Safety of Tumescent and Laser-Assisted Liposuction: Review of the Literature

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ABSTRACT

Background: Tumescent liposuction (TL) allows the removal of large volumes of fat with minimal blood loss or postoperative morbidity, excellent cosmesis, and a remarkable safety profile.
Objective: To review the literature on the safety of tumescent liposuction, liposuction under general anesthesia and laser-assisted liposuction.
Results: Aggregate safety data on liposuction under tumescent anesthesia reveals over 100,000 body areas treated with liposuction. There were no serious complications of death, emboli, hypovolemic shock, perforation of thorax or peritoneum, thrombophlebitis, seizures, or toxic reactions to drugs. In contrast, in the plastic surgery literature, liposuction under general anesthesia was associated with complications of deep venous thrombosis or pulmonary embolus, abdominal or other organ perforation, infection, and bleeding. Most recently, survey data in the European literature analyzed data showed 72 cases of severe complications from liposuction, including 23 deaths in a 5-year period from 1998 to 2002. The most frequent complications were bacterial infections such as necrotizing fasciitis, gas gangrene, and different forms of sepsis. Further causes of lethal outcome were hemorrhages, perforation of abdominal viscera, and pulmonary embolism.
Conclusion: Tumescent local anesthesia utilizing lidocaine with epinephrine allows the removal of large volumes of fat with minimal associated blood loss and postoperative morbidity.

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INTRODUCTION

The early history of liposuction begins with Fischer's description of hollow cannula liposuction in 1976.[1] In 1983, Ilouz, a Frenchman trained in obstetrics and gynecology, and Fournier, a general surgeon, began practicing liposuction using the "wet technique," involving injection of hypotonic saline and hyaluronic acid into the fat prior to suction.[2] Fournier pioneered the "criss-cross" technique and syringe liposuction and became a teacher of the technique.[3]

Subsequently in 1977, an American dermatologist, Lawrence Field, visited Paris and learned about liposuction and published his experience with the technique in 1984. Jeffrey Klein, an American dermatologist, was the first to publish a report of liposuction using exclusively tumescent local anesthesia (TL) in 1987.[4] Prior to this point, the pain associated with liposuction had necessitated the procedure be performed under general anesthesia.

In 1988, Hanke and Bernstein published a report on the safety of the tumescent liposuction (TL) technique, reporting the results of 9,478 patients treated by dermatologists.[5] Shortly after attending Fournier's liposuction course in Paris, C. William Hanke, the editor-in-chief of the *Journal of Dermatologic Surgery and Oncology*, commissioned an issue dedicated to liposuction. Further

innovations to the field evolved with the publication by Hanke and colleagues documenting the safety of TL in 336 patients in 1995.[6] Additionally, while initial reports by Klein established the safety of tumescent liposuction using a lidocaine dose of 35 mg/kg in 1990,[4] Ostad et al.[7] reported the safety at a total dose of 55 mg/kg. In 2000, Klein published a book entitled Tumescent Technique, highlighting many of his important contributions to the field including: TLA technique, the Klein microcannula, Klein infiltration pumps, multihole Klein Capistrano cannulas, and specific techniques for treating all body areas.[8]

Since Klein's introduction of the TL technique of in 1987, it has revolutionized the field of cosmetic body fat sculpting among dermatologic surgeons and surgeons of all specialties performing the procedure. Liposuction with TLA facilitates the removal of large volumes of fat with minimal blood loss or postoperative morbidity, a low infection rate, excellent aesthetic results, and a remarkably superior safety profile to general anesthesia.[9]

Liposuction is designed for individuals at their ideal body weight who seek correction of a single or multiple anatomic sites with focal excess adiposity and laxity.[9-13] The ideal liposuction patient is a patient of ideal body weight with focal disproportionate adiposity,

resulting in contour deformity.[9-13] Importantly, liposuction is not a weight loss procedure, and it should be emphasized that patients seeking the goal of weight loss are not good candidates for the procedure.[9-13] The results of liposuction in all anatomic sites are limited by the existing bony structure, the texture and quality of the skin, the tone and build of muscle, and the pre-existing adiposity in areas not amenable to liposuction. Liposuction can help to achieve a more idealized and balanced body contour, and patients will largely vary in seeking correction of a single area or multiple anatomic sites to achieve their own personal optimal correction.

