

Advances in Liposuction: Five Key Principles with Emphasis on Patient Safety and Outcomes

Geo N. Tabbal, MD,*
 Jamil Ahmad, MD,†
 Frank Lista, MD,†
 Rod J. Rohrich, MD*

Summary: Since Illouz's presentation of a technique for lipoplasty at the 1982 Annual Meeting of the American Society of Plastic and Reconstructive Surgeons, liposuction has become one of the most commonly performed aesthetic surgery procedures. The evolution of liposuction has seen refinements in technique and improvement of patient safety-related standards of care. Based on long-term experience with body contouring surgery, 5 principles of advanced liposuction are presented: preoperative evaluation and planning, intraoperative monitoring—safety measures, the role of wetting solutions and fluid resuscitation, circumferential contouring and complication prevention, and outcomes measurement. (*Plast Reconstr Surg Glob Open* 2013;1:e75; doi: 10.1097/GOX.0000000000000007; Published online 25 November 2013.)

Sound liposuction relies on an awareness of the “three-dimensional anatomy of the fat layers.” The majority of liposuction should be performed on the middle or deeper adipose layer. In fact, it is the preservation of the superficial adipose layer that is crucial in preventing skin irregularities including dimpling, waviness, hyperpigmentation, burns, and contour irregularities.

A variety of liposuction techniques have been described. Advantages and disadvantages for each technique have been described. Suction-assisted liposuction (SAL), ultrasound-assisted liposuction (UAL), and power-assisted liposuction (PAL) have the longest track record and are suitable for most applications.¹

*From the *Department of Plastic and Reconstructive Surgery, University of Texas Southwestern Medical Center, Dallas, Tex.; and †The Plastic Surgery Clinic, Mississauga, ON, Canada.*

Received for publication July 18, 2013; accepted September 12, 2013.

Copyright © 2013 The Authors. Published by Lippincott Williams & Wilkins on behalf of The American Society of Plastic Surgeons. PRS Global Open is a publication of the American Society of Plastic Surgeons. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 3.0 License, where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially.

DOI: 10.1097/GOX.0000000000000007

SUCTION-ASSISTED LIPOSUCTION

SAL was the first technique described in liposuction and remains the most commonly used method.¹ SAL removes adipocytes and other tissues through mechanical avulsion. SAL has been described for the treatment of localized fat deposits unresponsive to diet and exercise in virtually all areas of the body. SAL is performed starting with larger diameter cannula in the deeper plane and transitioning to smaller diameter cannula in the superficial plane.

ULTRASOUND-ASSISTED LIPOSUCTION

UAL technique has undergone many refinements since its introduction by Zocchi² in 1992. UAL is particularly advantageous in patients with diminished skin tone, in liposuction of fibrous areas, including treatment of gynecomastia, during secondary liposuction, and effectively permits true circumferential body contouring.³⁻⁵ UAL requires a 3-staged technique. During infiltration, the first of the stages, room temperature wetting solution is infiltrated into the intermediate fat layer in a 1:1 infiltrate to projected aspirate volume ratio. In the second stage, UAL treatment is performed from the deep to superficial planes with the endpoint being loss of tissue resistance and change in the character of the aspirate. Contour should not be assessed due to the abundance of emulsified fat that remains in the treatment

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

area. In the third and final stage, evacuation using traditional suction cannulas is performed.

POWER-ASSISTED LIPOSUCTION

PAL uses the reciprocating motion of the tip of the cannula to facilitate fat removal. Several studies comparing PAL with SAL have shown that PAL results in less operator fatigue and provides a faster rate of fat aspiration.⁶⁻⁸ PAL is particularly advantageous in large-volume liposuction where it can reduce operator fatigue, with the treatment of fibrous areas including gynecomastia surgery, and in secondary liposuction. Recently, PAL has been applied in difficult secondary cases for release of scarred areas and redistribution of existing fat and in harvesting large volumes of fat for transfer to other areas.⁹

PREOPERATIVE EVALUATION AND PLANNING

In 2004, the Committee on Patient Safety of the American Society of Plastic Surgeons published the first “Practice Advisory on Liposuction” to help guide appropriate selection and treatment of patients seeking liposuction, which was subsequently updated in 2009.^{10,11} Patients should be generally healthy and demonstrate a commitment to long-term lifestyle changes including both healthy diet and exercise.¹²⁻¹⁴ Additionally, patient goals and expectations should be appropriate and realistic. Furthermore, patients who are either obese or who have generalized adiposity, adolescents, and patients with certain preexisting medical conditions that place them in preclusive risk may not be suitable candidates. Venous thromboembolism, the most common cause of mortality during suction lipectomy, should be managed with preoperative risk stratification and treatment, as necessary. The American Society of Plastic and Reconstructive Surgeons recently published “Evidence-based Practices for Thromboembolism Prevention” to guide risk stratification and implementation of preventative measures (Fig. 1).¹⁵

Physician-patient dialogue is paramount in this evaluation; understanding patients’ goals and setting expectations is key. This can be supplemented with adequate patient education regarding preparation for surgery, the details of the surgery, potential risks and complications (Table 1), and the expected postoperative recovery period.

