Eric Swanson

Evidence-Based Body Contouring Surgery and VTE Prevention

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Evidence-Based Body Contouring Surgery and VTE Prevention *and its sister publication,* Evidence-Based Cosmetic Breast Surgery*, are dedicated to my wife, Cindy, who remains my most ardent supporter and most discerning critic. There have been many times when this work seemed too large and too diverse to complete. Cindy has patiently endured my long absences in the office assembling research data. These books are the culmination of that work.*

A big thanks goes to my patients, who have placed their confidence in me. Given the importance of appearance, there is hardly a more sincere gesture of trust, and it is a responsibility that I do not take lightly. Most of what I know has been learned from my patients, not textbooks. My patients have cooperated with dozens of clinical investigations, including outcome studies, laboratory studies, imaging with MRI and ultrasound, and repeated photographic sessions. There is no better education (and opportunity for surgeon humility) than interviewing patients and asking for their feedback. Experienced plastic surgeons understand that we do not teach our patients; our patients teach us.

Preface

This is the first publication to include the words “body contouring surgery” and “evidence-based” in the same title. Plastic surgery textbooks are often titled some variation of “The Art of Plastic Surgery.” This volume, like its sister publication, *Evidence-Based Cosmetic Breast Surgery*, focuses on science, relying on data rather than expert opinion. The source material has been published in the major peer-reviewed plastic surgery journals. Many of the conclusions challenge the status quo. The importance of evidence-based medicine is the theme of not only Chap. 1 but all of the chapters.

Body contouring surgery is generally understood to mean surgery of the trunk and extremities, not the face, neck, or breasts. Accordingly, breast surgery, head and neck procedures, and labiaplasty are not included in this volume.

Like *Evidence-Based Cosmetic Breast Surgery*, this single-author volume is open to criticism that it represents the experience and prejudices of one surgeon. My purpose in writing is not to recite the mainstream view but to challenge it. Existing textbooks are composed of many chapters written by well-known contributors describing their “how I do it” methods. This old habit makes for thick textbooks. A recently published textbook on body contouring surgery exceeded 600 pages. What is the reader to make of all this often conflicting information? It seemed to me that almost everything plastic surgeons “know” about body contouring surgery is based on clinical impressions (Table 1). The old adage has merit—what we measure we improve, and vice versa.

My interest in the scientific evaluation of body contouring surgery began in 2002. I realized that many basic questions about liposuction, and body contouring in general, remained unanswered, despite the fact that liposuction was the most common plastic surgical operation and had been in general use for 20 years. Although the effect seemed obvious, there was a lack of any studies quantifying the effect of liposuction on the fat layer. Magnetic resonance imaging in volunteer liposuction patients provided the answers (Chap. 2).

Many investigators subscribe to the popular view that fat redistributes after surgery. In 2011, an article appeared in *The New York Times*, reviewing an article published in *Obesity*, stating that fat came back, not to the original locations, but rather to untreated areas of the upper body, making women look like linebackers. The researchers were not deterred by the lack of any known physical mechanism that could account for such a phenomenon. Photometric studies exposed the myth of fat redistribution (Chap. 2).

Table 1 Things we "know" that are wrong

1	Individual risk stratification
2	Chemoprophylaxis
3	Danger of combined procedures
4	Operating time as an independent risk factor
5	Skin tightening with radiofrequency
6	Skin tightening with VASER
7	Laser treatment of cellulite
8	Laser liposuction
9	Cryolipolysis
10	Fat redistribution theory
11	Breast enlargement after liposuction
12	Safety of silicone buttock implants
13	Trivial blood loss after liposuction
14	Electrodissection as opposed to scalpel dissection
15	Scarpa fascia preservation
16	Limited-dissection abdominoplasty
17	Microfocused ultrasound for skin tightening
18	Prone patient positioning
19	General endotracheal anesthesia with paralysis
20	Rectus plication and DVT risk
21	Garments and DVT risk
22	Efficacy of sequential compression devices
23	Bupivacaine toxicity when used in wetting solution
24	Nerve blocks for abdominoplasty
25	Rectus abdominis intrafascial injections
26	Liposomal bupivacaine
27	Pain pumps
28	Gluteal autoaugmentation
29	Intramuscular fat injection of buttocks
30	Subrectus abdominis implants
31	Implantable mesh
32	Floating the umbilicus
33	Inverted-T abdominoplasty scar
34	Injections to dissolve fat
35	Reliability of meta-analyses
36	Practicality of randomized studies in surgery
37	Quilting sutures
38	Tumescent versus superwet technique
39	Routine screening for coagulopathies
40	Body-Q

Outcome studies were missing. Without this information, how could one answer the most basic patient questions, such as, How painful is liposuction or a tummy tuck? Or, when can I return to work? How likely is it that my expectations will be met? Patients are happy to provide the answers (Chaps. 3 and 6). Patient questions can be answered with data. Surgeons' opinions are notoriously optimistic.

When I undertook my studies, some state medical boards were imposing limits on liposuction aspirate volumes despite a general belief that blood loss was miniscule, based on the small amount of blood in the suction canister. Estimated blood loss calculations determined from postoperative hematocrits proved this misconception woefully inaccurate (Chap. 5). Third space blood loss (into the tissues) was much greater than expected and just as important hemodynamically as if the blood had been lost externally.

Popular belief holds that bupivacaine, a more potent and longer-lasting local anesthetic than lidocaine, is dangerous. Yet, there were no studies evaluating plasma bupivacaine levels after plastic surgery. The findings, contained in Chap. 5, revealed a surprisingly wide margin of safety. This is good news for surgeons who wish to provide long-lasting pain relief without ineffective and possibly dangerous pain pumps or nerve blocks. Liposomal bupivacaine is expensive and unnecessary. The body's fat cells act as a bupivacaine slow-release mechanism or "physiological pain pump."

What were the metabolic effects of liposuction? When I undertook this particular study, I believed that the blood tests would confirm the null hypothesis. After all, how could subcutaneous fat removal have any systemic metabolic effect? Not only did I find that it did, but the change appeared to be a healthy one, with a dramatic drop in triglyceride levels in patients with at-risk levels to start with. Another unexpected (and favorable) finding was that the white blood cell count significantly decreased after liposuction. This finding was made completely by serendipity. White blood cells were being counted along with red cells by the automated blood cell counters. These positive effects remain largely unappreciated by plastic surgeons and the public (Chap. 4).

As in cosmetic breast surgery, the literature is full of articles giving the surgeon's practice preferences to reduce complications. For abdominoplasty, these include a limited dissection to preserve blood vessels supplying the abdominal skin flap and preservation of the Scarpa fascia. The notion of limiting the dissection hardly seemed to require a formal study. The findings of a controlled study using laser perfusion to compare a limited and full dissection defied first principles (Chap. 6). Limiting the dissection to a tunnel does not significantly improve flap perfusion after all. Scientifically, this finding should not be surprising; it simply confirms the angiosome theory. There is no substitute for data.

There is no substitute for data.

Quilting sutures are increasingly used to limit the dead space and reduce the risk of seromas after abdominoplasty. A logical alternative, and one supported by clinical studies comparing electrical and scalpel dissection, is to limit the tissue injury by avoiding electrodissection (Chap. 6).

Nonsurgical alternatives to liposuction are a recurring theme. Many plastic surgeons believe that nonsurgical treatments will eventually replace surgery.

Proper scientific evaluation must take precedence over business considerations alone (Chap. 11). Otherwise, patients and surgeons risk disillusionment.

Venous thromboembolism (VTE) is a very serious topic, deserving of its own chapters (Chaps. 12 and 13). Individual risk stratification and routine chemoprophylaxis are a case study in patient management dictated not by factual evidence but by the perceived need to conform to guidelines. In debating this topic last year with Dr. Guyatt, the lead author of the 2012 guidelines of the American College of Chest Physicians, I was reminded of the story of the emperor who wore no clothes. Unfortunately, the term “evidence-based medicine,” coined by Dr. Guyatt himself, has become a cliché, like “validated.” Readers do well to decide for themselves the quality of the evidence and validity of a study and question the authors’ claims.

Individual risk stratification and chemoprophylaxis have largely gotten a free pass in the literature because these concepts represent the conventional wisdom, but a growing body of evidence shows, repeatedly, the failings of this approach: the lack of a scientific foundation for Caprini scores, the undisclosed financial conflicts, the misrepresentation of meta-data, the unjustified statistical adjustments, etc. The closer one looks, the worse it gets for those who believe in our ability to predict affected individuals and safely prevent VTEs by preemptively anticoagulating patients. But there is a silver lining: an opportunity to discard a nonscientific approach, learn more about the natural history of this problem, correct some bad (anesthesia) habits, embrace new technology (ultrasound), and make surgery safer for our patients. Ultrasound surveillance represents a new disruptive technology that has applications in the plastic surgery office that go well beyond early detection of deep venous thromboses (Chap. 13).

> There is a silver lining: an opportunity to discard a nonscientific approach, learn about this problem, correct some bad (anesthesia) habits, embrace new technology (ultrasound), and make surgery safer for our patients.

Leawood, KS, USA Eric Swanson, MD

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About the Author

Dr. Eric Swanson completed medical school and a residency in plastic and reconstructive surgery at the University of Toronto before starting private practice in Kansas City in 1989. Dr. Swanson is an outspoken advocate for evidence-based medicine. Dr. Swanson's self-funded clinical research has produced over 120 publications in the top peer-reviewed plastic surgery journals, including numerous articles and letters that challenge the conventional wisdom and offer science-based alternatives. In 2017, Dr. Swanson published the book *Evidence-Based Cosmetic Breast Surgery*.

Dr. Swanson is a frequent lecturer and panelist at national and international meetings and regularly provides instructional courses in cosmetic breast surgery and body contouring surgery. Dr. Swanson is a member of the American Society of Plastic Surgeons, the American Society for Aesthetic Plastic Surgery, and the American Association of Plastic Surgeons.

1 Evidence-Based Medicine and Conflict of Interest

Abstract

Conflict of interest represents a major obstacle to advancement in our specialty. About half of US physicians receive payments from pharmaceutical or medical device companies. Publications in our scientific journals are important marketing tools for manufacturers. New transparency laws make it easier to check for large payments to physicians. However, there are many other indirect ways that companies can reimburse investigators.

Conflicts are not just financial. Physicians may have an intellectual conflict if they become outspoken advocates. Our journals and societies are vulnerable when companies become partners and support society functions and journal publications. Expert witnesses have a medicolegal conflict once they testify regarding the standard of practice.

