
Cosmetic Special Topic

Practice Advisory on Liposuction

Ronald E. Iverson, M.D., Dennis J. Lynch, M.D., and the ASPS Committee on Patient Safety

Pleasanton, Calif.

Committee Statement: At the 69th annual meeting of the American Society of Plastic Surgeons (ASPS) in October of 2000, the ASPS Board of Directors convened the Task Force on Patient Safety in Office-Based Surgery Facilities. The task force was assembled in the wake of several highly publicized patient deaths involving plastic surgery and increasing state legislative and regulatory activity of office-based surgery facilities. In response to the increased scrutiny of the office-based surgery setting, the task force produced two practice advisories: "Procedures in the Office-Based Surgery Setting" and "Patient Selection in the Office-Based Surgery Setting." Since the task force's inception, professional and public awareness of patient safety issues has continued to grow. This heightened interest resulted in an increased need for plastic surgeons to communicate their views on the topic. To meet this challenge, the task force evolved into the Committee on Patient Safety, allowing the committee to address topics affecting the safety and welfare of plastic surgery patients, regardless of the facility setting.

The "Practice Advisory on Liposuction" is the first advisory developed since the committee was formed. It was a lengthy and painstaking process for the committee, which included representatives from related plastic surgery organizations as well as the American Society of Anesthesiologists (ASA). Committee members included Ronald E. Iverson, M.D., chair; Jeffery L. Apfelbaum, M.D., ASA representative; Bruce L. Cunningham, M.D., ASPS/Plastic Surgery Educational Foundation (PSEF) Joint Outcomes Task Force representative; Richard A. D'Amico, M.D., ASPS representative; Victor L. Lewis, Jr., M.D., ASPS Health Policy Analysis Committee representative; Dennis J. Lynch, M.D., ASPS representative; Noel B. McDevitt, M.D., ASPS Deep Vein Thrombosis Task Force representative; Michael F. McGuire, M.D., The American Society for Aesthetic Plastic Surgery (ASAPS) representative; Louis Morales, Jr., M.D., American Society of Maxillofacial Surgeons representative; Calvin R. Peters, M.D., Florida Ad Hoc Commission on Patient Safety representative; Robert Singer, M.D., American Association for Accreditation of Ambulatory Surgery Facilities representative; Thomas Ray Stevenson, M.D., American College of Surgeons representative; Rebecca S. Twersky, M.D., ASA representative; Ronald H. Wender, M.D., ASA representative; and James A. Yates, ASAPS representative. The authors thank members of the committee for the insights they brought to this process. The final document represents

their significant contributions to these efforts. They would also like to recognize DeLaine Schmitz and Pat Farrell of the ASPS staff for their work on and support of this project. (*Plast. Reconstr. Surg.* 113: 1478, 2004.)

Most surgical procedures are performed in one of three outpatient settings: hospitals, free-standing ambulatory surgery centers, or office-based surgery facilities.¹ The office-based surgery setting in particular has many advantages for both the plastic surgeon and the patient, including greater control over the schedule, greater privacy for the patient, convenience, and increased efficiency and consistency in nursing staff and support personnel.

In general, there is little scientific evidence available on patient safety issues and even less that specifically addresses liposuction performed in the office-based surgery setting. The research and published materials available focus more on the techniques and complications rather than on the provision of safe care. Therefore, this advisory is based on the best information available and largely reflects the collective opinion of the members of the American Society of Plastic Surgeons (ASPS) Committee on Patient Safety. The advisory provides a synthesis and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys.²

Attempts to reduce or eliminate localized adiposity by diet or exercise alone are often unsuccessful and discouraging. Liposuction, a surgical intervention designed to treat superficial and deep deposits of subcutaneous fat distributed in aesthetically displeasing proportions, has proven to be a successful method of improving body contour. Liposuction is so suc-

Received for publication May 15, 2003; revised July 28, 2003.

Approved by the American Society of Plastic Surgeons Board of Directors, March 15, 2003.

DOI: 10.1097/01.PRS.0000111591.62685.F8

cessful, in fact, that it is commonly performed in the office-based surgery setting and is the most frequently performed plastic surgery procedure.³

Developed in France, liposuction was introduced into the United States in 1982 after a blue ribbon investigative panel of American plastic surgeons, appointed by the ASPS, traveled to Paris to verify its effectiveness.⁴ Through the assistance of a series of educational programs by American plastic surgery organizations, the clinical availability of the procedure in the United States grew rapidly within a short period of time. With a corresponding increase in demand from the public, liposuction quickly became the most frequently performed cosmetic surgery procedure in the nation, a distinction it still holds. Because of the popularity of liposuction, the U.S. Food and Drug Administration recently issued a statement that gives consumers basic information on the procedure as well as points to consider when deciding upon this surgery.⁵

Liposuction was originally intended to treat minor contour irregularities. Advances in the liposuction surgical technique and a more complete understanding of the physiological consequences of liposuction have made the recontouring of large or even multiple areas of the body possible. At the same time, these advances have changed the nature of liposuction, taking it from the realm of a minor surgical procedure to that of major surgery.

DISCLAIMER

Practice advisories are strategies for patient management, developed to assist physicians in clinical decision making. This practice advisory, based on a thorough evaluation of the present scientific literature and relevant clinical experience, describes a range of generally acceptable approaches to diagnosis, management, or prevention of specific diseases or conditions. This practice advisory attempts to define principles of practice that should generally meet the needs of most patients in most circumstances. However, this practice advisory should not be construed as a rule, nor should it be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the appropriate results. It is anticipated that it will be necessary to approach some patients' needs in different ways. The ultimate judgment regarding the care of a particular patient must be

made by the physician in light of all the circumstances presented by the patient, the diagnostic and treatment options available, and the available resources.

This practice advisory is not intended to define or serve as the standard of medical care. Standards of medical care are determined on the basis of all the facts or circumstances involved in an individual case and are subject to change as scientific knowledge and technology advance and as practice patterns evolve. This practice advisory reflects the state of knowledge current at the time of publication. Given the inevitable changes in the state of scientific information and technology, periodic review and revision will be completed by the committee.

LIPOSUCTION TECHNIQUES

Over the years, a variety of terms have been used to describe liposuction techniques. A summary of these terms follows.

Suction-Assisted Lipoplasty

Adipose tissue is removed from the subcutaneous space by means of a blunt-tip hollow cannula attached to high-powered suction, usually one atmosphere of negative pressure.