Physical examination should be conducted with specific attention to skin tone and quality, the presence of scars, hernias, asymmetries, dimpling or cellulite, location of fat deposits, areas of adherence, and perceived deviations from the ide-

al gender-specific contour.¹⁶ Rohrich et al¹⁷ have suggested a preoperative data sheet (Fig. 2) to aid in appropriate documentation of examination findings that should be further supported with high-quality medical photography including anterior, posterior, oblique, and lateral views.

In the past, large-volume liposuction (>5000 mL of total aspirate) was more commonplace. However, with recognition of the increased risks of large-volume liposuction related to fluid shifts and lidocaine toxicity, American Society of Plastic and Reconstructive Surgeons recommends that large-volume liposuction be performed in an accredited/licensed facility and that overnight monitoring of postoperative vitals and urine output be performed. Consideration of modifying the lidocaine concentration of the infiltration solution, particularly in the obese (body mass index > 30 kg/m²), should be given. In addition, attention should be paid toward staging procedures or avoiding combining large-volume liposuction with other procedures.^{11,18,19}

Patient Marking

Preoperative marking of the patient is paramount for achieving desirable surgical outcomes. This should be performed in front of a mirror, which allows the patient to remain an active participant in the process. Areas that will require treatment are often labeled with circles using an indelible marker, whereas hash marks are used to label the zones of adherence (Fig. 3). Finally, proposed access incisions are placed with care taken so that they may be inconspicuous once fully healed. Often, this can be achieved by placing them asymmetrically, parallel with the relaxed skin tension lines or striae and/or scars. Most importantly, they should be located in a position that allows for complete treatment of all affected areas without having to place undue force or other distortion of the liposuction cannula during aspiration. Significant abnormalities such as scars, hernias, or contour irregularities should also be marked.

Appropriate Liposuction Technique Selection

Although SAL, UAL, and PAL may be suitable during primary liposuction, both unique anatomic regions and specific clinical settings arise in which specific modalities are advantageous over other methods of treatment.

Gynecomastia. The dense fibroglandular tissue such as that located in the male breast is treated best with UAL although some other have cited increased benefit with the use of PAL.²⁰⁻²² It is worth mentioning, however, that excisional techniques

Step I. Total = _____

| Exposing Risk Factors | | | |
|---|---|---|---|
| Check the box corresponding to each condition | | | |
| 1 Factor | 2 Factors | 3 Factors | 5 Factors |
| Minor surgery <input type="checkbox"/> | *Major surgery <input type="checkbox"/> | Previous myocardial infarction <input type="checkbox"/> | Hip, pelvis, or leg fracture <input type="checkbox"/> |
| | Immobilizing plaster cast <input type="checkbox"/> | Congestive heart failure <input type="checkbox"/> | Stroke <input type="checkbox"/> |
| | Patient confined to bed for > 72 hrs <input type="checkbox"/> | Severe sepsis <input type="checkbox"/> | Multiple trauma <input type="checkbox"/> |
| | Central venous access <input type="checkbox"/> | Free flap <input type="checkbox"/> | Acute spinal cord injury <input type="checkbox"/> |

*Major surgery is defined by the use of general anesthesia or any procedure lasting longer than 1 hour.

Step II. Total = _____

| Predisposing Risk Factors | | |
|--|---|---|
| Check the box corresponding to each condition | | |
| Clinical Setting | Inherited | Acquired |
| Age 40 to 60 (1 Factor) <input type="checkbox"/> | Any genetic hypercoagulable disorder (3 Factors) <input type="checkbox"/> | Lupus anticoagulant (3 Factors) <input type="checkbox"/> |
| Age > 60 (2 Factors) <input type="checkbox"/> | | Antiphospholipid antibodies (3 Factors) <input type="checkbox"/> |
| History of DVT/PE (3 Factors) <input type="checkbox"/> | | Myeloproliferative disorders (3 Factors) <input type="checkbox"/> |
| Pregnancy or < 1 month postpartum (1 Factor) <input type="checkbox"/> | | Heparin-induced thrombocytopenia (3 Factors) <input type="checkbox"/> |
| Malignancy (2 Factors) <input type="checkbox"/> | | Hyperviscosity (3 Factors) <input type="checkbox"/> |
| Obesity > 20% IBW (1 Factor) <input type="checkbox"/> | | Homocystinemia (3 Factors) <input type="checkbox"/> |
| Oral contraceptive / hormone replacement therapy (1 Factor) <input type="checkbox"/> | | |