Randomized studies are rarely practical in surgery. Meta-analyses suffer from confounding variables. Fortunately, prospective observational studies can provide reliable information, particularly when the method includes consecutive patients, a high inclusion rate, defined eligibility criteria, and a reliable measurement device. Patient satisfaction is the determinant of success in cosmetic surgery and may be assessed with patient-reported outcome studies.

No discipline can benefit more from critical thinking than cosmetic surgery, which is often (unfortunately) regarded as an art rather than a science. Evidence-based medicine sets aside conventional wisdom, first principles, and clinical impressions. Eventually, strongly held beliefs give way to the facts.

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Introduction

I have previously written regarding the limitations of the artistic model for cosmetic surgery [1] and the importance of evidence-based medicine in evaluating cosmetic breast surgery [2]. The need is no less in body contouring surgery. This discussion starts with conflict of interest and ends with an appeal to plastic surgeons to recommit to the principles of evidence-based medicine.

Conflict of Interest

Financial conflicts represent the most important problem facing evidence-based medicine today [2]. The link between commercial funding and study conclusions is undeniable in our specialty [3, 4]. Luce [4] writes, "conflicts in ethically problematic situations are those in which the practitioner participates in clinical investigation of new devices/technology, publishes that experience, and, in parallel, is paid a consultant's fee by the manufacturer."

Physician speakers are deemed more credible spokespeople than company representatives and are frequently paid to participate in symposia at our national meetings or locally at company-sponsored dinners [4]. Companies partner with our societies and even help fund journal supplements, blurring the separation of science and advertising. Peer-reviewed publications are linked to the financial growth of the company [4].

In considering a remedy, Luce [4] proposes that plastic surgeons with conflicts be excused as manuscript discussants and reviewers. He considers a more stringent editorial policy that would ban authorship of a scientific publication by individuals with a financial conflict of interest in the drug, device, or technology under study. True transparency would include disclosure of the magnitude of the compensation, in dollars [4]. Such a ban is widely presumed to be impractical, especially by those who have conflicts.

Can devices truly be evaluated without paying the investigators? Of course they can, as evidenced by my own work (Fig. 1.1) and the research efforts of many others without financial conflicts. Recent examples include the work of Hall-Findlay and her study of 626 patients and the incidence of seromas after insertion of Biocell (Allergan plc, Dublin, Ireland) implants [5] and Hidalgo and Weinstein and their randomized study of round versus shaped implants in 75 patients [6]. The findings of these studies challenge those of industry-sponsored publications.

What about the reward for the investigator? The investigator should find that publication of his or her research in a highly respected peer-reviewed journal and the accolades that come with it more than adequate compensation. Such recognition is likely to boost his or her professional standing, which can positively impact one's career.

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For too long, plastic surgeons have allowed themselves to be manipulated by industry. How often have we heard the moderator at meetings ask the attendees to visit the exhibits, "without which none of this (i.e., the meeting) would be possible?" Well, of course it would be possible. The physician-industry complex has gone on so long plastic surgeons find it difficult to imagine an arms-length relationship. Is it possible to function without the corrupting influence of industry sponsorship? Surgeons might have to pay more to attend meetings. Present meeting registration costs are trivial, about the same as a pair of breast implants. The prices of devices and implants would fall as companies are relieved of the tremendous financial burden (millions of dollars [4]) of payments to physicians and societies and continuing medical education activities. Any extra meeting expenditure, or paying for one's own dinner (surely we can afford it), would be compensated by reduced prices. The net financial

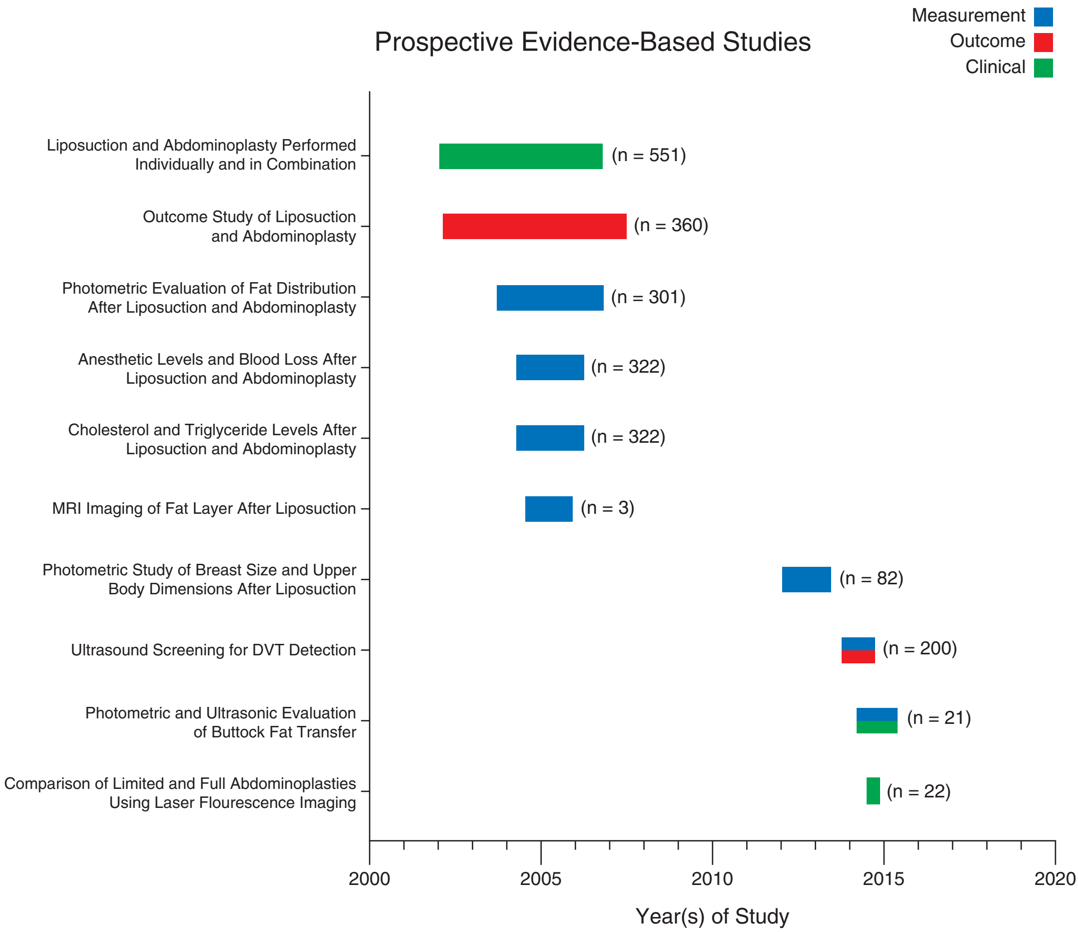

Fig. 1.1 Evidence-based measurement, outcome, and clinical studies undertaken by the author to learn more about the efficacy and safety of body contouring surgery

effect would be zero, but the integrity of our specialty would benefit tremendously.

Conflicts are not always just financial. Once an investigator becomes outspoken about an issue, he or she has an intellectual conflict. An investigator with numerous publications that are based on a faulty premise (e.g., Caprini scores, or a 14-point plan for reducing the risk of breast-implant-associated anaplastic large-cell lymphoma) may be unwilling to recognize the problem because of the consequences to his reputation. Our professional societies and journals may be confronted by a similar issue in determining website content, journal commentary, research funding, and awards. Once guidelines have been published, it is hard to backtrack.

Expert testimony can create a particularly insidious conflict of interest. For example, some plastic surgeons are willing to testify that individual risk stratification and chemoprophylaxis represent the standard of care and nonconformers are negligent, with tremendous consequences to patients, families, surgeons, and our insurance carriers (and therefore all of us). That surgeon is now forever conflicted because it is impossible to undo the consequences of wrongful testimony.

Expert testimony can create a particularly insidious conflict of interest.

Financial Disclosure

At meetings, surgeons often remark, "I have no relevant conflict of interest" or "I have no conflicts that would affect the content of my presentation." Some speakers will show a long list of conflicts and suggest that because they have so many, they are at least equal opportunity conflicters. Some investigators believe that if they previously received money but no longer receive payments, they are no longer conflicted and state "I have no disclosures." Is there an expiry date for financial conflicts?

Commercial affiliations may even be regarded as a badge of honor, reflecting one's status as a well-known and respected investigator. New transparency regulations help to inform the public regarding payments made to physicians [7].

> New transparency regulations help to inform the public regarding payments made to physicians.

Unfortunately, it is not difficult to sidestep such reporting requirements. A well-known investigator may be given a device (e.g., a VASER ultrasonic liposuction machine) at a heavily discounted price or even for free. A breast implant manufacturer may provide its researchers with complimentary or heavily discounted implants. There are many ways to reimburse surgeons indirectly. These considerations are substitutes for reportable cash payments, and they undermine the integrity of our research.

Remarkably, according to the *Journal of the American Medical Association*, about half of US physicians and 61% of surgeons received payments from the pharmaceutical and medical device industries in 2015, amounting to $2.4 billion. Any form or amount of compensation can influence prescribing behavior [8, 9]. At a recent meeting of the *American Society for Aesthetic Plastic Surgery*, four pages of fine print enumerated financial conflicts reported by the faculty.

It is possible for investigators to function as highly paid consultants or unbiased investigators but not both. It does not matter how well-meaning the investigator is. This is simply a reality of human nature—we do not bite the hand that feeds us. An example of this quid pro quo is to be found in the current debate regarding textured breast implants, which have been linked to anaplastic large-cell lymphoma (ALCL). Investigators with financial conflicts support the continued use of these devices and rely on a 14-point plan to reduce risk [10]. Investigators without financial links to the manufacturers oppose their continued use in women [11–13]. As physicians, we cannot accept a "buyer beware" philosophy.

Investigators who are not only passive investors but company officers and shareholders [14] have a financial obligation to the company. A fiduciary responsibility makes it impossible to remain objective [15].

FDA Clearance and Financial Conflict

When a device receives clearance by the US Food and Drug Administration, it is labeled with a stamp of authority that is reassuring to the public. This label also serves as a potent marketing tool. Unfortunately, the approval process is not protected from commercial influence. For example, Coolsculpting gained FDA clearance for treatment of the thighs based on studies performed by investigators that received major financial reimbursement [16]. The company itself was allowed to conduct ultrasound and photographic imaging [17]. The lead investigator was at one time a Zeltiq Aesthetics Inc. (Pleasanton, CA) paid consultant and shareholder [17] and reportedly now operates 26 Coolsculpting devices [18]. Zeltiq was purchased in 2017 by Allergan plc (Dublin, Ireland) for $2.48 billion [19].

Plastic surgeons are responsible for scientifically evaluating new devices. This obligation cannot be outsourced. Making important acquisitions based on commercial considerations alone is likely to lead to patient and surgeon disillusionment [20]. Critical appraisal of new products is discussed in Chap. 11.