Advantages of Tumescent Liposuction Technique

TL allows the removal of large volumes of fat with minimal blood loss or postoperative morbidity, excellent cosmesis, and a remarkable safety profile. TL technique with the use of a dilute epinephrine and anesthetic achieves the aims of hemostasis and anesthesia at the surgical site.[14-18] These advances have contributed to the enhanced safety profile and widespread growth in the popularity of the liposuction technique.[14-19]

Advantages of the TL technique include a significant reduction in blood loss attributed to the vasoconstrictive effects of epinephrine. This can be quantified by comparing the aspirate from TL (containing 1–3% whole blood) with that from the procedure performed under general anesthesia (40% whole blood).[16] Improved hemostasis results in both decreased blood loss as well as decreased bruising and discomfort for the patient in the postoperative phase.[16] In addition, the anesthetic and vasoconstrictive effects of the local anesthetic are directed towards the sites being treated, resulting in prolonged anesthesia of several hours' duration as a result of the reservoir effect of anesthesia,[13-16] which results in decreased reliance upon postoperative narcotics.

The local anesthetic solution also results in a hydrodissection effect, whereby the pressure of the solution allows easier and more uniform penetration and removal of adipose tissue by the cannula.[4-8,13-16] Tumescent fluid enlarges, magnifies, and lifts targeted fat, allowing for more precise removal of fat.[4-8,13-16]

With TL, patient convenience is significantly enhanced during the more rapid perioperative recovery period.[15-25] In contrast, recovery is much more prolonged after general anesthesia, both as a result of the after-effects of the anesthetic and from the increased bruising and discomfort associated with the procedure.[15-25] Complications with the TL technique include discomfort, swelling, bruising, temporary loss of sensation, postinflammatory hyperpigmentation, and minimal scarring at the incision sites, but these are significantly less than those associated with the procedure performed under general anesthesia.[15-25]

With patient comforting and proper technique for infusion of the tumescent fluid, tumescent local anesthesia can be performed without ancillary sedation and IV or general anesthesia. With tu-

mescent anesthesia, patient convenience is significantly enhanced during the peri-operative recovery period where there is more rapid recovery results after tumescent liposuction. In contrast, the recovery is much more prolonged after general anesthesia, both as a result of the after-effects of the anesthetic and form the increased bruising and discomfort associated with the procedure.

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Review of the Literature
Safety Studies

Liposuction under tumescent anesthesia is a procedure that was designed and developed by dermatologic surgeons.[6-25] It is a procedure with a documented safety record, longevity of results, and high levels of patient satisfaction. TL only in the office setting has a documented superior safety profile which has been documented in a number of studies in the dermatologic surgery literature by Bernstein, Hanke, Coleman, and Housman (Table 1).[6,20,25]

Several of largest studies to date, the first by Hanke et al in 1995,[6] reported data on 44,014 body areas treated with liposuction. There were no serious complications of death, emboli, hypovolemic shock, perforation of thorax or peritoneum, thrombophlebitis, seizures, or toxic reactions to drugs. Subsequently, in 2002, Housman et al[25] reported data on 66,570 liposuction procedures. No deaths were reported and the serious adverse event ratio was low at .68 per 1000. This study demonstrated that serious events were more common in nonaccredited offices compared to ambulatory surgery centers and hospitals. Additionally, greater adverse events occurred when tumescent anesthesia was combined with intravenous or intramuscular sedation than when combined with oral sedation or no sedation. In 2004, Hanke[28] surveyed 39 tumescent liposuction centers and 688 patients treated with the tumescent technique to examine liposuction practice and safety. The overall complication rate was .7 percent with the minor complication rate of .57 percent and the major complication rate of .14 percent (1/688 patients). This patient developed pneumothorax requiring hospitalization. Patient satisfaction was very high among the surveyed population where 91 percent of patients surveyed were positive about their decision to have liposuction and 84 percent had high levels of satisfaction with the procedure.

In contrast, in the plastic surgery literature (Table 1) the case fatality and complication rates were significantly higher for liposuction. In the largest study to date among plastic surgeons by Grazer and de Jong[29] in 2000 evaluating data on 496,245 procedures, the fatality rate was 19.1/100,000; where the most common causes of death included thromboembolism (23.1%), abdomen/viscus perforation (14.6%), anesthesia/sedation/medication (10%),

TABLE 1.