Step III. Total Step I and Step II = _____ Factors

Step IV. Orders

| | | |
|-------------|---------------|--|
| 1 Factor | Low risk | Ambulate patient TID <input type="checkbox"/> |
| 2 Factors | Moderate risk | Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating <input type="checkbox"/> |
| 3-4 Factors | High risk | Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating <input type="checkbox"/> |
| > 4 Factors | Highest risk | Intermittent pneumatic compression stockings with elastic compression stockings on at all times when not ambulating <input type="checkbox"/> + 1. Enoxaparin (Lovenox) 40mg SQ once daily post op <input type="checkbox"/> |

For 1 : Give first dose 12 hours Post Op

Signature _____
Print Name _____

Date/Time _____
Pager # _____

Fig. 1. A plastic surgery venous thromboembolism prophylaxis order form as devised by Seruya et al.¹⁶ Reprinted with permission from *Plast Reconstr Surg.* 2008;122:1701–1708.

Table 1. Risks and Complications

| Common Sequelae | Potential Complications |
|---|-------------------------|
| Ecchymosis | Volume overload |
| Edema | Thermal injury |
| Paresthesias | Seroma |
| Temporary weight gain secondary to fluid administration | Dysesthesia |
| | Dyschromia |
| | Venous thromboembolism |
| | Contour deformity |

do play an adjunctive role in the management of gynecomastia.

Large Volume/Fat Harvest. Harvesting fat is particularly suited for PAL as it efficiently removes fat without the use of energy although simple syringe suction is a reliable alternative.

Revision Liposuction. UAL and PAL may be beneficial in secondary cases due to their ability to break up

BODY CONTOURING DATA SHEET - PRE - OP

Patient Name: _____ Date: _____ Age: _____ Sex: male female Race: _____

Proposed Procedure: _____ Surgeon: _____

Past Surgical History: _____

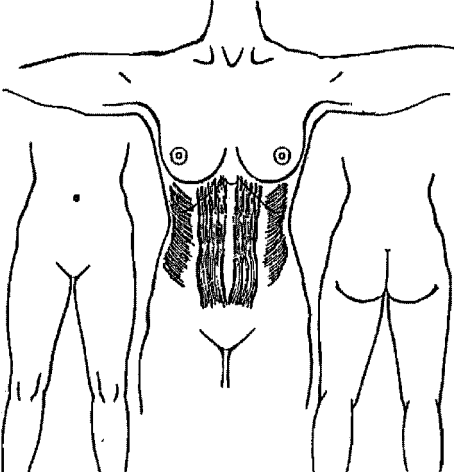
Medical History: Diabetes Hypertension Hepatitis Pneumonia COPD Myocardial Infarction Pulmonary embolus/DVT
 Smoker (if yes, how long? _____ /packs per day) Other (note below)

Medications: _____ Allergies: _____

Exercise Frequency: sporadic (1 times/week) occasional (2-3 times/week) regular (4-6 times/week) daily

Weight: _____ lbs. Weight loss/Gain (last 12 months) loss: _____ lbs. gain: _____ lbs. height: _____

* Circle Body Contouring Areas



| Skin Exam | Left | Right |
|------------------|---------------|-------|
| • Skin Tone | normal _____ | _____ |
| | flaccid _____ | _____ |
| • Asymmetry | _____ | _____ |
| • Dimpling | _____ | _____ |
| • Stria | _____ | _____ |
| • Telangiectasia | _____ | _____ |
| • Varicose veins | _____ | _____ |

Fig. 2. Preoperative data sheet.

adhesions between fascia and dermis due to scarring. In many cases, revision liposuction will also involve redistribution of fat and fat grafting to sites that have been previously overtreated.