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The Scientific Method

A disregard of the scientific method has real consequences that affect patient care and, in some cases, their lives. Even the plastic surgeon's life can be devastated by wrong assumptions (e.g., in the case of venous thromboembolism prevention). Proper methodology is not complicated. It starts with consecutive patients, a reasonable inclusion rate, and an objective measuring device (Tables 1.1 and 1.2) [21].

Surprisingly, measurements have not reached the mainstream in our discipline. Not only do plastic surgeons not measure their results, but many do not wish to measure their results. Even today, well into the twenty-first century, it is possible to sit through an entire day of presentations on any subject in cosmetic surgery without seeing a set of standardized photographs and measurements. One of our journal editors commented at a recent meeting, "It's aesthetic, so evidence-based medicine does not apply." An upcoming meeting sponsored by one of our professional societies promotes not just speakers and moderators but "pundits," who opine like political commentators. No wonder the same debates take place at our meetings year after year. The noted American statistician, Deming, [22] commented, "Without data you are just another person with an opinion."

> *Without data, you are just another person with an opinion.*
>
> – Deming.

Evidence-based medicine considers expert opinion and first principles (e.g., "it makes sense that…") to represent the lowest level of evidence.

Table 1.1 Cosmetic level of evidence and recommendation (CLEAR): description of levels and recommendations

Level	Description	Recommendation
1.	Randomized trial with a power analysis supporting sample sizes	A
2.	Prospective study, high inclusion rate (≥ 80%), and description of eligibility criteria Objective measuring device (i.e., not surgeon's opinion) or patient-derived outcome data Power analysis if treatment effect is compared No control or comparative cohort is needed if effect is profound	A
3.	Retrospective case-control study using a contemporaneous control group Prospective clinical study with an inclusion rate < 80% Prospective study without controls or comparison group and a treatment effect that is not dramatic	B
4.	Retrospective case series of consecutive patients Case/control study using historical controls or controls from other publications Important confounder that might explain treatment effect	C
5.	Case report, expert opinion, nonconsecutive case series	D

Table 1.2 Grade of recommendation

A	Conclusion strongly supported by the evidence, likely to be conclusive
B	Conclusion strongly supported by the evidence
C	Moderate support based on the evidence
D	Inconclusive based on the evidence presented

[Reprinted from Swanson E. Levels of evidence in cosmetic surgery: analysis and recommendations using a new CLEAR classification. Plast Reconstr Surg Glob Open 2013;1:e66. With permission from Wolters Kluwer Health.]

Even the most accepted clinical impressions require a scientific foundation. For example, it seems to make sense that anticoagulating patients after surgery would reduce their risk of a deep venous thrombosis. However, studies undertaken to support chemoprophylaxis are not only inconclusive but some show the opposite effect [23].

Plastic surgeons for years have discussed the importance of preserving medial row perforators and Scarpa fascia when performing abdominoplasty, based on first principles. It makes sense that, by preserving more blood vessels, perfusion of the flap is optimized. Similarly, it stands to reason that, by preserving the Scarpa fascia, lymphatic drainage channels are protected and seromas avoided. A rigorous controlled laser perfusion study and a cadaveric anatomical study expose the failings of clinical impressions and first principles [24, 25] (Chap. 6).

Measurements are the missing link in objective analysis (Fig. 1.1). In many ways, evidence-based medicine is measurement-based medicine [2]. What we measure we tend to improve, and vice versa.

> Measurements are the missing link in objective analysis. In many ways, evidence-based medicine is measurement-based medicine. What we measure we tend to improve, and vice versa.

When he stepped down as the longtime former editor of *Plastic and Reconstructive Surgery*, Goldwyn [26] worried most about commercial influence and keeping the specialty "pure." He cautioned the incoming managing editor that he would need a strong sense of ethics because "you'll need them in this business." Goldwyn, quoting his father, wrote: "It is amazing how easy it is to be truthful if one wants to be." [27].

In a recent discussion published in *Plastic and Reconstructive Surgery*, Lista [28] commented, "Our careers as plastic surgeons typically began with an undergraduate degree in sciences, where we studied the scientific method and the principles of systematic observation, measurement, and experimentation, and the formulation, testing and modification of hypotheses. We then went to medical school, where we learned the idea of scientific skepticism, that claims need to be reproducible and supported by empirical research. However, as soon as we become plastic surgeons practicing aesthetic surgery, all that annoying scientific stuff was thrown out the window."

Such observations can certainly cause cynicism. It is time we return to our role as scientists and scholars. Such a renewed commitment is not only good for our patients but good for us because it is the only path to patient satisfaction and the future well-being of our specialty.

> It is time we return to our role as scientists and scholars.

Meta-Analyses

A meta-analysis is considered the highest level of evidence [21]. Systematic reviews combine data from numerous studies, providing large sample sizes. Large sample sizes are statistically desirable because they reduce the likelihood of error, particularly a type II (false negative) error [21]. Such studies are particularly valuable when there are few confounding variables.

Unfortunately, plastic surgery is full of confounding variables, and therefore our specialty is largely unsuitable for meta-analyses. For example, three meta-analyses were recently published within the space of a few months on the subject of seroma rates after abdominoplasty [29–31]. Confounding variables undermined the conclusions (Chap. 6).

A meta-analysis of venous thromboembolism (VTE) in surgical patients, published in *Annals of Surgery*, contained a bewildering number of confounders, including cancer diagnosis, type of surgery, anesthesia, method of VTE detection, follow-up time, and the use of sequential compression devices [23]. Over 1000 patients did not even have surgery.

Studies that minimize confounding variables are likely to be more reliable. Using the example of seroma rates, a study done by operators using the same method but varying one variable—the use of electrodissection—is likely to produce a reliable conclusion [32, 33].

Prospective Observational Studies

Randomized studies are suitable for the study of nonsurgical methods such as the use of drains or for the study of commercial fillers, for example. They are not suitable for studies of plastic surgical operations because patients have the freedom to choose their operation and cannot be forced to participate in randomization. As patients are excluded from the randomized group, generalizability is compromised [21]. Equipoise may be difficult to achieve [21]. A Catch-22 exists in that it is unethical to knowingly recommend an inferior treatment to a patient and it is pointless to conduct a study evaluating an operation that is believed to be no better than the existing standard [21]. Fortunately, well-done observational studies can provide the information we need.

Prospective studies are considered a higher level of evidence than retrospective studies [21]. The outcome is unknown at the beginning of the study, reducing the opportunity for bias. Some studies are inaccurately labeled prospective despite the fact that the data have already been gathered when the study is undertaken. Such a study is retrospective, by definition.

A notable example of bias is provided by a recent study supporting a 14-point plan to reduce the risk of BIA-ALCL [10]. The eight authors grouped together their favorable experience inserting macrotextured breast implants and (allegedly) the 14-point plan in 21,650 women. Of course, the outcome was already known. No doubt the experience of another group of eight surgeons not using the 14-point plan and reporting no cases of BIA-ALCL could have been gathered just as easily.

A disadvantage of a prospective study is that it cannot be done in a week or two. The study must be designed, institutional review board approval obtained, and data collected using well-considered eligibility criteria over a period of time (Fig. 1.1). Prospective studies avoid cherry-picking patients that conform to the authors' preferred outcome. They also give the investigator the opportunity to be surprised by the findings.

Prospective studies avoid cherry-picking patients that conform to the authors' preferred outcome. They also give the investigator the opportunity to be surprised by the findings.

Outcome Studies

Plastic surgeons do not have a particularly good track record when it comes to asking patients for their opinion of the result. In most surgical disciplines, a successful outcome is not subjectively defined. However, in cosmetic surgery, the outcome is measured by patient satisfaction [21]. The author's staff has conducted in-person surveys with >1000 patients. There is no better education for surgeons than asking for patient feedback. Unfortunately, the Q-tests, such as the Body-Q [34], do not provide useful clinical information. Questionnaires should be surveys, not psychometric tests [21]. Really, plastic surgeons, and the surgery, are being evaluated, not the patient. In the absence of an accepted generic survey, ad hoc surveys provide clinically useful information and can be used to compare procedures (e.g., liposuction and abdominoplasty) (Chaps. 3 and 6).

It is not difficult for a surgeon in either academic or private practice to undertake prospective clinical, outcome, and measurement studies (Fig. 1.1). The author hopes that the next generation of plastic surgeons will honor their scientific pedigree and make plastic surgery the evidence-based specialty that it should be.

> *Courage is rightly esteemed the first of human qualities… because it is the quality which guarantees all others.*
> – Winston Churchill [35].

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The Myth of Fat Redistribution

2

Abstract

Some investigators believe that fat returns after liposuction. To evaluate this possibility, the author undertook a prospective study among predominantly nonobese consecutive patients undergoing 301 liposuction and abdominoplasty procedures. Lower body dimensions were measured using standardized photographs taken before and at least 3 months after surgery.

The average weight change was a loss of 2.2 lbs after lower body liposuction ($p < 0.01$) and 4.6 lbs when combined with abdominoplasty ($p < 0.001$). Liposuction significantly reduced abdominal, thigh, knee, and arm width ($p < 0.001$). Midabdominal and hip width were more effectively reduced by liposuction and abdominoplasty than liposuction alone ($p < 0.001$).

There was no difference in upper body measurements when comparing patients who had simultaneous liposuction and/or abdominoplasty with patients who had cosmetic breast surgery alone. Measurements in patients with at least 1 year of follow-up ($n = 46$) showed no evidence of fat re-accumulation. Both liposuction and abdominoplasty are valid techniques for long-term fat reduction and improvement of body proportions. There is no evidence of fat regrowth.

Similarly, some investigators suggest that liposuction may cause breast enlargement. To evaluate the possibility of secondary breast hypertrophy and fat redistribution after liposuction, 82 women were enrolled in a prospective controlled study. No significant increases in upper pole projection, breast projection, or breast area were found in patients treated with liposuction alone and those who received liposuction plus abdominoplasty. Neither liposuction nor abdominoplasty produces secondary breast enlargement.

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Introduction

A lack of rigorous study limits our present understanding of fat distribution after liposuction. The effect of liposuction on the thickness of the lower body subcutaneous fat layer has been determined by magnetic resonance imaging [1]. Surveys document patient satisfaction and a subjective awareness of a reduction in body size in treated areas [2, 3]. In 2012, the author published a quantitative photometric analysis of liposuction and abdominoplasty in a large number of patients [4].