Liposuction Safety Studies					
Study/Author	Year	Number of Procedures	Specialty	Number of Fatalities	Fatality Rate
Newman, Dolsky	1984	5,458	Cosmetic Surgeons (derm, ENT, etc.)	0	1/38,426
Bernstein, Hanke	1988	9,478	Dermatologic Surgeons	0	0
Temourian, Rogers	1991	112,756	Plastic Surgeons	15	12.7/100,000
Dillerud	1991	3,511	Plastic Surgeons	0	0
Hanke et al.	1995	15,336	Dermatologic Surgeons	0	0
ASPRS Task Force on Liposuction	1998	24,295	Plastic Surgeons	5	20.6/100,000
Jackson, Dolsky	1999	200,000	Cosmetic Surgeons (derm, ENT, etc.)	1	2.4/100,000
Grazer, De Jong	2000	496,245	Plastic Surgeons	95	19.1/100,000
Hughes	2001	94,159	Plastic Surgeons	Not stated	1/47,415 (lipo only) 17,314 (lipo and other procedures) 1/3281 (lipo and abdominoplasty)
Housman et al.	2002	66,570	Dermatologic Surgeons	0	0
Hanke et al.	2004	688	Dermatologic Surgeons	0	0

fat embolism (8.5%), cardiorespiratory failure (5.4%), massive infection (5.4%) and hemorrhage (4.6%). The authors noted a trend in death on the first postoperative night and thus advocated for overnight medical supervision after the procedure.

Potential risks of liposuction under general anesthesia are significantly greater and include deep venous thrombosis or pulmonary embolus, abdominal or other organ perforation, infection, and bleeding.[9] A study in 2005 by Coldiron and colleagues reviewed all reported adverse incidents (the death of a patient, serious injury, and subsequent hospital transfer) occurring in an office setting from March 1, 2000, through March 1, 2004, from the Florida Agency for Health Care Administration.[9] There were 286 reported office adverse events reported, 77 occurring in association with an office surgical procedure (19 deaths and 58 hospital transfers).[9] There were seven complications and five deaths associated with the use of intravenous sedation or general anesthesia.[9] There were no adverse events associated with the use of dilute local tumescent anesthesia.[9] In contrast, liposuction and/or abdominoplasty under general anesthesia or intravenous sedation were the most common surgical procedures associated with a death or complication.[9]

Similarly, a recent study in the plastic surgery literature in Germany by Lehnhardt M and colleagues demonstrated a number of severe complications from liposuction performed under general anesthesia in the setting of the operating room.[30] These authors performed a retrospective analysis of severe or lethal complications related to cosmetic liposuction in Germany.[30] To collect pertinent information, 3500 questionnaires were sent to departments of pathology and forensic medicine, intensive care units, and others.[30] After the identification of cases with major

complications, the second phase of the investigation consisted of interviews with the physicians performing the liposuction.[30] 2,275 questionnaires (65%) were returned. The analyzed data showed 72 cases of severe complications, including 23 deaths following cosmetic liposuction in a 5-year period from 1998 to 2002.[30] The most frequent complications were bacterial infections such as necrotizing fasciitis, gas gangrene, and different forms of sepsis.[30] Further causes of lethal outcome were hemorrhages, perforation of abdominal viscera, and pulmonary embolism.[30] In all cases of serious complication, aggressive volumes of fat were removed with liposuction under general anesthesia, including a case where 24 L of fat were removed in a patient who died after liposuction from complications of necrotizing fasciitis and gas gangrene.[30] The authors concluded that major risk factors for the development of severe complications from liposuction included insufficient standards of hygiene, infiltration of multiple liters of tumescent solution, permissive postoperative discharge, and selection of unfit patients.[30] The lack of surgical experience was a contributing factor, particularly regarding the timely identification of developing complications.[30]

There are several additional cases reported in the literature of fasciitis after liposuction, including a case of group A streptococcal fasciitis complicating tumescent liposuction.[31] In this case, a 62-year-old woman presented 8 days after submental liposuction and a platysmal plication procedure with signs and symptoms of cervical fasciitis.[31] Microbiological analysis confirmed a group A streptococcal infection. By using early aggressive medical and surgical treatments, the disease was arrested before the onset of any necrotizing process.[31] A high index of suspicion is required to make an early diagnosis of this potentially disfiguring and life-threatening infection.[31]