INTRAOPERATIVE MONITORING—SAFETY MEASURES

Anesthesia

Liposuction can be performed using general or local anesthesia. However, several key principles exist which should help guide the appropriate choice of anesthetic. Small-volume liposuction (≤ 1000 mL) can be safely performed with local anesthetic, a proper wetting solution, and additional sedation as needed. However, general anesthesia may be more preferable and comfortable in more complex, large volume or combination procedures with an emphasis on endotracheal intubation if the patient is to be in the prone position. Because of their potential for vasodilation and hypotension, with resultant risk of fluid overload due to aggressive fluid resuscitation, both epidural and spinal anesthesia should be avoided.¹²

Positioning

Body contour surgeons are able to safely perform liposuction from the prone and/or the supine and lateral decubitus positions. As much as 75% of the body can be accessed from the prone position, includ-

ing the arms, back, hips/flanks, the lateral/posterior areas, and a portion of the medial thigh. Adequate padding of all pressure points must be performed along with routine sterile prepping and draping of the patient. The remaining areas can be addressed with the patient supine. Utmost effort should be made to use sequential compression devices on the lower extremities including placement on the feet when more complete lower body preps are employed.^{15,23,24} Passive and active warming maneuvers, such as maximizing preoperative warming, increasing ambient room temperatures, minimizing exposed areas, application of cutaneous warming devices or forced air warming blankets, and warming of all fluids, should be employed to prevent hypothermia.^{25,26}

ROLE OF WETTING SOLUTIONS AND FLUID RESUSCITATION

Wetting Solutions

The use of wetting solutions has enabled liposuction treatment to be performed more safely, in larger volumes, with improved outcomes and, in part, reduced complications. Various types of wetting solutions now exist and can be classified into one of the four categories: dry, wet, superwet, and tumescent (Tables 2 and 3).

Nearly all of the current, commonly used wetting solutions combine a crystalloid (Lactated Ringers or

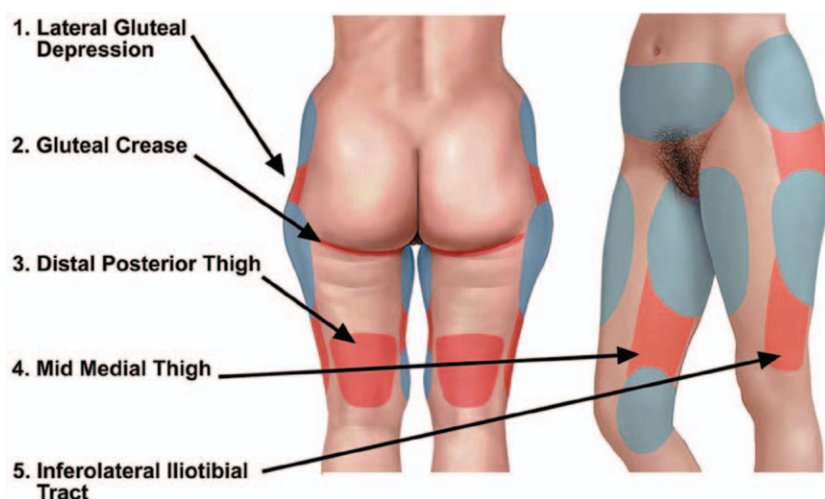


Fig. 3. Anatomic zones of adherence (marked in red) include the lateral gluteal depression, gluteal crease, distal posterior thigh, mid-medial thigh, and inferolateral iliotibial tract. Commonly treated areas for liposuction are marked in blue. Reprinted with permission from *Plast Reconstr Surg.* 2001;107:1562–1569.

normal saline) with epinephrine and lidocaine. Previous research has established guidelines for the safe use of lidocaine in liposuction. Lidocaine concentrations up to 35 mg/kg have been used safely.²⁷ Peak serum concentrations of lidocaine occur approximately 6 to 12 hours following infiltration.²⁸ Recent work by Hatef et al²⁹ studying the effect of varying concentrations of lidocaine on intraoperative anesthesia requirements and postoperative pain when general anesthesia has been administered showed that decreasing concentrations of lidocaine in infiltrative wetting solutions did not significantly affect intraoperative anesthesia requirements or postoperative pain. Peak concentrations of lidocaine and its active metabolite, monoethylglycinexylidide, occur 15.2 hours (range, 8–28 h) post infiltration despite subtherapeutic tissue levels of lidocaine within 4 to 8 hours.³¹ The use of Marcaine should be avoided due to higher potential cardiac toxicity and duration of action.¹¹

Fluid Resuscitation

During liposuction, fluid shifts can manifest in both extremes of fluid status: hypovolemia due to under resuscitation or pulmonary edema and/or congestive heart failure due to over resuscitation. Monitoring urine output with a Foley catheter and constant dialogue between the anesthesia provider and the surgeon should be maintained throughout the procedure to ensure optimal fluid resuscitation. Four crucial elements should guide intraoperative resuscitation: intravenous fluid maintenance (body weight dependent), third space losses, volume of wetting solution infiltrated, and the total volume of lipoaspirate.¹⁷

Even higher regard for fluid management is required for large-volume liposuction. In 2006, Rohrich et al³¹ proposed guidelines to aid in this management:

1. Preoperative fluid losses should be repleted as needed and at the discretion of the surgeon and anesthesiologist.
2. Maintenance fluids and fluid boluses should be administered during surgery based on the patient's vital signs and urine output.
3. Superwet technique should be employed.
4. An additional 0.25 mL of lactated Ringer's solution should be given intraoperatively for every 1 mL of aspirate.