Previously, a deficiency in our knowledge base allowed for the promulgation of different opinions regarding postoperative fat distribution, including the concept of "fat return" [2, 5, 6]. A widely publicized study published in *Obesity* in 2011 claimed that fat redistributes after liposuction, leaving treated areas of the lower body and re-accumulating in untreated areas of the upper body [6], including the upper abdomen, shoulders, and triceps [7]. A 2011 report in the *New York Times* [7], featuring an artist's caricature of this idea (Fig. 2.1), was widely publicized on the Internet [8, 9]. The patient looks like a linebacker after surgery. In addition, several studies based on surveys suggest that women's breasts tend to enlarge after liposuction [10–15], but physical measurements were lacking [16].

A Prospective Measurement Study of Fat Redistribution

To investigate the possibility of fat redistribution to untreated areas of the upper body after liposuction, the author undertook a prospective measurement study among 301 consecutive liposuction and abdominoplasty cases (294 patients) that met the inclusion criteria, which included (1) liposuction or abdominoplasty, with no simultaneous thigh lift, (2) photographs at least 3 months after surgery, and (3) no subsequent surgery between the surgery date and the date of the postoperative photographs [4]. The usual reason for exclusion was no follow-up visit 3 months or more after surgery. There were 426 liposuction and abdominoplasty procedures performed during this time

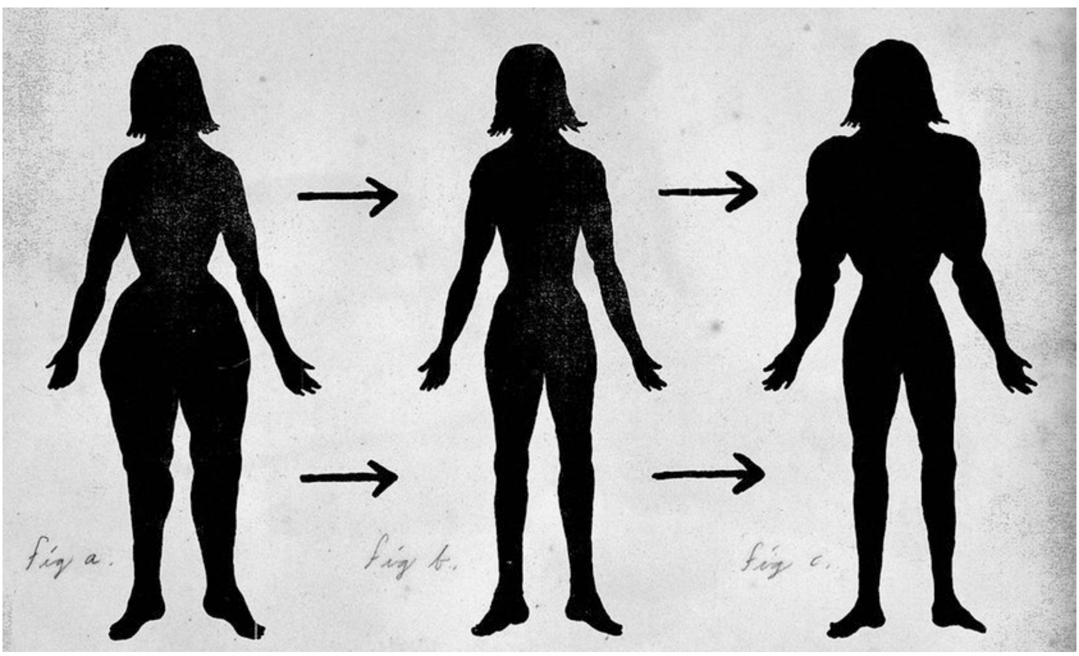

Fig. 2.1 *New York Times* artist's caricature of body shape changes after liposuction [7] as proposed by Hernandez et al. [6]. This concept recognizes a lasting effect of liposuction on the thighs but postulates compensatory regrowth in the abdomen, shoulders, and arms [Courtesy of Jonathon Rosen]

Fig. 2.2 Size- and orientation-matched photographs of a 24-year-old woman before (*left*) and 1 year after (*right*) liposuction of her lower body, arms, and axillae and a breast augmentation. The total aspirate volume was 3250 cc. Measurements show a reduction in width at each of the treated levels (the calves were not treated). Magnetic resonance imaging measurements of this patient are provided in Fig. 2.10 [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

period, for an inclusion rate of 70.7%. This study did not evaluate breast size changes. Breast size was evaluated in a separate measurement study [16] and is described later in this chapter.

The superwet technique and the Lysonix 3000 (Mentor Corp., Santa Barbara, CA) ultrasonic system were used for all liposuction procedures. Commonly, lower body liposuction was performed, treating the abdomen, flanks, thighs, and knees (Fig. 2.2). The abdomen and flanks were treated in men (Fig. 2.3). All abdominoplasties included umbilical transposition, and all except one (99%) were primary abdominoplasties (Fig. 2.4). Mini-abdominoplasties were excluded. Rectus abdominus fascial plication was performed in all abdominoplasties using two layers of monofilament polypropylene sutures. Most abdominoplasties (89%) were performed with simultaneous liposuction of the abdomen and flanks. Details of the surgery and anesthesia are provided in Chaps. 3 and 5, respectively.

Photographs and Measurements

To ensure standardization [17], all digital photographs were taken in the same room, using the same background, lighting, body positioning, focal distance, and 60 mm camera lens. All preoperative photographs were taken on the day of surgery. Measurements were made at the same level of the upper abdomen (narrowest level, just below the costal margin), mid-abdomen (umbilical level), hip (iliac crests), outer thighs (greatest width), knees (medial femoral epicondyles), and calves (greatest width), using the Canfield 7.1.1

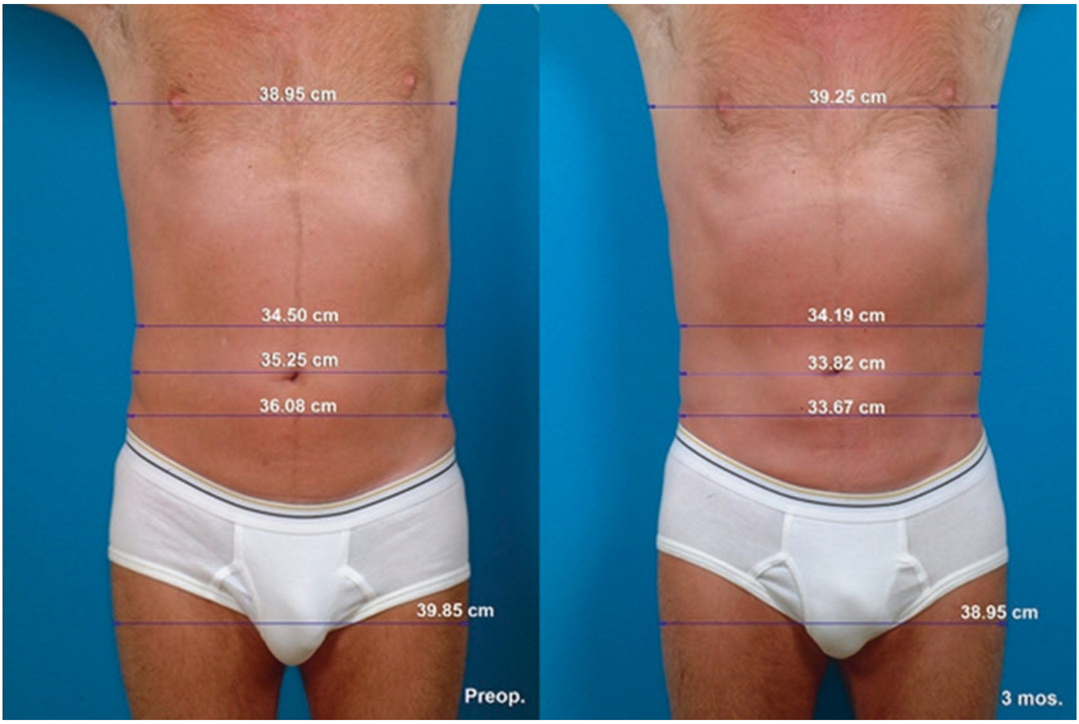

Fig. 2.3 Size- and orientation-matched photographs of a 62-year-old man before (*left*) and 3 months after (*right*) liposuction of the abdomen and hips. The aspirate volume was 1125 cc. The greatest reductions are at the level of the mid-abdomen and flanks

(Canfield Scientific, Fairfield, N.J.) imaging software. Arms were measured at the level of the deltoid insertion (Fig. 2.5). All patient weights were recorded on the day of surgery and at follow-up appointments using the same hospital scales.

Upper Body Measurements

Upper body dimensions were measured to investigate whether an increase in upper body size occurs after liposuction, as claimed by Hernandez et al. [6]. Among the 245 women who underwent liposuction and/or abdominoplasty, a subset of 67 women underwent simultaneous cosmetic breast surgery and had upper body photographs available at least 3 months after surgery. These images were used to measure changes in upper body (not breast) dimensions and to compare these measurements with a separate group of 78 consecutive women who underwent cosmetic breast surgery alone during the same study period. Measurements included (1) shoulder width, measured at the level of the preaxillary crease, (2) mid-humeral width, and (3) upper abdominal width (Fig. 2.6).

Although not specific, shoulder and mid-humeral measurements are expected to be sufficiently sensitive over a large number of patients to detect an increase in subcutaneous fat volume of the arms, triceps, and mid-axillary areas—sites where Hernandez et al. reported "trends for increases" [6].

Facial Measurements

Preoperative and at least 3-month postoperative facial photographs (n = 83) were compared and tested for reliability among study patients who had simultaneous facial procedures, usually submental lipectomies, excluding patients treated with facial fillers and facelifts (i.e., no procedures affecting facial volume).