Dry Technique

The first method developed, the dry technique was performed under general anesthesia without the infiltration of subcutaneous solutions before insertion of the liposuction cannula. Substantial swelling and discoloration, along with suction aspirate containing 20 to 45 percent blood, were common consequences of the technique. These sequelae sharply limited the amount of fat that could be removed without transfusion or hospitalization, which resulted in the abandonment of this approach,⁶ except in limited applications.

Wet Technique

The wet technique entails injecting 200 to 300 ml of infiltrate or wetting solution, with or without additives, into the operative field before insertion of the liposuction cannula. Small doses of the vasoconstrictor epinephrine were added to the infiltrate, which significantly decreased the blood loss to 4 to 30 percent of the aspirate. The wet technique was the method of choice in the early 1980s.⁶

Superwet Technique

The superwet technique, introduced in the mid-1980s, utilizes larger volumes of subcutaneous infiltrate, infusing 1 cc of solution for each 1 cc of fat to be removed. The infiltrate solution consists of saline or Ringer's lactate solution with epinephrine and, in some cases, lidocaine. Using this method, blood loss generally decreases to less than 1 percent of the aspirate volume.^{6,7}

Tumescent Technique

Introduced in 1985, the tumescent technique uses the largest volume of infiltrate and involves infusing 3 to 4 cc of the infiltrate solution for each planned milliliter of aspirate.^{7,8} Drug concentrations in the tumescent infiltrate solution vary, but typically they consist of a range of 0.025% to 0.1% lidocaine and epinephrine 1:1,000,000 in a Ringer's lactate or normal saline solution.^{9,10} Estimated blood loss with the tumescent technique is approximately 1 percent of the aspirate, comparable to the superwet technique.^{6,7}

Ultrasound-Assisted Liposuction

Introduced in the late 1980s, ultrasound-assisted liposuction uses a cannula or probe to deliver fat-liquefying ultrasound subcutaneously, permitting fat to be removed with less physical effort by the surgeon.¹¹ This technique permits the removal of fat from fibrous areas such as the upper abdomen, back, and flanks with greater ease, especially during secondary procedures. To prevent thermal injuries while performing ultrasound-assisted liposuction, two technique rules are of critical importance. First, the ultrasound probe or cannula must be kept in motion; second, the infiltrate solution is a required component of ultrasound-assisted liposuction as it plays a crucial role in the process of fat emulsification. The dry technique should never be used in ultrasound-assisted liposuction, regardless of the planned volume of aspirate.⁷

External Ultrasound Assistance

External ultrasound assistance delivers adjunctive ultrasound through an external paddle, but this technique remains under investigation. Some researchers have reported that external ultrasound assistance benefits skin retraction and ease of aspirate extraction,^{12,13} while others have found no significant clinical

benefits to external ultrasound and recommended further study.¹⁴

Recommendations

1. Due to the amount of blood loss associated with the dry technique, its use is not recommended except in limited applications with a volume of 100 cc of total aspirate or less.
2. The dry technique should never be used in conjunction with ultrasound-assisted liposuction.
3. No one single liposuction technique is best suited for all patients in all circumstances. Factors such as the patient's overall health, the patient's body mass index, the estimated volume of aspirate to be removed, the number of sites to be addressed, and any other concomitant procedures to be performed should be considered by the surgeon to determine the best technique for the individual patient.

LIPOSUCTION CANNULAS

A liposuction cannula is a hollow rod with a blunt to sharp tip and an opening or openings through which the fat is detached from the subcutaneous skin and evacuated into the aspirator. Cannula design varies in both dimension and length. The sharper or more pointed the tip of the cannula, the more likely damage can occur to surrounding tissue. However, very blunt-tipped cannulas require more physical exertion and can cause more physician fatigue. Many cannulas have more than one opening, in various configurations, at or near the tip. Multiple openings facilitate extraction of fat and traumatize the tissue less because repeated movement over a given area is minimized.

The design, size, and length of the liposuction cannula vary greatly depending on the area(s) to be suctioned, the type of liposuction performed, and the physician's preference.¹⁵⁻¹⁸ The diameters of cannulas typically range from 2 to 6 mm and are available in a variety of lengths.^{17,18} No one cannula is appropriate for all procedures, patients, or surgeons.

Specialized Cannulas

Power-assisted liposuction. Power-assisted liposuction is an approach in which the system that drives the cannula is a power source other than the surgeon's arm. Systems are either electrically driven or gas-driven by nitrogen or compressed air tanks. A small motor moves the 2- to 4-mm cannula tip in a forward and backward motion, replicating the motion of the surgeon and decreasing physician fatigue. The cannulas

are small and flexible and are comparable in length and diameter to standard suction-assisted liposuction cannulas. Power-assisted liposuction is effective for large-volume removals, fibrous areas, and revisions. It is typically used in conjunction with the tumescent or superwet technique. The excessive vibration of the cannula and noise of the power system are the two main disadvantages of this technique.¹⁹

Ultrasound-assisted liposuction. Ultrasound-assisted liposuction probes are made of titanium and deliver the ultrasound energy utilized to emulsify fat. Two probe designs are available, either solid with no aspiration port or hollow with a central lumen. The hollow probe design allows for aspiration of a continuous stream of emulsion during the ultrasound phase of liposuction.^{20,21} The solid probe is thought to be a more efficient fat emulsification device, but its use requires a two-step process in which the fat must be emulsified and then evacuated separately.²² Regardless of the probe design, a sheath or skin protector of some kind is required to prevent thermal injury at the incision site.^{15,23}

Recommendations

No one cannula is best suited for all patients in all circumstances. Factors such as the patient's overall health, the volume of aspirate to be removed, the areas of the body to be treated, the number of sites to be addressed, the technique chosen (suction-assisted, power-assisted, or ultrasound-assisted liposuction), and physician preference determine the cannula best suited for the individual patient.

ANESTHESIA

Various types of anesthesia or anesthesia combinations are appropriate for liposuction, depending on the overall health of the patient, the estimated volume of the aspirate to be removed, and the postoperative dismissal plan.

A physician should have the primary responsibility for providing and/or supervising anesthesia. All anesthesia should be ordered by a physician. Anesthetics may be administered by either a qualified physician, a certified registered nurse anesthetist under physician supervision, or another qualified health care provider under the supervision of a qualified physician as required by law.²⁴ The responsible physician must be physically present in the operating room throughout the conduct of the anesthetic.