Similarly, a case report in the Dutch literature reported a 41-year-old otherwise healthy woman who was admitted for toxic shock-like syndrome with necrotizing fasciitis and myositis, three days after liposuction of the lower abdomen.[32] The patient was treated by radical debridement of the skin, subcutis, fascia, and part of the pectoral muscle, plus antibiotics.[32] Postoperatively she required artificial respiration for respiratory insufficiency.[32] One week after the operation the wound was covered by transplantation of autologous skin.[32] The patient survived but was seriously disfigured.[32] The authors of this case report emphasized that necrotizing fasciitis is a progressive soft-tissue infection, characterized by widespread necrosis of the superficial and deep fascia, often associated with severe systemic toxic reactions.[32] Unless quickly recognized and aggressively treated, the course of necrotizing fasciitis is often fatal.[32] Due to the absence of cutaneous findings in the early stages, diagnosis is difficult.[32] Important diagnostic aids are routine laboratory tests, contrast-MRI, and a combination of the finger test and frozen-section biopsy.[32] Treatment consists of early radical debridement, broad-spectrum antibiotics, and supportive care.[32]

Infection Risk Associated With TL

TL has a very low complication rate and a particularly low infection rate relative to liposuction performed under general anesthesia. One possible explanation for the low infection rate of liposuction under TL is that the lidocaine, epinephrine, and bicarbonate utilized in the tumescent solution have all been proven to have some antimicrobial effects on a diverse range of pathogens (bacteria, fungi, viruses). Thus, the large dilute volume of anesthetic solution may have a role in the low rates of infection associated with this procedure. However, a more recent study indicated that these antimicrobial properties have only been demonstrated using concentrations of lidocaine above 0.8%, significantly higher than those used in tumescent liposuction.[26] A study by Craig SB[26] demonstrated that the minimum inhibitory concentration of lidocaine was not less than 0.5% for any of the bacteria, whereas the lowest minimum inhibitory concentration of the combined solution was 0.25%. The lowest inhibitory concentration as determined by spectrophotometric analysis for the combined solution was 0.13% ($P<0.01$).[26] Thus, at the commonly used tumescent mixture containing dilute concentrations of lidocaine, epinephrine, and bicarbonate, these results suggest that there is no significant inhibition of the growth of commonly encountered bacteria.[26]

The most common infectious complication associated with TL include superficial infections, usually around incision sites, which are typically culture positive for *staphylococcus* and streptococcus.[27] However, there are also rare reports of deeper infections which occur in a delayed fashion several months after the procedure occur with atypical mycobacterial species (*Mycobacterium abscessus, M. chelonae, M. fortuitum*) and have

been associated with improper cleaning and sterilization of surgical instruments.[27] Any signs of infection should be evaluated and cultured as soon as possible. With atypical mycobacterial infections, it is important to obtain the culture medium requirements of the laboratory and to notify the laboratory that special processing of the specimen is needed. Rare cases of necrotizing fasciitis have been reported with liposuction.[30-32] Thus, any patient presenting with severe pain out of proportion to examination, surface blistering, and tenderness should be promptly evaluated for possible debridement and started immediately on broad-spectrum antibiotics and supportive care.

While TL is associated with very low rates of local and systemic infections,[5-27] many dermatologic surgeons administer prophylactic doses of antibiotics pre- and/or postoperatively to performing liposuction under TL. Additionally, there is little or no consensus on the bacterial class and/or type of antibiotics, which are optimal for patients undergoing TL. While there are extensive studies reporting upon the incidence of transient bacteremia and associated risks of endocarditis during dental procedures,[33-41] we performed the first study to evaluate the incidence of bacteremia during TL. Additionally, we set out to determine the bacterial type and most appropriate antibiotic class for prophylaxis in these patients.[42]

Four sets of blood cultures were drawn for each patient at t=0 (prior to start of procedure), t=15 minutes into the procedure t=30 minutes into the procedure and at the conclusion of the procedure. Each time point included an aerobic and anaerobic culture vial.[33-41] After 2 weeks of growth, no bacteremia was observed in any of the aerobic or aerobic cultures taken from any patient at each of the three time intervals.[33-41]

While our study demonstrated no detectable incidence of transient bacteremia during upper extremity and flank TL procedures,[33-41] the rare reports of severe, life threatening necrotizing fasciitis and atypical mycobacterial infections[29-32] highlight the importance of sterile technique and may warrant prophylactic antibiotic administration in susceptible patient populations.