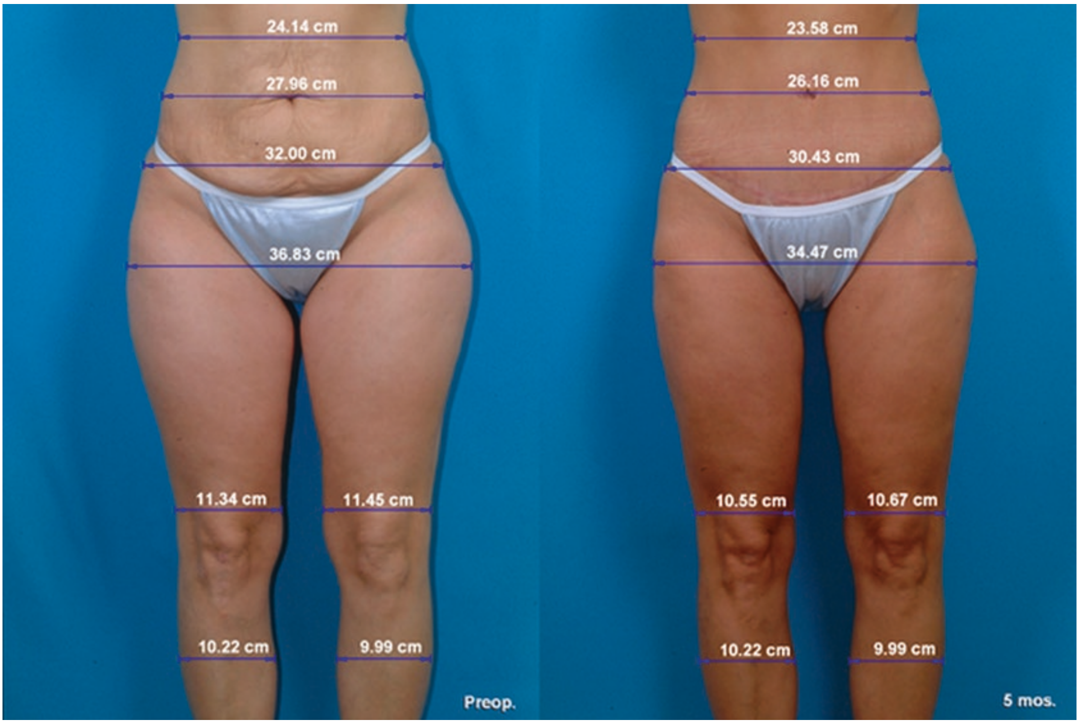

Fig. 2.4 Size- and orientation-matched photographs of a 32-year-old woman before (*left*) and 5 months after (*right*) abdominoplasty and liposuction of the lower body (not including calves). The aspirate volume was 1725 cc and the flap weight was 2.0 lbs. Measurements show a reduction for each of the treated areas [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

Patient Weights

The proportion of obese study patients (body mass index $\geq$30 kg/m^2) was 19.3%, significantly less than the obesity rate for the American adult population (33.8%) at the time of the study [18]. The mean change in weight after liposuction of the lower body was a loss of 2.20 lbs and 4.58 lbs when combined with an abdominoplasty ($p < 0.001$) [4].

Lower Body Dimensions After Surgery

The combined data revealed significant reductions at all three trunk levels after liposuction and abdominoplasty in women (Figs. 2.7 and 2.8), with significantly greater decreases at the mid-abdomen and hip levels for women treated with liposuction/abdominoplasty compared with women treated using liposuction alone ($p < 0.001$). Thigh, knee, and calf measurements were reduced in patients who had liposuction and in patients who did not have liposuction of these areas. The magnitude of the reduction, however, was significantly greater when the thighs and knees were treated ($p < 0.01$). Arm measurements were significantly reduced after liposuction ($p < 0.001$). Men experienced significant reductions at the mid-abdominal and hip levels after liposuction ($p < 0.001$), but not at the upper abdominal level, and there was no significant change for untreated thighs in men.

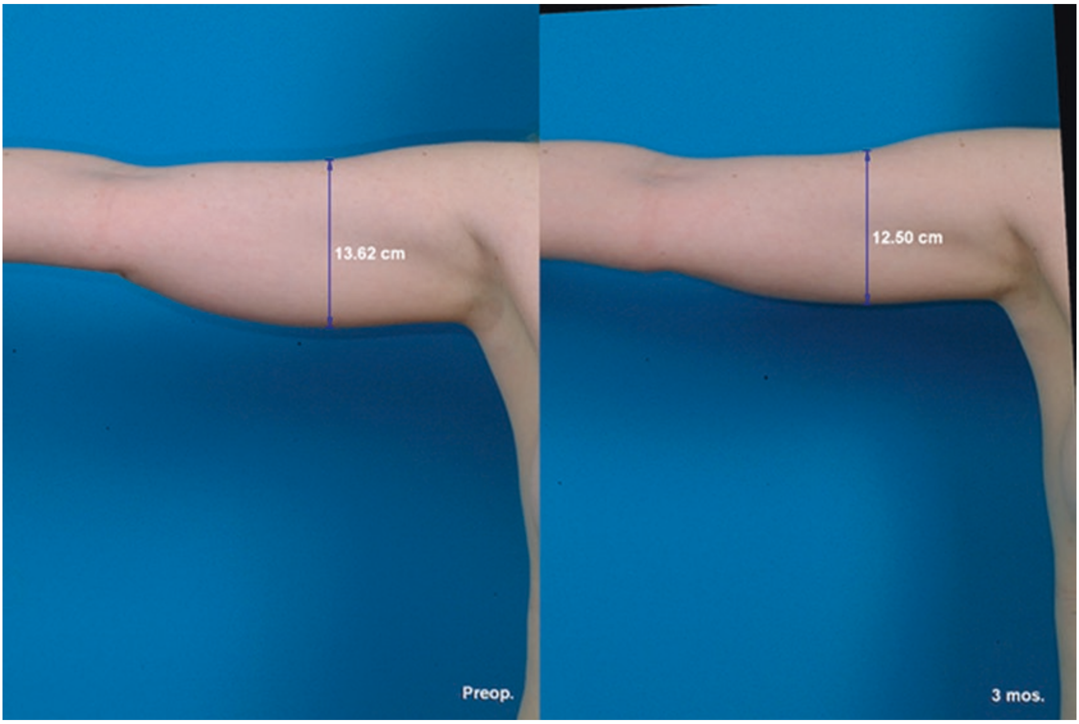

Fig. 2.5 Size- and orientation-matched photographs of the right arm before (*left*) and 3 months after (*right*) liposuction of the lower body, arms, and axillae in a 40-year-old woman. The aspirate volume was 150 cc for each arm and 50 cc for each axilla. The total aspirate volume was 2650 cc. The black upper and right border of the postoperative image (*right*) shows the matching tilt provided by the computer imaging software [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

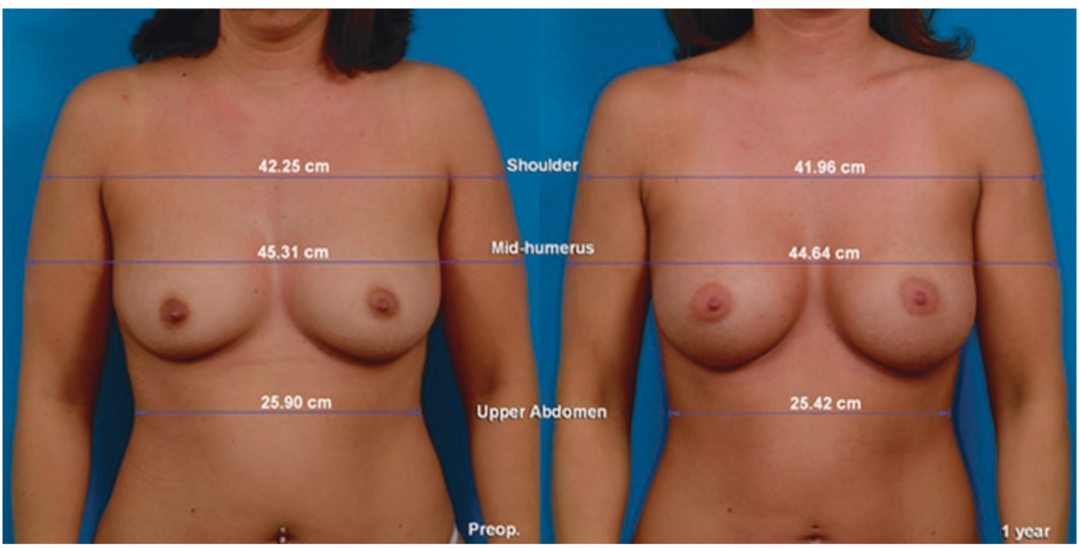

Fig. 2.6 Size- and orientation-matched upper body photographs, before (*left*) and 1 year after (*right*) liposuction of the lower body, arms, and axillae and a breast augmentation. The subpectoral breast implants (Mentor Corp., Santa Barbara, CA) were smooth, round, and saline-filled, with volumes of 325 cc on the right and 285 cc on the left. Width measurements of the upper body are very similar before and after surgery [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

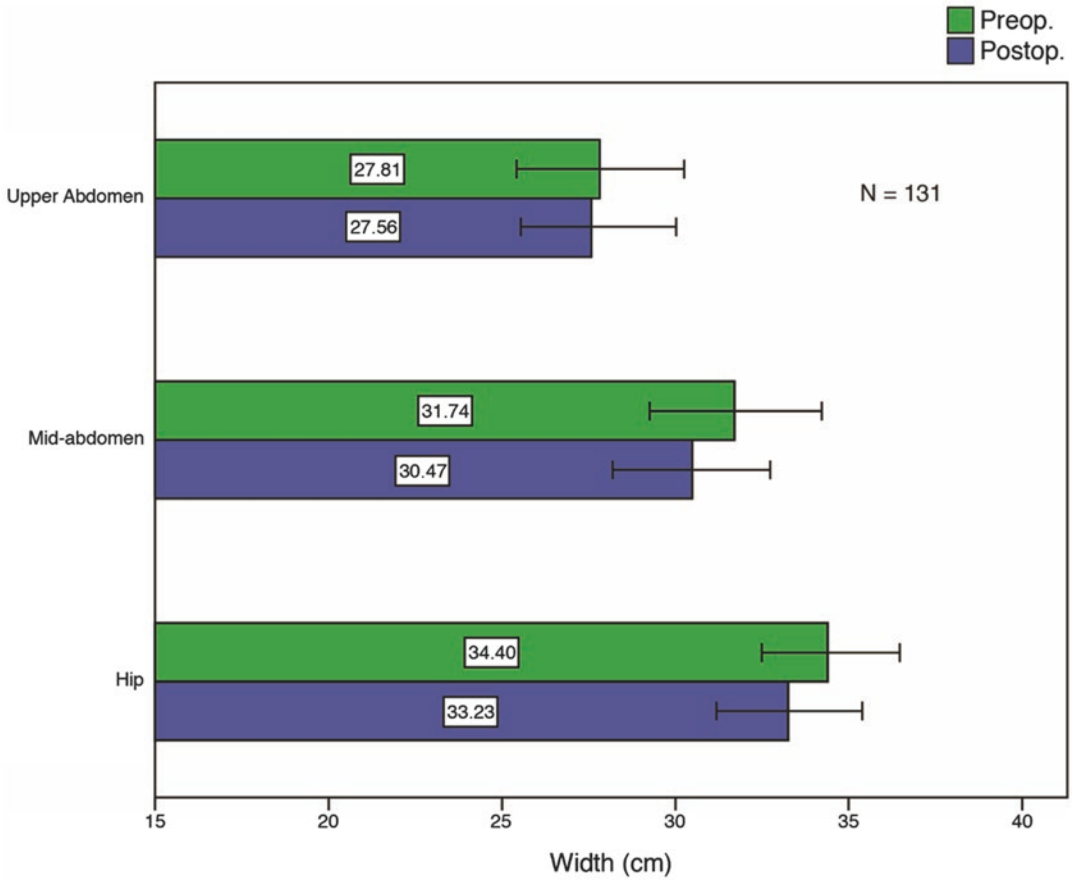

Fig. 2.7 Upper abdomen, mid-abdomen, and hip measurements before and after liposuction in women. Data are presented as means +/− SD [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

Upper Body Measurements

Chest width measurements in men were minimally affected by liposuction or direct excision of breast tissue. Male untreated chests showed a small but significant reduction ($p < 0.01$). There were no significant changes for any of the three upper body dimensions among women, whether or not they were treated with liposuction and/or abdominoplasty at the time of their cosmetic breast surgery.