Anesthetic Infiltration Solutions

As liposuction techniques evolved, anesthetic agents were added to the wetting solutions to provide preemptive and prolonged postoperative local analgesia. In smaller-volume liposuction cases, anesthetic infiltrate solutions alone may provide adequate pain relief. However, in larger-volume liposuction cases, the superwet and tumescent techniques are often accompanied by sedation, general anesthesia, or epidural anesthesia to ensure adequate patient comfort.⁷ It should be noted that when infiltration methods such as the tumescent technique are utilized, they should be regarded as regional or systemic anesthesia because there is potential for systemic toxic effects.^{25,26}

Marcaine

In the early stages of the wet technique, low-dose Marcaine (bupivacaine; Abbott Laboratories, North Chicago, Ill.) was occasionally added to the wetting solution. Marcaine, the longest-acting anesthetic in its class, is rapidly absorbed, has the slowest elimination in its class, and is not readily reversed.²⁷ Marcaine toxicity affects the cardiovascular, neurologic, and hematologic systems and may result in cardiac arrhythmias, seizure, and coma with respiratory depression.²⁷⁻²⁹ Marcaine has not been studied for use in liposuction wetting solutions.

Lidocaine

Lidocaine is used more often as the anesthetic agent in the wetting solution. It has a wider range of safety than Marcaine and is more easily reversed. Historically, the recommended dose of lidocaine is less than 7 mg/kg.^{27,30,31} However, this dose does not take into consideration the slow absorption from fat, the persistent vasoconstriction from epinephrine, and the lidocaine removed in the liposuction aspirate, which all contribute to a reduced risk of systemic toxicity from the lidocaine.^{6,7} It is generally accepted that a lidocaine dose of up to 35 mg/kg is safe when injected into the subcutaneous fat with solutions containing epinephrine, although doses up to 50 mg/kg have been utilized.

Although lidocaine is safe when administered at an appropriate dose and when the patient is appropriately monitored, toxicity can present as cardiac and neurologic complica-

tions. Signs and symptoms of lidocaine toxicity include light-headedness, restlessness, drowsiness, tinnitus, a metallic taste in the mouth, slurred speech, and numbness of the lips and tongue. These signs can be seen at plasma levels between 3 and 6 $\mu\text{g}/\text{ml}$. Shivering, muscle twitching, and tremors can occur when plasma levels reach 5 to 9 $\mu\text{g}/\text{ml}$. Convulsions, central nervous system depression, and coma follow at plasma levels greater than 10 $\mu\text{g}/\text{ml}$. Above these levels, respiratory depression and cardiac arrest can occur.^{23,32} It is important to note that plasma lidocaine levels can peak 10 to 12 hours after infiltration when epinephrine is present in the wetting solution.⁷

Various factors affect the likelihood of lidocaine toxicity, including the level and rate of drug absorption, drug interactions, fluid management, prothrombogenic factors, and volume of wetting solution and aspirate. To decrease the risk of lidocaine toxicity in large-volume liposuction cases, two options are available. First is to decrease the concentration of lidocaine in the wetting solution. The second is to utilize smaller volumes of infiltrate with the superwet technique rather than choose the larger volumes of infiltrate with the tumescent technique. Lidocaine toxicity has been implicated in a series of liposuction-related deaths.^{25,33} In fact, studies have shown that lidocaine may not always be necessary in liposuction when other forms of anesthesia are utilized.¹⁰

Epinephrine

Epinephrine is a critical additive in the infiltrate solution. Advantages of its use include vasoconstriction resulting in hemostasis and delayed absorption of the anesthetic agent, which prolongs its effect, decreases the amount of anesthetic needed, and reduces the risk of lidocaine toxicity. The epinephrine dosage utilized in infiltrate solutions varies and may range from 1:100,000 to 1:1,000,000 depending on such variables as the liposuction technique, the volume of infiltrate infused, and the type of alkalized fluid utilized in the infiltrate mixture.³⁴ It is recommended that epinephrine doses not exceed 0.07 mg/kg, although doses as high as 10 mg/kg have been used safely.³⁴ It should be noted that if the dose of vasoconstrictor (epinephrine) is high, its systemic absorption can affect hepatic blood flow and modify the rate of disposition of the local anesthetics such as lidocaine and bupivacaine

that are metabolized by the liver.²⁶ In larger-volume liposuction cases, staged infiltration of multiple anatomic sites will provide a wider safety margin.

Epinephrine use should be avoided in patients who present with pheochromocytoma, hyperthyroidism, severe hypertension, cardiac disease, or peripheral vascular disease. In addition, cardiac arrhythmias can occur in predisposed individuals or when epinephrine is used with halothane anesthesia. Alterations in the rate and force of contraction or cardiac irritability and hypertension can occur, particularly in hyperthyroid patients.³⁴

Recommendations

1. In small-volume liposuction, infiltrate solutions containing local anesthetic agents may be sufficient to provide adequate pain relief without the need for additional anesthesia measures. The patient or the surgeon may prefer the use of sedation or general anesthesia even with small volumes of liposuction.
2. Marcaine (bupivacaine) should be used cautiously as an additive in infiltrate solutions due to the severity of side effects, slow elimination, and inability to reverse potential toxicity.
3. Lidocaine administered in wetting solutions to large or multiple regions of the body has the potential to cause systemic toxicity. Preventive measures include the following:
 - Limit the lidocaine dose to safe levels of 35 mg/kg. This level may not be safe in patients with low protein levels and other medical conditions where the metabolic byproducts of lidocaine breakdown may reach problematic levels.
 - Calculate the dose for total body weight.
 - Reduce the concentration of lidocaine when necessary.
 - Utilize the superwet rather than the tumescent technique.
 - Consider not using lidocaine when general or regional anesthesia is utilized.
4. Epinephrine use should be avoided in patients who present with pheochromocytoma, hyperthyroidism, severe hypertension, cardiac disease, or peripheral vascular disease. In addition, cardiac arrhythmias can occur in predisposed individuals or when epinephrine is used with halothane anesthesia. The surgeon

must carefully evaluate these types of patients before performing liposuction.

5. Consider staging the infiltration of multiple anatomic sites to reduce the possibility of an excess epinephrine effect.