CIRCUMFERENTIAL CONTOURING AND COMPLICATION PREVENTION

Systematic Use of Body Contouring

To achieve the best results from currently available techniques, one must employ a specific sequence of techniques, the goal of each being to complement the next. For example, during UAL, the surgeon should begin by infiltration with the wetting solution using a 1:1 superwet technique. Next, large-volume ultrasound liposuction is performed using a 3-mm round tip cannula, approximately 35 cm in length, working in a superficial to deep direction. Finally, during the evacuation phase, SAL is performed working in a deep to superficial plane with consecutively smaller (3.7–3.0) diameter tip cannula used as one works more superficially. Pertinent volumes and other data collected

Table 2. Infiltration to Aspiration Ratios of Wetting Solutions Used in Liposuction

| Technique | Infiltrate Volume | Aspirate |
|-----------|--------------------------------|--|
| Dry | No infiltrate | To treatment endpoint |
| Wet | Symmetrical pinch test results | To treatment endpoint |
| Superwet | 1 mL infiltrate: 1 mL aspirate | 1 mL aspirate/infiltrate (treatment endpoints) |
| Tumescent | Infiltrate to skin turgor | 2–3 mL aspirate/mL infiltrate |

Table 3. Estimated Blood Loss of Wetting Solutions Used in Liposuction

| Technique | Estimated Blood Loss as % of Volume Aspirated |
|-----------|---|
| Dry | 20–45 |
| Wet | 4–30 |
| Superwet | 1 |
| Tumescent | 1 |

during this time are recorded onto an intraoperative data sheet (Fig. 4).

Prevention of Contour Irregularities

Surgical technique is the key to safety and patient outcomes. Variations in surgical approach exist and are dependent on the type of liposuction being performed. For example, during UAL, the skin should never be grasped or held around the cannula while maintaining the depth of the cannula at least 1–1.5 cm deep to the dermis. However, regardless of the liposuction modality, the employment of smooth, uniform, radial pattern gestures is paramount to preventing contour irregularities. Depth of the cannula is of critical importance as liposuction in the superficial subcutaneous tissues is more likely to result in a contour deformity. Liposuction is a dynamic process that requires constant reevaluation. Familiarity with primary and secondary clinical endpoints of liposuction is critical to guiding treatment (Table 4).

Other key technical considerations include not overtreating areas adjacent to access incisions as they have a potential to be overtreated due to the frequency of cannula passes they may be exposed to and turning off the suction when inserting and withdrawing the cannula. It is the senior author’s experience that when encountering contour irregularities, the best course of action is to proceed with immediate fat grafting into the area of deficit with a 50% overcorrection. Users should be warned that attempting to suction the periphery of the contour depression only worsens the irregularity.

Appropriate Instrument Selection and Optimal Cannula Size and Shape

Site-specific treatment includes choosing the appropriate instruments, namely, length and diameter of cannula with appropriate tip and vacuum settings. Nu-

merous cannulas are commercially available ranging in length and diameter (2–5 mm) as well as tip configuration (blunt to sharp). Each cannula has particular advantages and should be implemented with regard to the specific technique being used. Such examples of modality-specific variations in tip design include the 2-probe design of UAL in which either a solid or a hollow probe may be used. The latter allows for continuous aspiration of emulsion during the ultrasound phase but considered to be of poorer design in the emulsion of fat.

Cannula Position

Using the nondominant hand to gently palpate the skin is necessary to maintain constant awareness of tip position. When treating areas on the trunk, it is important to carefully control the depth and direction of the cannula to avoid intrathoracic or intra-abdominal injury. One must be extremely conscientious for any encountered resistance which should be managed by adjusting the direction of cannula.