Facial Width Measurements

The mean postoperative facial width (13.35 cm) was slightly less than mean preoperative width (13.41 cm, $p < 0.01$). The intraclass correlation coefficient was 0.98.

1-Year Follow-Up Group

Among a subset of 46 patients with measurements 1 year or more after surgery (mean follow-up time, 27.6 months; range, 12.2–85.5 months), there was a significant reduction in hip measurements for patients treated with liposuction alone ($n = 22$, $p < 0.01$) and for both mid-abdominal and hip measurements in liposuction/abdominoplasty patients ($n = 22$, $p < 0.001$).

Patients Who Gained Weight After Surgery

Patients who gained at least 5 lbs after surgery ($n = 34$, 11.6%) had a mean weight gain of 9.3 lbs and a range of 5–19 lbs. Hip measurements were

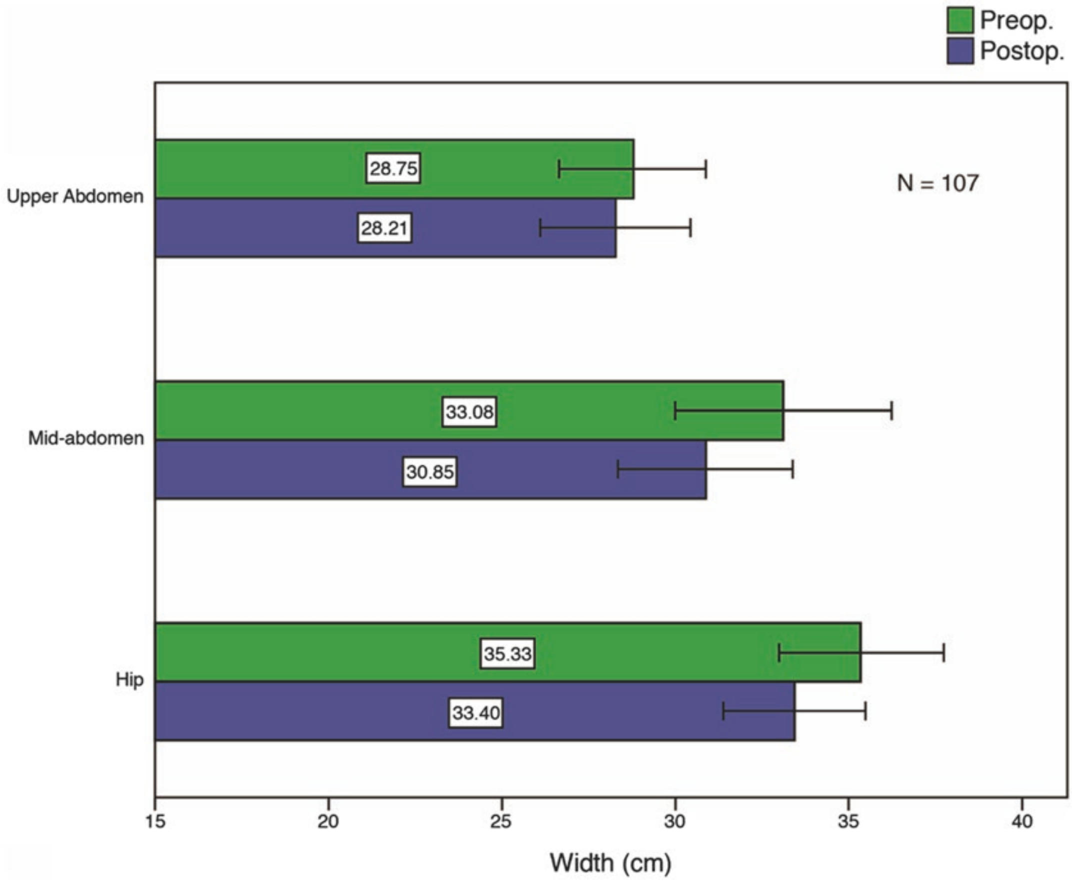

Fig. 2.8 Upper abdomen, mid-abdomen, and hip measurements before and after liposuction/abdominoplasty in women. Data are presented as means +/− SD [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

reduced after both liposuction ($n = 24$, $p < 0.01$) and liposuction/abdominoplasty ($n = 10$, $p < 0.01$) despite weight gain. Other trunk measurements were not significantly changed.

Follow-Up Time

A minimum follow-up time of 3 months was chosen to allow resolution of most of the surgical swelling [1] while optimizing the inclusion rate. Any persistent swelling present at 3 months would be expected to diminish the effects of surgery, so that reductions evident at 3 months are likely to be reliable.

Limitations of Study Claiming Fat Redistribution

Seeking to validate their a priori hypothesis of body fat redistribution [19], Hernandez et al. conclude that liposuction removes fat from the thighs but that this fat returns within 1 year to the abdomen and upper body [6]. Of course, strictly speaking, the word “return” is incorrect; the concept really implies “replacement” of lost fat cells, presumably by recruitment of new adipocytes from local precursor cells. Their study was randomized and controlled but included only 14 patients who had surgery. Importantly, the treated patients did not remain calorically neutral. Treated patients experienced an early weight reduction after surgery, but their mean weight returned almost to their preoperative weight at 1 year. The mean aspirated fat volume in their study was 2936 cc, excluding infranatant fluid, weighing 2.6 kg [7], so that treated patients gained a similar amount of weight after surgery.

In the study by Hernandez et al., abdominal fat volume calculations were based on axial magnetic resonance images from the level of the twelfth thoracic vertebra to the space between the fourth and fifth lumbar vertebrae [6]. The umbilicus is usually located at or below the level of the fourth lumbar vertebra [20]. The fact that liposuction was performed only inferior to the umbilicus, and the abdomen was not treated at all in three patients, in the context of a substantial postoperative weight gain, explains why there was an increase in measured fat volume in the abdomen but not the thighs, after liposuction. There is no need to resort to redistribution theory—a concept the proponents admit has not been confirmed by other investigators and is without a known physical explanation [6].

> There is no need to resort to redistribution theory—a concept the proponents admit has not been confirmed by other investigators and is without a known physical explanation.

Furthermore, new fat deposition without a positive energy balance, as claimed by the authors (relying on four 3-day food surveys), contradicts the first law of thermodynamics [21]. It is much more likely that these investigators simply observed fat volume increases in untreated areas in patients who gained weight.

In fact, Hernandez et al. did not actually prove fat redeposition in the upper body. Citing a "trend" based on such limited sample sizes, imprecise measurement devices, p values >0.05, and no Bonferroni correction or use of a more rigorous alpha level for multiple comparisons, are statistically indefensible. Another problem is that a small group of patients who happened to gain weight formed the treatment cohort. This confounding influence would be less likely in a larger, normally distributed sample.

The conclusion by Hernandez et al. [6] supporting fat redistribution is undermined by methodological deficiencies that include: (1) a limited sample size of 14 surgical patients, (2) imprecise measurement techniques, (3) nonsignificant changes, and (4) a cohort that gained weight after surgery [4].

Critical Appraisal of the Theory of Fat Redistribution After Liposuction

Fat redistribution theorizes that the body forms new fat cells in untreated areas to compensate for fat cells lost after liposuction [6]. Such a mechanism would require a memory for the original allotment of adipocytes and an ongoing inventory of site-specific fat cell numbers, directing different anatomical areas to manufacture new fat cells as needed [16].

It is known from a landmark study of carbon-14 isotope incorporation in genomic DNA that a homeostatic mechanism maintains adipocyte numbers, with a constant 10% renewed annually, and that this rate does not vary by age or body mass index in adults [22]. This finding confirms earlier work indicating that adipocyte hypertrophy accounts for increased fat volume in conditions of moderate obesity [23–25]. With weight loss, fat cells shrink, but their absolute number is unchanged [26–28]. Fat cell numbers are reduced only by liposuction or other fat resections (e.g., abdominoplasty) [29].

The traditional "adipocyte theory," described by Fournier and Illouz and Illouz and de Villers [30, 31], holds that fat cells are permanently removed by liposuction (Fig. 2.9). The present photographic study supports this concept.

> The traditional "adipocyte theory" holds that fat cells are permanently removed by liposuction.