Plastic surgeons recognize the definitions of the American Society of Anesthesiologists regarding the types and levels of sedation and analgesia. These definitions comprise a continuum of levels ranging from minimal sedation (anxiolysis) to general anesthesia (Table I).²

General Anesthesia

The use of general anesthesia for liposuction has been a source of professional debate and unsubstantiated implications regarding its safety.^{35,36} However, studies indicate that general anesthesia is safe and effective in an accredited office-based surgery facility. In a review of 23,000 patients undergoing general anesthesia in the office-based setting, no intraoperative or postoperative deaths and no significant complications occurred.³⁷ General anesthesia is particularly suitable for complex or long operations and may provide a greater margin of safety than other routes of anesthesia because the anesthetic dose is more precise. During general anesthesia, the patient is comfortably asleep, allowing the surgeon to focus full attention on the procedure without the distraction of inadvertent patient movement. General anesthesia also decreases the risk of intraoperative airway obstruction, aspiration, and intraoperative laryngospasm.³⁷

Epidural Anesthesia

Studies indicate that epidural anesthesia combined with the infusion of anesthetic infiltrate provides patients with a consistent intraoperative comfort level. Chloroprocaine is often the anesthetic agent utilized because it is rapidly metabolized and has the lowest sys-

temic toxicity risk of local anesthetic agents. However, epidural anesthesia can cause vasodilation and hypotension, which result in the administration of extra fluid and increased risk of fluid overload.³⁸

Moderate Sedation/Analgesia

Anesthetic techniques utilizing intravenous sedatives, hypnotics, and narcotics are widely utilized in the office-based surgery setting. When applied to liposuction procedures, clinical experience suggests an excellent safety margin.^{39,40}

Recommendations

1. Plastic surgeons should utilize the American Society of Anesthesiologists' Guidelines for Sedation and Analgesia.²
2. General anesthesia can be used safely in the office setting.
3. General anesthesia has advantages for more complex liposuction procedures that include precise dosing, controlled patient movement, and airway management.
4. Epidural and spinal anesthesia in the office setting is discouraged because of the possibility of vasodilation, hypotension, and fluid overload.
5. Moderate sedation/analgesia augments the patient's comfort level and is an effective adjunct to anesthetic infiltrate solutions.

PATIENT SELECTION

One of the most important aspects in the success of any surgical procedure is the physical condition of the patient at the time of surgery. A discussion of patient selection criteria for the office-based surgery facility can be found in the ASPS patient selection practice advisory.⁴¹

TABLE I
Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia

	Minimal Sedation (anxiolysis)	Moderate Sedation/Analgesia ("conscious sedation")	Deep Sedation/Analgesia	General Anesthesia
Responsiveness*	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

* Reflex withdrawal from a painful stimulus is not considered a purposeful response. Source: www.asahq.org.

Localized Adiposity

Liposuction is a very effective treatment for recontouring localized fat deposits of the trunk, abdomen, and thighs. It has also been used to a more limited extent to correct areas on the upper arms and breasts as an adjunct to reduction mammoplasty or treatment for gynecomastia.⁴²⁻⁴⁵ Facial aesthetic surgery has also utilized liposuction for recontouring the neck and localized areas of the face, and it has even been used in some reconstructive procedures, such as flap defatting, to advantage.

Obesity

Large-volume liposuction has become a technique for addressing contour irregularities, but preliminary studies also suggest improvement in cardiovascular risks, blood pressure reduction, and reduced levels of fasting insulin after liposuction.⁴⁶ While liposuction may provide some physiologic benefit to the obese patient, there are inherent risks in these patients that must be considered, such as poor wound healing, infection, deep venous thrombosis, and sleep apnea.⁴⁷ This is particularly true with respect to the morbidly obese patient, defined as a patient with a body mass index of 30 or higher. The relative risk/benefit of surgery can be estimated based on the body mass index of the patient, which is calculated as kilograms per meter squared (kg/m²). A reference chart is

provided in Table II.⁴⁸ Liposuction is not considered a standard treatment for obesity.

Special Considerations

Some patients may be unsuitable for liposuction, including patients with minimal localized adiposity, patients with existing medical conditions that preclude surgical intervention, and patients with unrealistic expectations. For these patients, exercise, diet, medical consultation, and even psychological intervention are still viable options.

Recommendations

1. Even though liposuction is generally an elective procedure, the liposuction patient must be assessed using the same standards as those used for anyone who is undergoing any type of surgery, including a complete preoperative history and physical examination.
2. In some cases, liposuction may be used in the treatment of gynecomastia, breast hypertrophy, and obesity.
3. The body mass index is a good method to assess the liposuction patient's relative risk/benefit for the procedure.
4. In obese patients receiving large-volume liposuction, it may be necessary to modify the anesthetic infiltrate solution to prevent lidocaine toxicity.
5. Not all patients are appropriate liposuction candidates. These patients may wish to con-

TABLE II
Body Weight in Pounds According to Height and Body Mass Index

Height (inches)	BMI (kg/m ²)													
	19	20	21	22	23	24	25	26	27	28	29	30	35	40
	<i>Weight in pounds</i>													
58	91	96	100	105	110	115	119	124	129	134	138	143	167	191
59	94	99	104	109	114	119	124	128	133	138	143	148	173	198
60	97	102	107	112	118	123	128	133	138	143	148	153	179	204
61	100	106	111	116	122	127	132	137	143	148	153	158	185	211
62	104	109	115	120	126	131	136	142	147	153	158	164	191	218
63	107	113	118	124	130	135	141	146	152	158	163	169	197	225
64	110	116	122	128	134	140	145	151	157	163	169	174	204	232
65	114	120	126	132	138	144	150	156	162	168	174	180	210	240
66	118	124	130	136	142	148	155	161	167	173	179	186	216	247
67	121	127	134	140	146	153	159	166	172	178	185	191	223	255
68	125	131	138	144	151	158	164	171	177	184	190	197	230	262
69	128	135	142	149	155	162	169	176	182	189	196	203	236	270
70	132	139	146	153	160	167	174	181	188	195	202	207	243	278
71	136	143	150	157	165	172	179	186	193	200	208	215	250	286
72	140	147	154	162	169	177	184	191	199	206	213	221	258	294
73	144	151	159	166	174	182	189	197	204	212	219	227	265	302
74	148	155	163	171	179	186	194	202	210	218	225	233	272	311
75	152	160	168	176	184	192	200	208	216	224	232	240	279	319
76	156	164	172	180	189	197	205	213	221	230	238	246	287	328

Source: <http://www.consumer.gov/weightloss/bmi.htm>.

tinue diet and exercise routines, seek medical intervention to treat an existing condition(s), consider bariatric evaluation, or, in the case of patients who have unrealistic expectations about their condition or potential outcomes, be referred for a psychiatric or psychological evaluation.