Regard for Avoidance of the Zones of Adherence

When treating the lower extremities, the 5 zones of adherence—where the superficial subcutaneous tissues are adherent to the fascia of the underlying muscle—should be avoided. These include the lateral gluteal depression, the gluteal crease, the distal posterior thigh, the middle medial thigh, and the inferolateral iliotibial tract (Fig. 3). Of these, the most important is the gluteal crease, which should never be violated. The key element is that you can go through the zone of adherence but never directly suction them to prevent deformity. However, as described by Rohrich et al,¹³ treatment during large-volume liposuction cases may involve treatment of the other zones of adherence, albeit with a small (<3.0 mm) cannula and a low pressure vacuum.

Incision Closure and Dressing

At the conclusion of the liposuction, any readily encountered fluid should be massaged out from the access incisions. A single 5-0 absorbable suture is used to close these incisions with a single interrupted knot, this allows for further fluid to egress out. Next, a single layer of topiFoam (Byron Medical, Tucson, Ariz.) is placed after which the patient is placed in compression garments.

BODY CONTOURING DATA SHEET - OPERATIVE

PATIENT NAME: _____ DATE: _____ SURGEON: _____

SEX: male female WEIGHT: _____ lbs. AGE: _____ yrs.

SKIN ASSESSMENT: normal flaccid dimpling stria other

WETTING SOLUTION: _____

AREAS TREATED - UAL: _____

AREAS TREATED - SAL: _____

ANCILLARY PROCEDURES: _____

UAL GENERATOR UNIT: _____ OUTPUT SETTING: _____ CANNULA NUMBER: _____ /SIZE: _____ EXTERNAL SHEATH: YES/NO _____

| Specific Anatomic Areas | Wetting Solution Volume (cc) | | UAL | | | SAL | | | Total Volume |
|-------------------------|------------------------------|---------------|-------------|--------------|--------------|-------------|--------------|--------------|----------------|
| | Wetting Solution | Running Total | Volume (cc) | Time Minutes | Cannula Size | Volume (cc) | Time Minutes | Cannula Size | UAL + SAL (cc) |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| Right | | | | | | | | | |
| Totals | | | | | | | | | |

PLASTIC AND RECONSTRUCTIVE SURGERY

Fig. 4. Intraoperative body contouring sheet used to collect data. Reprinted with permission from *Plast Reconstr Surg.* 1998;101:1090–1102.

Table 4. Primary and Secondary Clinical Endpoints of Suction/Power- and Ultrasound-assisted Liposuction

| Endpoint | Suction-assisted Liposuction/ Power-assisted Liposuction | Ultrasound-assisted Liposuction |
|-----------|---|---------------------------------|
| Primary | Final contour | Loss of tissue resistance |
| | Symmetrical pinch test results | Bloody aspirate |
| Secondary | Treatment time | Treatment time |
| | Treatment volume | Treatment volume |

OUTCOMES MEASUREMENT

Postoperative Care and Prevention of Complications

Compression garments are worn at all times for the first 2 weeks followed by nightly for an additional 2 weeks. The majority of small-volume patients can be counseled that they may return to work in 3–5 days, whereas, generally, 7–10 days is needed for patients undergoing larger volume procedures. Most patients will return to regular activities in 3 to 4 weeks.

Safe lipectomy depends not only on the intended action of the surgeon but also on the management of risk and prevention of complications. Gargan and

Courtiss³². broke these risks into 2 distinct subgroups: undesirable sequelae include surface contour irregularities, hypesthesia, edema, ecchymosis, and discoloration while potential complications include excessive blood loss, hematoma, seroma, infection, thrombosis, fat emboli, and skin necrosis. Notably, hypesthesia of the treatment area is to be expected rather than considered an avoidable consequence to suction lipectomy. Typically, a 3- to 6-month waiting period will allow for normal sensation to return.

Contour irregularities that are evident during the operation should be immediately addressed by fat grafting. Postoperatively, contour irregularities that arise should be treated conservatively for at least 6 months during which time they should be treated with massage therapy. Depending on the severity of the irregularity, methods of correction include liposuction of areas of prominence or adjacent to areas of depression, fat grafting, or even dermolipectomy.

More severe consequences of lipectomy include not only morbidity but also mortality. In a review by Grazer and de Jong³³ of 1200 active board-certified plastic surgeons, there were 95 fatalities in nearly 500,000 lipectomy procedures, producing a mor-

tality rate of 19 in 100,000 with 23% attributable to pulmonary embolism. In a discussion of these findings, Rohrich and Muzaffar³⁴ suggested the following Safety Guidelines in Liposuction:

1. Appropriate patient selection (American Society of Anesthesiologists class I, within 30% of ideal body weight)
2. Use of superwet technique
3. Meticulous monitoring of volume status (urinary catheterization, noninvasive hemodynamic monitoring, constant communication with anesthesiologist)
4. Judicious fluid resuscitation
 - a. For aspirate < 5 L: maintenance of fluid plus subcutaneous infiltrate
 - b. For aspirate > 5 L: maintenance of fluid plus subcutaneous infiltrate plus 0.25 mL on intravenous crystalloid per 1 mL of aspirate > 5 L.
5. Overnight monitoring of large-volume (>5 L total aspirate) liposuction patients in an appropriate healthcare facility
6. Use of pneumatic compression devices in cases performed under general anesthesia or lasting longer than 1 hour
7. Maintaining total lidocaine doses below 35 mg/kg (wetting solution)

Outcomes

Follow-up studies, although limited in quantity, have sought to characterize the long-term results of patients undergoing liposuction.^{14,15,35} In work derived from a survey distributed to 600 liposuction patients, several key findings were discovered. Notably, a responder's opinion of their appearance was the pivotal determinant in their satisfaction with their liposuction procedure. This, in turn, influenced whether they would have the procedure again or recommend it to another. Other factors, including weight gain, revision rate, the return of fat, and the level and duration of postoperative pain, did not have a statistical effect on these decisions. However, weight gain has been shown to have a direct negative impact on appearance, which, in part, impacts their satisfaction, willingness to continue therapy, and, ultimately, outcomes. These findings reiterate what has already been emphasized in body contouring, proper patient selection and physician-patient dialogue are crucial given that those patients who were not satisfied with their liposuction treatment were also those with the lowest opinion of their appearance. In a separate publication reviewing the same data, the authors relate the importance of educating patients on postoperative lifestyle changes, including continued exercise

and healthy eating, which are paramount to successful liposuction treatment.

CONCLUSIONS

Over the past 30 years, there have been many advances in surgical technique and patient-related standards for liposuction. Applying these 5 principles shown here will lead to consistent and safe results although more level II and III evidence-based research is needed to further improve outcomes and diminish risk.

Rod J. Rohrich, MD

Department of Plastic and Reconstructive Surgery
University of Texas Southwestern Medical Center
1801 Inwood Road
WA4.248
Dallas, TX 75390-9132
E-mail: rod.rohrich@utsouthwestern.edu

REFERENCES

1. Ahmad J, Eaves FF III, Rohrich RJ, et al. The American Society for Aesthetic Plastic Surgery (ASAPS) survey: current trends in liposuction. *Aesthet Surg J*. 2011;31:214–224.
2. Zocchi M. Ultrasonic liposculpturing. *Aesthetic Plast Surg*. 1992;16:287–298.
3. Zocchi ML. Ultrasonic assisted lipoplasty. Technical refinements and clinical evaluations. *Clin Plast Surg*. 1996;23:575–598.
4. Zocchi ML. *New Perspective in Lipoplasty: The Ultrasonic Assisted Lipectomy (UAL)*. Paris: Congress of the French Society of Aesthetic Surgery; 1998.
5. Rod JR, Samuel JB, Jeffrey MK, et al. *Ultrasound-Assisted Liposuction*. St. Louis, MS:Quality Medical Publishing; 1998.
6. Fodor PB. Power-assisted lipoplasty versus traditional suction-assisted lipoplasty: comparative evaluation and analysis of output. *Aesthetic Plast Surg*. 2005;29:127.
7. Scuderi N, Paolini G, Grippaudo FR, et al. Comparative evaluation of traditional, ultrasonic, and pneumatic assisted lipoplasty: analysis of local and systemic effects, efficacy, and costs of these methods. *Aesthetic Plast Surg*. 2000;24:395–400.
8. Scuderi N, Tenna S, Spalvieri C, et al. Power-assisted lipoplasty versus traditional suction-assisted lipoplasty: comparative evaluation and analysis of output. *Aesthetic Plast Surg*. 2005;29:49–52.
9. Wall S Jr. SAFE circumferential liposuction with abdominoplasty. *Clin Plast Surg*. 2010;37:485–501.
10. Iverson RE, Lynch DJ; American Society of Plastic Surgeons Committee on Patient Safety. Practice advisory on liposuction. *Plast Reconstr Surg*. 2004;113:1478–1490; discussion 1491–1495.
11. Haeck PC, Swanson JA, Gutowski KA, et al; ASPS Patient Safety Committee. Evidence-based patient safety advisory: liposuction. *Plast Reconstr Surg*. 2009;124:28S–44S.
12. Rohrich RJ, Smith PD, Marcantonio DR, et al. The zones of adherence: role in minimizing and preventing contour deformities in liposuction. *Plast Reconstr Surg*. 2001;107:1562–1569.
13. Broughton G II, Horton B, Lipschitz A, et al. Lifestyle outcomes, satisfaction, and attitudes of patients after