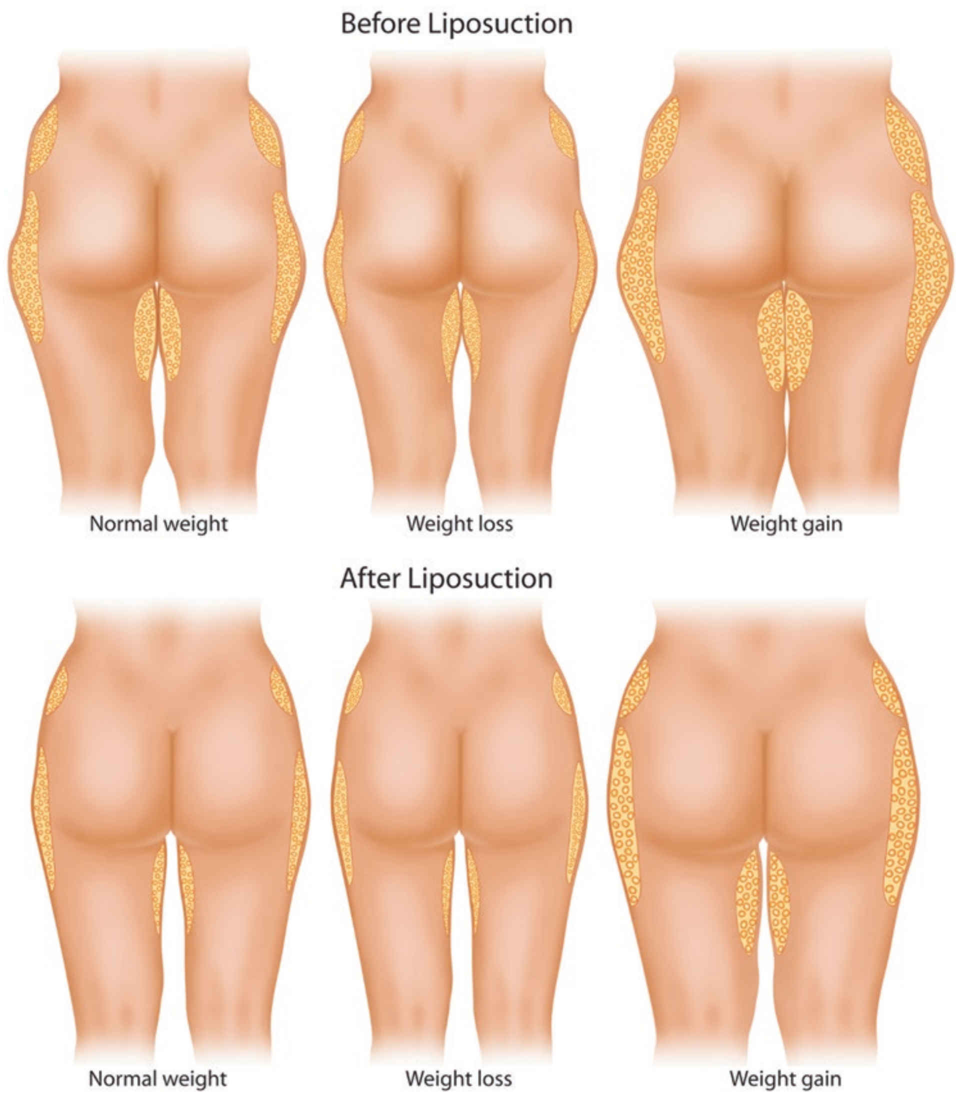

Fig. 2.9 Illustration of the effects of weight loss and gain on body shape. Fat cells enlarge and shrink with weight gain and loss, but do not change in number. Body disproportion persists. After liposuction, the number of fat cells is permanently reduced in the treated areas. The patient is trimmer in the treated areas than she would have been without liposuction, whether she gains or loses weight. There is no effect on untreated areas [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

This theory is the basis for the efficacy of liposuction in permanently improving body proportions (Fig. 2.9). If this concept were incorrect, liposuction would represent an unattractive therapeutic option. Most women would be unwilling to trade fat from the thighs for fat in the arms, axillary areas, and shoulders, which might create an unfeminine appearance [4].

Limitations of Measurement Devices

Measurements of body and limb circumferences, skin folds, and other nonradiologic techniques have overall errors in the range of 3–15% [32]. Dual-energy x-ray absorptiometry may be affected by factors such as age, body cell mass

[33], and state of hydration [34]. The accuracy of subcutaneous fat measurements by magnetic resonance imaging [1] has been validated by cadaveric dissections [35]. Radiographic area and volume calculations, however, are affected by image artifacts and interobserver variation, causing differences in repeated measurements in the range of 10% [36]. Such variability is too high to allow reliable conclusions when expected therapeutic changes are in this range and sample sizes are small. Type I false-positive (e.g., fat redistribution [6]) and type II false-negative (e.g., no metabolic effect of liposuction [6, 37]) statistical errors are inevitable.

Photographic Study of Body Dimensions

Photographs are inexpensive, require only a few minutes of patient time, and maximize patient participation. Large sample sizes are feasible and permit statistical analyses with a very low risk of type I or II errors, ensuring a high degree of reliability [38]. Because an increase in fat volume accounts for about 80% of increased body mass in nonobese adults [39], change in physical dimensions correlates closely with expansion or reduction of subcutaneous fat volume. Of course, change in external body dimensions is the relevant issue from the patient's perspective. Linear measurements on standardized and size-matched photographs have an intraclass correlation of 0.98 on repeated measurements [4], sufficiently precise to be clinically useful.

Effect of Liposuction on Fat Distribution

Linear measurements on magnetic resonance images in three weight-stable study patients reveal an average reduction of 45.6% in subcutaneous fat thickness in the abdomen, flanks, and thighs ($p < 0.001$) with no sign of subsequent fat accumulation up to 1 year (Fig. 2.10) [40]. Imaging data corroborate the study findings; both photographs (Figs. 2.2 and 2.5) and nuclear magnetic resonance images (Fig. 2.10) reveal fat reduction in treated areas without evidence of redistribution.

It is not surprising that abdominoplasty reduces the mid-abdominal and hip measurements more than liposuction alone, in view of this technique's full-thickness excision of lower abdominal skin and fat and the expected contribution of the muscle repair. This finding is also consistent with higher patient-reported result ratings for liposuction/abdominoplasty than liposuction alone [3]. The reductions in measurements in untreated areas (thighs, knees, and calves in women, chest in men, face in both sexes) were unexpected. Although they are small, these differences are likely to be reliable owing to the statistical power provided by large sample sizes. These findings may reflect a psychological boost provided by improved body proportions; 91.0% of surveyed patients reported a greater motivation to stay in shape after surgery [3]. Such decreases in untreated areas provide further evidence against the notion of a compensatory positive caloric shift or fat redistribution after liposuction.

Such decreases in untreated areas provide further evidence against the notion of a compensatory positive caloric shift or fat redistribution after liposuction.

Physical removal, by liposuction or lipectomy, offers the only option for reducing the absolute number of fat cells [29] and changing body proportions. In moderate obesity, increase in fat mass is caused by fat cell hypertrophy rather than hyperplasia [23–25]. Reduction in the number and mass of subcutaneous fat cells is the most likely explanation for the significant decrease in plasma triglyceride levels observed after liposuction in patients with elevated preoperative levels [41]. These findings are discussed in detail in Chap. 4.

Removal of excess fat cells by liposuction and abdominoplasty provides a long-term reduction

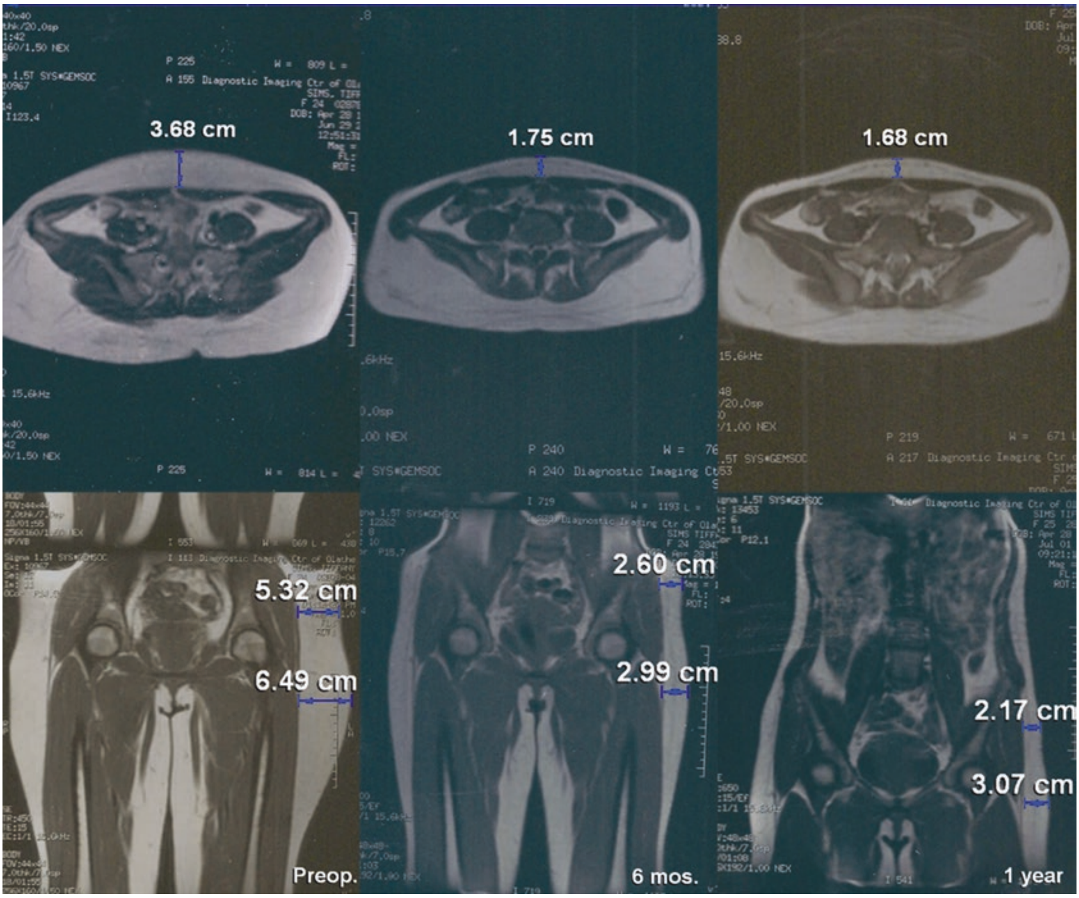

Fig. 2.10 This 24-year-old woman's clinical photographs are shown in Figs. 2.2, 2.5, and 2.6. Axial abdominal (*above*) and coronal lower body (*below*) magnetic resonance imaging scans were taken before (*left*), 6 months after (*center*), and 1 year after (*right*) liposuction of her lower body, arms, and axillae and a breast augmentation. The subcutaneous fat appears white in these T1-weighted images. Measurements are indicated at the level of the abdomen, left flank, and thigh. One year after surgery (*above, right*), there is no evidence of compensatory fat deposition in the abdomen on the axial view. The coronal image at 1 year (*below, right*) also shows the torso, with no evidence of fat redistribution [Reprinted from Swanson E. Photographic measurements in 301 cases of liposuction and abdominoplasty reveal fat reduction without redistribution. Plast Reconstr Surg. 2012;130:311e–322e; discussion 323e–324e. With permission from Wolters Kluwer Health]

in treated areas. Measurements show there is no reliable evidence to support the concept of fat regrowth or re-accumulation in treated or untreated areas of the body.

> Measurements show there is no reliable evidence to support the concept of fat regrowth or re-accumulation in treated or untreated areas of the body.

Breast Enlargement After Liposuction

Several studies claim that women's breasts enlarge after liposuction [10–15]. Van der Lei et al. [15] recommend informing prospective patients about this possibility. This curious phenomenon, however, had not been evaluated using breast measurements. Accordingly, the author undertook a study to determine whether liposuction causes breast enlargement. The previous study [4], discussed above, did not specifically evaluate possible postsurgical changes in breast size. Possible compensatory changes in upper body dimensions were also evaluated, as was done in the previous study [4].