LIPOSUCTION VOLUME

After determining that the patient is an appropriate liposuction candidate, the surgeon must determine the appropriate volume of fat to remove. Advances in liposuction equipment and technique, along with reduced intraoperative blood loss, have made it possible for skilled surgeons to safely remove larger volumes of fat. Large-volume liposuction is defined as the removal of 5000 cc or greater of total aspirate during a single procedure. A review of the scientific literature shows that there are no scientific data available to support a specific volume maximum at which point liposuction is no longer safe,²¹ although the risk of complications is unavoidably higher as the volume of aspirate and the number of anatomic sites treated increase. Body mass index and the potential physiological consequences of the tissue loss should be considered to ensure that the volume of aspirate removed is proportional to the patient's overall size and medical condition. In some instances, it may be best to perform larger-volume aspirations as separate, serial procedures and avoid combining additional procedures with large-volume liposuction.⁴⁹

It is important for health policy makers and state regulators to note the distinction between total fat removed and total aspirate removed. Total aspirate is defined as the combination of total fat and fluid that is removed during liposuction. It is the position of the ASPS that when referring to liposuction volume, total aspirate should be the volume recorded.

Recommendations

1. Regardless of the anesthetic route, large-volume liposuction (greater than 5000 cc of total aspirate) should be performed in an acute-care hospital or in a facility that is either accredited or licensed. Postoperative vital signs and urinary output should be monitored overnight in an appropriate facility by qualified and competent staff who are familiar with perioperative care of the liposuction patient.
3. Under certain circumstances, it may be in the

best interest of the patient to perform large-volume procedures as separate serial procedures and to avoid combining them with additional procedures.

FLUID MANAGEMENT

Profound metabolic alterations accompany large volume liposuction. An understanding of the physiological impact of liposuction is essential for the physician performing the procedure. Fluid management is one of the fundamentals of surgical training. Supervising the fluid and electrolyte balance of a patient during a liposuction procedure is comparable to managing an acute burn, a major abdominal operation, or a trauma patient. These are everyday experiences for surgical trainees.

Before large preinfiltrates came into common use, predictable responses to intravenous fluid administration made replacement a straightforward task. Large preinjectate techniques, such as the tumescent technique, complicate fluid replacement estimates. While the tumescent technique is very safe when administered in appropriate doses and monitored by properly trained personnel, it is not without potential complications, especially when used in large volumes. Because tumescent liposuction relies on high-volume hypodermoclysis, the possibility of fluid overload exists. This, in turn, can result in serious complications, such as pulmonary edema and fluid imbalance.^{26,50} Because of the increasingly large volumes of infiltrate used in larger-volume liposuction, careful attention must be paid to all fluid infused, whether as part of the infiltrate solution or as intravenous fluids administered during the procedure. It is essential that all remaining fluid be accounted for when assessing total output, including the total volume of aspirate, any additional blood loss from concomitant procedures, and urine output. It is estimated that 50 to 70 percent of the residual fluid volume is left behind when a liposuction procedure is completed.⁵¹ The residual fluid volume can be calculated using Table III. Maintenance fluid is the amount of fluid to be replaced from the preoperative, nothing-by-mouth status. Seventy percent of subcutaneous infiltrate is presumed to be intravascular.⁵²

Patients with a residual volume of wetting solution greater than 70 ml/kg are more likely to experience fluid overload and require an extended period of observation and diuretic treatment. Signs and symptoms of fluid over-

TABLE III
Liposuction Fluid Resuscitation Guidelines

Small-Volume Aspirations (<5 liters)	Large-Volume Aspirations (>5 liters)
Maintenance fluid* Subcutaneous infiltrate†	Maintenance fluid* Subcutaneous infiltrate† 0.25 ml of intravenous crystalloid per milliliter of aspirate >5 liters

* Amount of fluid to be replaced from preoperative, nothing-by-mouth status.

† Seventy percent is presumed to be intravascular (Rohrich, R. J., and Beran, S. J. Is liposuction safe? *Plast. Reconstr. Surg.* 104: 819, 1999).

load include increased blood pressure, jugular vein distension, full bounding pulse, cough, shortness of breath, and moist crackles on auscultation of the lungs.²³

Recommendations

1. A data sheet should be used to facilitate communication.
2. The intake and output of all fluids utilized in the operative and postoperative periods should be accurately monitored.
3. Communication with the anesthesia care provider about fluid management is critical.
4. Fluid management and liposuction surgery must account for maintenance requirements, preexisting deficits, and intraoperative losses of aspirated tissue and third-space deficit.
5. Preexisting fluid deficits should be minimal after an overnight fast.
6. Blood loss estimates should be made and confirmed with preoperative and postoperative hemoglobin measurements. However, due to fluid shifts, hemoglobin levels may not be reliable during the first 24 hours postoperatively.
7. Calculation of residual fluid volumes after liposuction is helpful in planning postoperative care.

MULTIPLE PROCEDURES

The cumulative effect of multiple procedures performed during a single operation increases the potential that complications may develop.⁵³ However, limited liposuction aspiration volumes are routinely and safely obtained in combination with additional plastic surgery procedures in office-based facilities. Some states restrict the use of liposuction in combination with other procedures in the office facility, and surgeons should be aware of their individual state's regulations. While there are some data to support these local limitations, the data tend to be anecdotal or in studies lacking the rigor necessary to establish standards of practice. However, when large-volume liposuction is combined with procedures such

as abdominoplasty, serious complications have been reported.⁵³

Recommendations

1. Large-volume liposuction combined with certain other procedures has resulted in serious complications, and such combinations should be avoided.⁵⁴
2. Individual patient circumstances may warrant performing liposuction as a separate procedure.⁵⁴

INTRAOPERATIVE CARE

There are several precautions that can be taken intraoperatively to maximize the postoperative recovery, including warming the skin preparation and intravenous and infiltrate solutions to body temperature with approved devices and using surface forced conductive hot air warmers to preserve body core temperature. Patients in the supine position should be properly positioned and padded on the operating table, with their knees slightly flexed so as to maximize blood flow through the popliteal vein. Special attention to positioning is also required for patients in the prone and decubitus positions. Intermittent pneumatic compression devices should be used intraoperatively to prevent deep vein thrombosis, particularly with patients at moderate to high risk of blood clots. Low-molecular-weight heparin may also be administered to those patients at higher risk.⁵⁵

POSTOPERATIVE CARE

Immediate postoperative care should include assessment of fluid and electrolyte balance and administration of replacement fluids, as needed. In addition, red blood cell loss needs to be assessed and replacement red blood cells administered, if needed. Patients who undergo large-volume liposuction or multiple procedures should be warmed as they recover, using surface forced conductive hot air warmers.

