German G. Rapidly fatal necrotizing fasciitis after aesthetic liposuction. *Aesthetic Plast Surg* 2000;24:344–7.
20. Saylan Z. Liposhifting instead of lipofilling: treatment of postlipoplasty irregularities. *Aesthet Surg J* 2001;21:137–41.
21. Hetter GP. Surgical technique. In: Hetter GP, editor. Lipoplasty: the theory and practice of blunt suction lipectomy. Boston: Little, Brown and Co; 1984. p.137–54.
22. Mladick RA, Morris RL. Alternative patient positioning and pretunneling. In: Hetter GP, editor. Lipoplasty: the theory and practice of blunt suction lipectomy. Boston: Little, Brown and Co; 1984. p.137–54.
23. Mangubat EA. Fat disruption using the Blugerman liposhifting instrument. Philadelphia: American Academy of Cosmetic Surgery Fall Symposium on Body Augmentation and Contouring; October 2003.
24. Scuderi N, de Vita R, d'Andrea F, et al. Nuove prospettive nella liposuzione: la lip-oemulsificazione. *Giorn Chir Plast Ricostr Estet* 1987;2:1.
25. Rosenberg GJ, Cabrera RC. External ultrasonic lipoplasty: an effective method of fat removal and skin shrinkage. *Plast Reconstr Surg* 2000;105:785–91.
26. Brown SA, Greenbaum L, Shtukmaster S, et al. Characterization of nonthermal focused ultrasound for noninvasive selective fat cell destruction (lysis). *Plast Reconstr Surg* 2009;124:92–101.
27. Neira R, Arroyave J, Ramirez H, et al. Fat liquefaction: effect of low-level laser energy on adipose tissue. *Plast Reconstr Surg* 2000;110:912–22.
28. Brown SA, Rohrich RJ, Kenkel J, et al. Effect of low-level laser therapy on abdominal adipocytes before lipoplasty procedures. *Plast Reconstr Surg* 2004;113:1796–804.
29. Coleman WP III. Powered liposuction. *Dermatol Surg* 2000;26:315–8.
30. Apfelberg D. Laser-assisted liposuction may benefit surgeons and subjects. *Clin Laser Mon* 1992;10:259.
31. Prado A, Andrades P, Danilla S, et al. A prospective, randomized, double-blind, controlled clinical trial comparing laser-assisted lipoplasty with suction-assisted lipoplasty. *Plast Reconstr Surg* 2006;118:1032–45.
32. Araco A, Gravante G, Araco F, et al. Comparison of power water-assisted and traditional liposuction: a prospective randomized trial of postoperative pain. *Aesthetic Plast Surg* 2007;31:259–65.