The incidence of transient bacteremia has been evaluated in a number of procedures in the dental, orthodontic and general surgical literature and has varied documented rates of bacteremia ranging from 10%–96%, depending upon the procedure analyzed.[33-42] Specifically, transient bacteremia has been reported after a diversity of procedures, including percutaneous, and transjugular liver biopsies, dental and orthodontic procedures, tattoos and body art and recently, tooth brushing in patients with orthodonture and associated appliances.[33-42] One of the primary health concerns related to transient bacteremia during surgical procedures, in addition to overall increased infection risk, is increased risk of bacterial endocarditis, a potentially life threatening condition. There have been a number of case re-

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ports in the literature documenting incidence of bacterial and mycobacterial endocarditis in patients undergoing dental, orthodontic, and other surgical procedures.[33-41]

Laser Assisted Liposuction

Current studies are underway to evaluate the ability to liquefy or rupture fat cells using various lasers.[43-51] The laser devices most widely utilized to assist with liposuction include a helium-neon laser (635<nm), a diode laser (600–800 nm), and most recently, a 1064 nm neodynium:yttrium aluminum garnet (Nd:YAG) laser.[43-51] The studies utilizing a 635 nm diode laser to release fat from adipocytes demonstrated changes in the adipose structure when analyzed by electron microscopy and magnetic resonance imaging (MRI).[43] Six minutes of exposure to the 635 nm diode laser at 1.2 J/cm^2 resulted in a temporary pore in the cell membrane with resultant release of the fat into the interstitial space.[43]

Recent studies have evaluated both the clinical and histopathologic effects of the 1064 nm Nd:YAG laser and 980 nm diode laser in laser-assisted lipolysis.[44] A recent study by Mordon and colleagues[43] demonstrated both enhanced lipolysis and skin contraction with the laser-assisted devices. Using an optimal thermal modeling approach, the authors demonstrated that increased heat generated by the laser in the deep reticular dermis may result in collagen and elastin synthesis and resultant skin tightening which they observed clinically after laser lipolysis. Goldman demonstrated skin contraction and enhanced lipolysis with the use of the 1064 nm Nd:YAG laser for submental liposuction.[44] Clinical results of tissue tightening were correlated with histologic analysis confirming laser-induced rupture of the adipocyte membrane. Kim and colleagues[45] reported the results of 29 patients treated with laser lipolysis with the 1064 nm Nd:YAG device and demonstrated clinical improvement (at 3 months, average of 37%) as well as decreased adiposity as measured by MRI (average of 17% reduction in volume). Greater improvement was noted in smaller volume areas, such as the submentum, in both clinical outcome, and dermal tightening. However, several other recent comparative trials evaluating laser-assisted liposuction with the 1064 nm Nd:YAG laser have shown equivocal results with laser-assisted liposuction relative to liposuction alone.[49-51]

While laser assisted TL (LAL) is still in evolution, theoretical benefits of LAL include less mechanical trauma associated with the procedure, resulting in a theoretical risk of less bacteremia. Two recent studies have evaluated the complication rate and safety, including incidence of infections with laser assisted TL (LAL). A total of 537 consecutive TL cases with LAL were evaluated retrospectively to determine the number of adverse events associated with the LAL procedure and the number of touch-up procedures performed.[48] No systemic complications were identified and only five local complications were found. These complications included one local infection and four skin burns. This represents a complication rate of 0.93%.

Similarly, a recent study by Reynaud JP and colleagues evaluated 534 LAL procedures retrospectively performed on 334 patients.[51] Different areas were treated: hips (197), inner thighs (86), abdomen (86), knees (61), flanks (57), buttocks (28), chin (22), arms (18), back (4).[51] Mean cumulative energy was area-dependent, ranging from a minimum of 2200 J (knee) to a maximum of 51,000 J (abdomen).[47] Contour correction and skin retraction were observed almost immediately in most patients. There was no incidence of scarring, infection, burns, hypopigmentation, bruising, swelling, or edema.[51] Ecchymoses were observed in almost all patients but resolved in under one week for 322 patients. Patient satisfaction was very high.[51] Because LAL is an outpatient procedure, patients were able to resume normal daily activities after 24 hours.[51] Ultrasound imaging confirmed that the thermal effect generated by the laser results in melting and rupture of the collagenous and subdermal bands.[51]

LAL has been purported to result in both mechanical cavitation of fat resulting in greater ease of suction and greater skin retraction after the procedure resulting in enhanced tightening. However, further studies are highly needed to evaluate scientifically the benefits of pretreatment with lasers for ease of adipose removal, enhanced cosmesis and safety profile, including incidence of transient bacteremia and infection.[39-47]

CONCLUSION

Tumescent liposuction is a procedure that was designed and developed by dermatologic surgeons. The safety profile for liposuction is significantly improved when tumescent local anesthesia technique is employed. Tumescent local anesthesia utilizing lidocaine with epinephrine allows the removal of large volumes of fat with minimal associated blood loss and postoperative morbidity.

DISCLOSURES

The authors have no relevant conflicts of interest to disclose.

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