All patients who have received general anesthesia, regional anesthesia, or deep or moderate sedation should receive appropriate post-anesthesia management.² Medical supervision and coordination of the patient's care should be performed by a physician. Observation and monitoring by methods appropriate to the patient's condition by qualified and competent staff are essential. Depending on the amount of aspirate removed, the patient needs to be monitored for several hours or, possibly, overnight. Before a patient is discharged, the patient must be alert and oriented and all vital signs must be stable. Compression garments and elastic stockings are generally used for several weeks following surgery. The patient should expect significant bruising and swelling for at least the first 48 to 72 hours postoperatively. Pain management in the immediate postoperative period may require small doses of parenteral narcotics. The patient may be sent home with oral pain medication, which may be needed for several days. The need for pain medication should lessen after that time. In fact, if progressively worsening pain is present, this must be reported immediately to the physician, as it may be indicative of infection or other complications.⁵

Long-term follow-up care includes assessment of postoperative recovery at regular intervals, depending on the extent of the procedure. This assessment should examine wound healing and scar maturation as well as patient satisfaction.

POSSIBLE COMPLICATIONS

Serious medical complications are rare following liposuction, though their frequency increases with the number of sites treated and the volume of fat aspirated.⁵³ In addition to the lidocaine toxicity and fluid overload discussed earlier, complications may range from relatively minor conditions to more serious or life-threatening events. Minor complications that resolve on their own or with little additional treatment include small hematomas, seromas, and minor contour irregularities. More severe complications include skin perforation, major contour defects, skin necrosis, thermal injury, vital organ injury, adverse anesthesia reaction, pulmonary embolus, and fat embolus.^{23,56,57} Some of the most severe complications may require additional surgery or hospitalization.

Infection can be one of the more serious complications of liposuction. Localized wound

infection can progress, sometimes rapidly, causing serious to fatal outcomes. The most serious of these complications include toxic shock and necrotizing fasciitis.^{56,58} Aggressive management of the initial infection can forestall more serious complications. The use of prophylactic antibiotics is a decision that is best made by the physician. It is essential that wounds be kept clean and that any change in the wound site be reported to the physician immediately.

Pulmonary embolus results from one or a combination of these three mechanisms: venous stasis, activation of blood coagulation, or injury to the vascular endothelium. Signs and symptoms of deep venous thrombosis include calf pain, leg edema, and venous engorgement. Signs and symptoms of pulmonary embolism include chest pain, dyspnea, hemoptysis, tachycardia, tachypnea, altered mental status, rales, rhonchi, and decreased oxygen saturation.^{23,33,59}

One of the most important ways to prevent pulmonary embolism is to adequately assess the patient regarding his or her risk of pulmonary embolus. The mechanisms of pulmonary embolism are discussed in detail in the ASPS statement on deep vein thrombosis prophylaxis.⁵⁵ The patient should be assessed for genetic and acquired conditions that predispose him or her to coagulation disorders, such as the use of oral contraceptives or hormone replacement therapy. Once the patient's relative risk is determined, appropriate prophylaxis can be implemented, including preoperative and intraoperative interventions such as thromboembolic disease stockings, compression devices, and prophylactic anticoagulation therapy.⁵⁴ The likelihood of dying from pulmonary embolism depends on the size of the embolus, the size and number of pulmonary arteries blocked, and the person's overall health.

Fat emboli, while somewhat less common than pulmonary emboli, have been implicated in liposuction deaths.^{33,59} There are two theories as to the origin of fat emboli, one mechanical and the other biochemical.^{23,33} In liposuction cases, a mechanical blockage can occur when the rupture of vessels and damage to adipocytes allow the entrance of globules of triglyceride into the venous circulation. The fat globules are too large to pass through the pulmonary capillaries, where they become trapped. Symptoms of a fat embolus include tachycardia, tachypnea, elevated temperature, hypoxemia, hypocapnia, thrombocytopenia,

and occasionally mild neurological symptoms. It is essential to distinguish fat embolus from pulmonary embolus because the treatment is different.^{23,59} In contrast to a mechanical fat embolism, fat embolism syndrome occurs later and is an inflammatory and biochemical condition. In theory, the syndrome occurs when circulating or hydrolyzed free fatty acids in the pulmonary system damage the endothelial cells and pneumocytes. The clinical course of the syndrome can vary from mild dyspnea to adult respiratory distress syndrome. The three classic symptoms of fat embolism syndrome are respiratory distress, cerebral dysfunction, and petechial rash, which usually occur within 24 to 48 hours after surgery. Treatment includes pulmonary support, evaluation of hemodynamics, monitoring of fluid status, and, in some cases, the use of high doses of corticosteroids.²³

Hypothermia also poses cardiovascular and wound-healing risks, and preventive warming measures should be instituted.⁵⁴

FACILITY SELECTION

The surgical technique used and the surgical facility where the liposuction is to be performed should be determined by the physician after consideration of the patient's overall health and the area(s) of the body that will be liposuctioned. While a surgeon can safely perform most liposuction procedures in an accredited office-based surgery facility or ambulatory surgery facility, hospitalization may be required for some patients. A discussion of patient selection criteria for the office-based setting can be found in the ASPS patient selection advisory⁴¹ and should be consulted for that purpose. Plastic surgeons who are members of ASPS are required to perform office-based surgery in accredited facilities as well as meet their individual state facility regulations.

TRAINING AND QUALIFICATIONS

Physicians who perform liposuction without having surgical training may not be as prepared as trained surgeons to handle an unexpected complication of liposuction when it occurs. Liposuction is a surgical procedure, and as such, physicians performing liposuction must be trained as surgeons. Surgical training is defined by one of the 10 surgical boards recognized by the American Board of Medical Specialties (ABMS).

Recommendations

1. Physicians performing liposuction must be trained as surgeons. A surgeon's scope of practice is defined by one of the 10 surgical boards recognized by the ABMS.
2. Surgeons performing procedures outside of his or her area of training, defined by the surgeon's specialty, must obtain additional education, certification, and experience. The ABMS surgeon must have liposuction and body-contouring training and must operate in his or her area of anatomic expertise. The physician who performs liposuction in any surgical setting must meet *all* of the following minimal formal training requirements:
 - a. The physician must have a basic education: M.D. or D.O.
 - b. The physician must be qualified for examination or be certified by a surgical board recognized by the ABMS, *and* the physician must
 - i. Complete training in liposuction/body contouring during an accredited residency or fellowship; or
 - ii. Complete an 8-hour liposuction/body-contouring training course approved for category I Continuing Medical Education credit with at least 3 hours of hands-on bio-skills cadaver training and a comprehensive instructional program on fluid replacement. Observation by a proctor with liposuction privileges for the first three clinical procedures is recommended.
 - c. The physician must operate within his or her area of training and area of anatomic expertise, which is defined by his or her ABMS surgical specialty board.
3. A physician should have the primary responsibility for providing and/or supervising anesthesia. All anesthesia should be ordered by a physician. Anesthetics may be administered by either a qualified physician, a certified registered nurse anesthetist under physician supervision, or another qualified health care provider under the supervision of a qualified physician as required by law.²⁴ The responsible physician must be physically present in the operating room throughout the conduct of the anesthetic.