- liposuction: a Dallas experience. *Plast Reconstr Surg.* 2006;117:1738–1749.
14. Rohrich RJ, Broughton G II, Horton B, et al. The key to long-term success in liposuction: a guide for plastic surgeons and patients. *Plast Reconstr Surg.* 2004;114:1945–1952.
 15. Seruya M, Venturi ML, Iorio ML, et al. Efficacy and safety of venous thromboembolism prophylaxis in highest risk plastic surgery patients. *Plast Reconstr Surg.* 2008;122:1701–1708.
 16. Stephan PJ, Kenkel JM. Updates and advances in liposuction. *Aesthet Surg J.* 2010;30:83–97; quiz 98–100.
 17. Rohrich RJ, Beran SJ, Kenkel JM, et al. Extending the role of liposuction in body contouring with ultrasound-assisted liposuction. *Plast Reconstr Surg.* 1998;101:1090–1102; discussion 1117–1119.
 18. Commons GW, Halperin B, Chang CC. Large-volume liposuction: a review of 631 consecutive cases over 12 years. *Plast Reconstr Surg.* 2001;108:1753–1763; discussion 1764–1767.
 19. Iverson RE, Pao VS. MOC-PS(SM) CME article: liposuction. *Plast Reconstr Surg.* 2008;121(4 Suppl):1–11.
 20. Rohrich RJ, Ha RY, Kenkel JM, et al. Classification and management of gynecomastia: defining the role of ultrasound-assisted liposuction. *Plast Reconstr Surg.* 2003;111:909–923; discussion 924–925.
 21. Lista F, Ahmad J. Power-assisted liposuction and the pull-through technique for the treatment of gynecomastia. *Plast Reconstr Surg.* 2008;121:740–747.
 22. Pitman GH. Liposuction: refinement in technique for improved cosmetic results and increased safety. *Aesthet Surg J.* 1998;18:455–457.
 23. Geerts WH, Pineo GF, Heit JA, et al. Prevention of venous thromboembolism: the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest* 2004;126(3 Suppl):338S–400S.
 24. Green D. VTE prophylaxis in aesthetic surgery patients. *Aesthet Surg J.* 2006;26:317–324.
 25. Lista F, Doherty CD, Backstein RM, et al. The impact of perioperative warming in an outpatient aesthetic surgery setting. *Aesthet Surg J.* 2012;32:613–620.
 26. Iverson RE, Lynch DJ; ASPS Task Force on Patient Safety in Office-Based Surgery Facilities. Patient safety in office-based surgery facilities: II. Patient selection. *Plast Reconstr Surg.* 2002;110:1785–1790; discussion 1791–1792.
 27. Klein JA. Tumescent technique for regional anesthesia permits lidocaine doses of 35 mg/kg for liposuction. *J Dermatol Surg Oncol.* 1990;16:248–263.
 28. Samdal F, Amland PF, Bugge JF. Plasma lidocaine levels during suction-assisted lipectomy using large doses of dilute lidocaine with epinephrine. *Plast Reconstr Surg.* 1994;93:1217–1223.
 29. Hafez DA, Brown SA, Lipschitz AH, et al. Efficacy of lidocaine for pain control in subcutaneous infiltration during liposuction. *Aesthet Surg J.* 2009;29:122–128.
 30. Kenkel JM, Lipschitz AH, Shepherd G, et al. Pharmacokinetics and safety of lidocaine and monoethylglycinexylidide in liposuction: a microdialysis study. *Plast Reconstr Surg.* 2004;114:516–524; discussion 525–526.
 31. Rohrich RJ, Leedy JE, Swamy R, et al. Fluid resuscitation in liposuction: a retrospective review of 89 consecutive patients. *Plast Reconstr Surg.* 2006;117:431–435.
 32. Gargan, T.J., Courtiss, E. H. The risks of suction lipectomy. Their prevention and treatment. *Clinics in plastic surgery* 11: 457–463, 1984.
 33. Grazer FM, de Jong RH. Fatal outcomes from liposuction: census survey of cosmetic surgeons. *Plast Reconstr Surg.* 2000;105:436–446; discussion 447–448.
 34. Rohrich RJ, Muzaffar AR. Fatal outcomes from liposuction: census survey of cosmetic surgeons. *Plast Reconstr Surg.* 2000;105:447–448.
 35. Goyen MR. Lifestyle outcomes of tumescent liposuction surgery. *Dermatol Surg.* 2002;28:459–462.