FACILITY ACCREDITATION

In addition to the training and qualifications of the physician performing the liposuction, the location where the surgical procedure is

performed is very important. Plastic surgery, including liposuction, performed under anesthesia, other than minor local anesthesia and/or minimal oral tranquilization, should be performed in a surgical facility that meets at least one of the following criteria:

- Accredited by a national or state-recognized accrediting agency/organization such as the American Association for Accreditation of Ambulatory Surgery Facilities, the Accreditation Association for Ambulatory Health Care, the American Osteopathic Association, or the Joint Commission on Accreditation of Healthcare Organizations.
- Certified to participate in the Medicare program under Title XVIII.
- Licensed by the state in which the facility is located.

CONCLUSIONS

For the past two decades, liposuction has proven to be a safe, effective, and popular intervention for the surgical removal of adipose tissue. Liposuction techniques have advanced from the treatment of minor contour irregularities to more extensive body contouring. Even with these advances, liposuction should be performed only after careful consultation with the patient's primary physician. Liposuction patients should be assessed like any other surgical patient. This includes a complete preoperative evaluation with particular attention to anything that might predispose the patient to complications.

The surgeon has a choice of a variety of liposuction techniques, cannula designs, and anesthesia options. When selecting the most appropriate technique(s) for each individual patient, it is the surgeon's responsibility to weigh such factors as the anticipated liposuction volume, number of unrelated procedures, treatment sites, anesthesia route, facility type, and the patient's overall health status.

The management of the postoperative period is critical to the outcome of liposuction. Qualified staff provide the appropriate postanesthesia and postoperative care. Particularly in larger-volume cases, management of fluid and electrolyte balance, pain management, and monitoring for complications are important duties.

When performed by a surgeon with knowledge of the physiologic implications of this

surgery, liposuction can be a safe procedure that results in significant patient satisfaction.

Ronald E. Iverson, M.D.
The Plastic Surgery Center
1387 Santa Rita Road
Pleasanton, Calif. 94566

REFERENCES

1. American Hospital Association. *Hospital Statistics, 2000*. Chicago: American Hospital Association, 2001.
2. American Society of Anesthesiologists. *Information on Publications and Standards*. Available at www.asahq.org/publications/and_services/standards. Accessed May 5, 2002.
3. American Society of Plastic Surgeons. *Information on Procedural Statistics*. Available at www.plasticsurgery.org. Accessed May 5, 2002.
4. Hait, P. History of the American Society of Plastic and Reconstructive Surgeons, Inc. 1931–1994. *Plast. Reconstr. Surg.* 94 (Suppl.): 79A, 1994.
5. Food and Drug Administration. *Liposuction Information*. Available at www.fda.gov/cdrh/liposuction. Accessed January 30, 2003.
6. Rohrich, R. J., Beran, S. J., and Fodor, P. B. The role of subcutaneous infiltration in suction-assisted lipoplasty: A review. *Plast. Reconstr. Surg.* 99: 514, 1997.
7. Fodor, P. B. Wetting solutions in ultrasound-assisted lipoplasty. *Clin. Plast. Surg.* 26: 289, 1999.
8. Klein, J. A. Tumescence technique for local anesthesia improves safety in large volume liposuction. *Plast. Reconstr. Surg.* 92: 1085, 1993.
9. Pitman, G. H., Aker, J. S., and Tripp, Z. D. Tumescence liposuction, a surgeon's perspective. *Clin. Plast. Surg.* 23: 633, 1996.
10. Perry, A. W., Petti, C., and Rankin, M. Lidocaine is not necessary in liposuction. *Plast. Reconstr. Surg.* 104: 1900, 1999.
11. Matarasso, A. Ultrasound-assisted lipoplasty: Is this new technology for you? *Clin. Plast. Surg.* 26: 369, 1999.
12. Mendes, F. H. External ultrasound-assisted lipoplasty from our own experience. *Aesthetic Plast. Surg.* 24: 270, 2000.
13. Gasperoni, C., and Salgarello, M. The use of external ultrasound combined with superficial subdermal liposuction. *Ann. Plast. Surg.* 45: 369, 2000.
14. Rohrich, R. J., Morales, D. E., Krueger, J. E., et al. Comparative lipoplasty analysis of in vivo treated adipose tissue. *Plast. Reconstr. Surg.* 105: 2152, 2000.
15. Thornton, L. K., and Nahai, F. Equipment and instrumentation for ultrasound-assisted lipoplasty. *Clin. Plast. Surg.* 26: 299, 1999.
16. Pitman, G. H. *Liposuction and Aesthetic Surgery*. St. Louis, Mo.: Quality Medical Publishing, 1993. Pp. 87-93.
17. MicroAire. *Online Product Catalog, Information on Cannulas*. Available at www.microaire.com. Accessed January 30, 2003.
18. Byron Medical. *Online Product Catalog, Information on Cannulas*. Available at www.byronmedical.com. Accessed January 30, 2003.
19. Young, V. L. Safety and efficacy report: Power-assisted lipoplasty. *Plast. Reconstr. Surg.* 108: 1429, 2001.
20. Chang, C. C., and Commons, G. W. A comparison of various ultrasound technologies. *Clin. Plast. Surg.* 26: 261, 1999.

21. Commons, G. W., Halperin, B., and Chang, C. C. Large-volume liposuction: A review of 631 consecutive cases over 12 years. *Plast. Reconstr. Surg.* 108: 1753, 2001.
22. Grotting, J. C., and Beckenstein, M. S. The solid-probe technique in ultrasound-assisted lipoplasty. *Clin. Plast. Surg.* 26: 245, 1999.
23. Gingrass, M. K. Lipoplasty complications and their prevention. *Clin. Plast. Surg.* 26: 341, 1999.
24. American Association for Accreditation of Ambulatory Surgical Facilities, Inc. *AAAASF Resource Guide*. Mundelein, Ill.: American Association for Accreditation of Ambulatory Surgical Facilities, Inc., 2002. P. 37.
25. Rao, R. B., Ely, S. F., and Hoffman, R. S. Deaths related to liposuction. *N. Engl. J. Med.* 340: 1471, 1999.
26. Rubenstein, E. H. An anesthesiologist's perspective of lipoplasty. *Clin. Plast. Surg.* 26: 423, 1999.
27. Miller, R. D. *Anesthesia*, 5th Ed. Philadelphia: Churchill Livingstone, 2000. Pp. 503-517.
28. Naguib, M., Magboul, M. M., Samarkandi, A. H., and Attia, M. Adverse effects and drug interactions associated with local and regional anesthesia. *Drug Saf.* 18: 221, 1998.
29. Barash, P. G., Cullen, B. F., and Stoelting, R. K. *Clinical Anesthesia*, 3rd Ed. Philadelphia: Lippincott-Raven, 1997. Pp. 212-227.
30. *Physicians' Desk Reference*. Montvale, N.J.: Medical Economics, 2002.
31. Elkins-Sinn, Inc. *Lidocaine* (Package Insert). Cherry Hill, N.J.: Elkins-Sinn, 1990.
32. Meister, F. Possible association between tumescent technique and life-threatening pulmonary complications. *Clin. Plast. Surg.* 23: 642, 1996.
33. Platt, M. S., Kohler, L. J., Ruiz, R., Cohle, S. D., and Ravichandran, P. Deaths associated with liposuction: Case reports and review of the literature. *J. Forensic Sci.* 47: 205, 2002.
34. Matarasso, A. The tumescent technique: The effect of high tissue pressure and dilute epinephrine on absorption of lidocaine. *Plast. Reconstr. Surg.* 103: 997, 1999.
35. Bruner, J. G., and de Jong, R. H. Lipoplasty claims experience of U.S. insurance companies. *Plast. Reconstr. Surg.* 107: 1285, 2001.
36. Twersky, R. S. Update on office-based anesthesia: Caveats on the professional finger pointing. *A.S.A. Newsletter* 65: 17, 2001.
37. Hoefflin, S. M., Bornstein, J. B., and Gordon, M. General anesthesia in an office-based plastic surgical facility: A report on more than 23,000 consecutive office-based procedures under general anesthesia with no significant anesthetic complications. *Plast. Reconstr. Surg.* 107: 243, 2001.
38. Knize, D. M., and Fishell, R. Use of perioperative subcutaneous "wetting solution" and epidural block anesthesia for liposuction in the office-based surgical suite. *Plast. Reconstr. Surg.* 100: 1867, 1997.
39. Bitar, G., Mullis, W., Jacobs, W., et al. Safety and efficacy of office-based surgery with monitored anesthesia care/sedation in 4778 consecutive plastic surgery procedures. *Plast. Reconstr. Surg.* 111: 150, 2003.
40. Marcus, J. R., Tyrone, J. W., Few, J. W., Fine, N. A., and Mustoe, T. A. Optimization of conscious sedation in plastic surgery. *Plast. Reconstr. Surg.* 104: 1338, 1999.
41. Iverson, R. E., Lynch, D. J., and the ASPS Task Force on Patient Safety in Office-Based Surgery Facilities. Patient safety in office-based surgery facilities: II. Patient selection. *Plast. Reconstr. Surg.* 110: 1785, 2002.
42. Price, M. F., Massey, B., Rumbolo, P. M., and Paletta, C. E. Liposuction as an adjunct procedure in reduction mammoplasty. *Ann. Plast. Surg.* 47: 115, 2001.
43. Gray, L. N. Update on experience with liposuction breast reduction. *Plast. Reconstr. Surg.* 108: 1006, 2001.
44. Nahai, F. Update on experience with liposuction breast reduction (Discussion). *Plast. Reconstr. Surg.* 108: 1011, 2001.
45. Samdal, F. Surgical treatment of gynecomastia: Five years' experience with liposuction. *Scand. J. Plast. Reconstr. Hand Surg.* 28: 123, 1994.
46. Giese, S. Y., Bulan, E. J., Commons, G. W., Spear, S. L., and Yanovski, J. A. Improvements in cardiovascular risk profile with large-volume liposuction: A pilot study. *Plast. Reconstr. Surg.* 108: 510, 2001.
47. de Jong, R. H. Body mass index: Risk predictor for cosmetic day surgery. *Plast. Reconstr. Surg.* 108: 556, 2001.
48. Partnership for Healthy Weight Management. *Body Mass Index (BMI) Chart*. Washington, D.C.: Partnership for Healthy Weight Management. Available at www.consumer.gov/weightloss/bmi.htm. Accessed January 30, 2003.
49. Hunstad, J. P. Body contouring in the obese patient. *Clin. Plast. Surg.* 23: 647, 1996.
50. Gilliland, M. D., and Coates, N. Tumescent liposuction complicated by pulmonary edema. *Plast. Reconstr. Surg.* 99: 215, 1997.
51. Trott, S. A., Beran, S. J., Rohrich, R. J., Kenkel, J. M., Adams, W. P., and Klein, K. W. Safety considerations and fluid resuscitation in liposuction: An analysis of 53 consecutive patients. *Plast. Reconstr. Surg.* 102: 2220, 1998.
52. Rohrich, R. J., and Beran, S. J. Is liposuction safe? *Plast. Reconstr. Surg.* 104: 819, 1999.
53. Hughes, C. E., III. Reduction of lipoplasty risks and mortality: An ASAPS survey. *Aesthetic Surg. J.* 21: 120, 2001.
54. Iverson, R. E., and the ASPS Task Force on Patient Safety in Office-Based Surgery Facilities. Patient safety in office-based surgery facilities: I. Procedures in the office-based surgery setting. *Plast. Reconstr. Surg.* 110: 1337, 2002.
55. McDevitt, N. B., and the American Society of Plastic Surgeons. Deep vein thrombosis prophylaxis. *Plast. Reconstr. Surg.* 104: 1923, 1999.
56. Cedidi, C. C., and Berger, A. Severe abdominal wall necrosis after ultrasound-assisted liposuction. *Aesthetic Plast. Surg.* 26: 20, 2002.
57. Talmor, M., Fahey, T. J., Wise, J., Hoffman, L. A., and Barie, P. S. Large-volume liposuction complicated by retroperitoneal hemorrhage: Management principles and implications for the quality improvement process. *Plast. Reconstr. Surg.* 105: 2244, 2000.
58. Umeda, T., Ohara, H., Hayashi, O., Ueki, M., and Hata, Y. Toxic shock syndrome after suction lipectomy. *Plast. Reconstr. Surg.* 106: 204, 2000.
59. Ross, R. M., and Johnson, G. W. Fat embolism after liposuction. *Chest* 93: 1294, 1988.