The inclusion criteria consisted of (1) women undergoing cosmetic surgery not including breast surgery, (2) consent for breast photographs, (3) postoperative photographs at least 3 months after surgery, (4) no subsequent breast surgery prior to postoperative photographs, and (5) no pregnancies during the study period. Patients undergoing other simultaneous procedures with liposuction, such as an abdominoplasty, were included. Patients with existing breast implants were also included. Patient weights were recorded before and after surgery using the same hospital scales.

A total of 102 consecutive women underwent cosmetic surgery that did not include breast procedures [16]. Twelve women declined to participate in the study. Seven patients were unavailable for follow-up appointments at least 3 months after surgery. One patient had a breast procedure within 3 months of her surgery, making her ineligible. These exclusions left 82 patients available for study (inclusion rate, 80.4%).

Patients were compared in three groups. The control group ($n = 24$) consisted of women having cosmetic procedures that did not include liposuction. The treatment groups were composed of women having liposuction alone ($n = 41$) or in combination with an abdominoplasty ($n = 17$). Liposuction/abdominoplasty patients underwent liposuction of the abdomen and flanks in combination with an abdominoplasty. Most liposuction/abdominoplasty patients also underwent liposuction of the thighs and medial knees.

Photographs were calibrated by having the patient hold a ruler in one of the photographs. All upper body photographs were taken with the patient standing and the arms resting at the sides (Figs. 2.11 and 2.12). Lower body photographs were taken with the arms raised (Fig. 2.13). Lower body measurements were not compared in this study, having been previously evaluated [4].

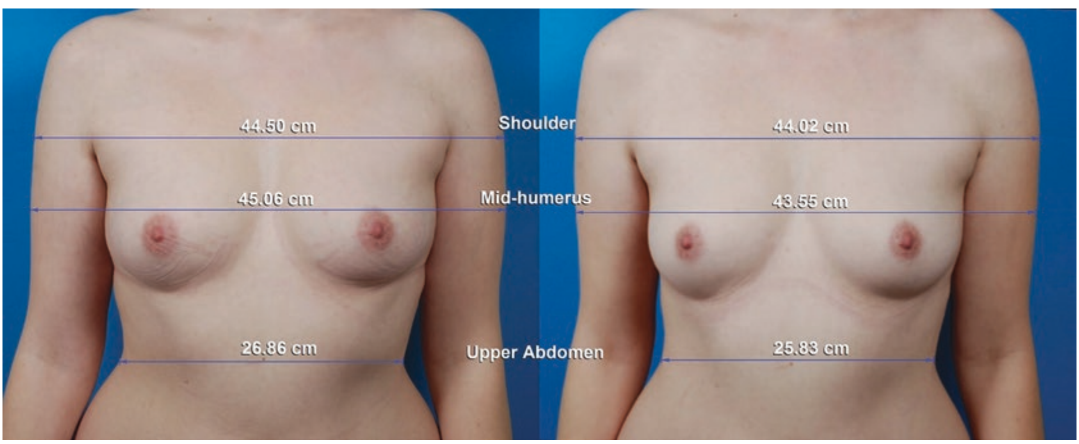

Fig. 2.11 This 39-year-old woman's upper body was photographed before (*left*) and 4 months after (*right*) liposuction of the lower body (abdomen, flanks, thighs, and knees). The total liposuction volume was 3150 cc. Her preoperative weight was 178 lbs and her postoperative weight was 170 lbs. This 8 pound weight loss was only slightly greater than the 6 pounds expected from the fat removal (1 L = 2 pounds), making her calorically neutral after surgery. The upper body measurements show no evidence of fat redistribution. Photographs are matched for size and orientation. This patient's lateral breast and lower body photographs are shown in Figs. 2.12 and 2.13 [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

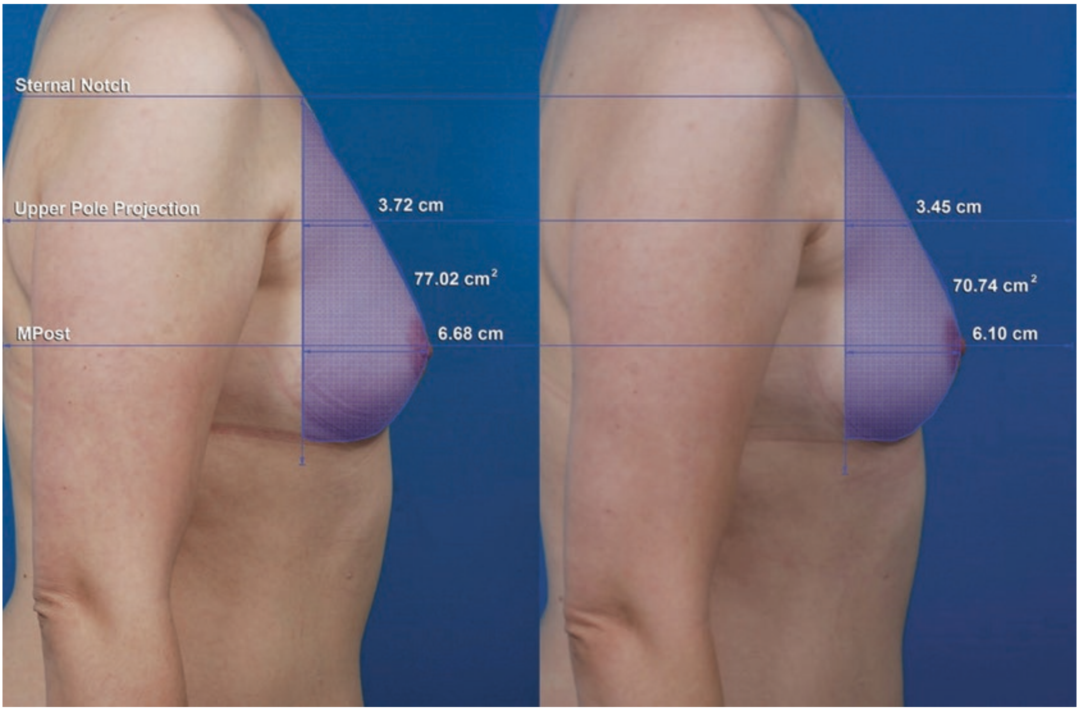

Fig. 2.12 Lateral breast measurements before (*left*) and 4 months after liposuction (*right*) show no evidence of breast enlargement after liposuction. Photographs are matched for size and orientation. *MPost*, maximum postoperative breast projection [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

Measurements

Breast measurements were made on standardized lateral photographs matched for size and orientation using the method previously published [42] and the Canfield 7.1.1 Mirror imaging software (Canfield Scientific Inc., Fairfield, NJ) (Fig. 2.12). Measurements were made on the frontal photographs to evaluate any possible changes in upper body dimensions after liposuction [4]. These horizontal measurements included shoulder width, bihumeral width, and upper abdominal width at the same vertical level (Fig. 2.11). Shoulder and mid-humeral measurements are expected to detect an increase in subcutaneous fat volume of the arms, triceps, and mid-axillary areas [4]—anatomic sites thought to be affected by fat redistribution [6]. The measurements are compared between the three procedure groups in Figs. 2.14–2.19. To conserve figure space, only the right breast measurements are illustrated.

Findings

There were no significant differences between treatment and control patients in mean age, follow-up time, body mass index, or change in weight [16]. The mean follow-up time was 5.6 months (range, 3–19 months). There were no significant differences in these parameters, liposuction volumes, or flap resection weights comparing study participants and nonparticipants. No patient with existing breast implants developed a clinical capsular contracture or a known implant deflation during the study period. The mean weight change for the control group was a gain of 0.73 lbs after surgery. Liposuction patients lost 0.66 pounds and liposuction/abdominoplasty patients lost 3.91 pounds, on average (not significant).

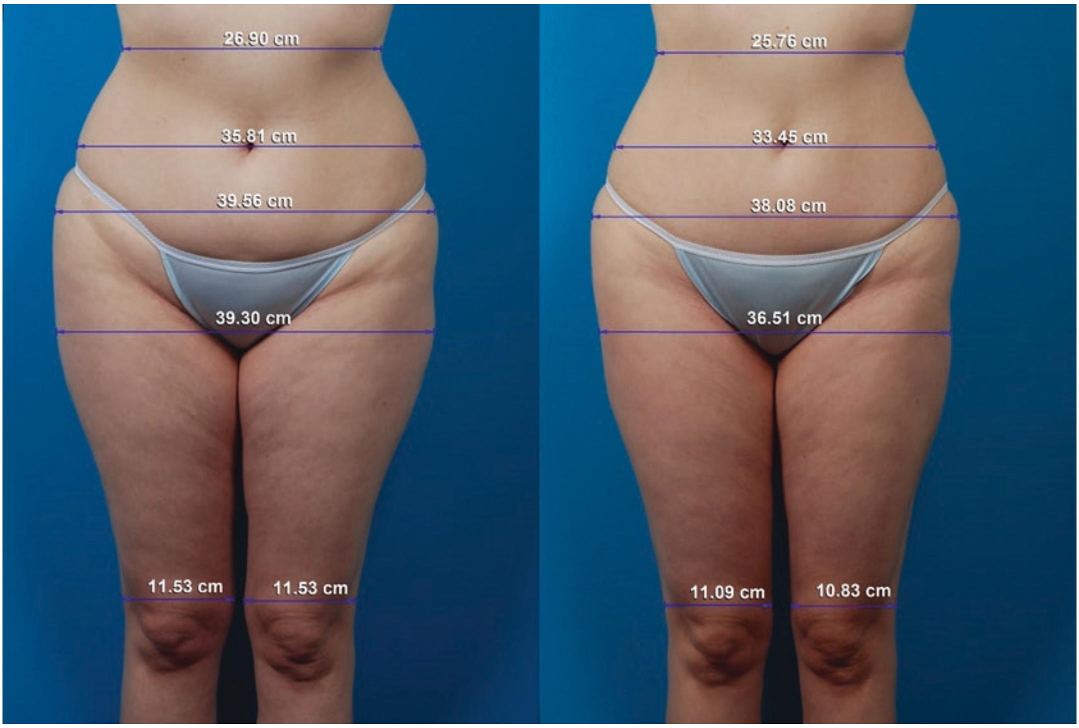

Fig. 2.13 Size- and orientation-matched lower body photographs of the patient also depicted in Figs. 2.11 and 2.12 taken simultaneously with the upper body and breast photographs before (*left*) and 4 months after liposuction (*right*). The patient's lower body dimensions are reduced at all treatment levels [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

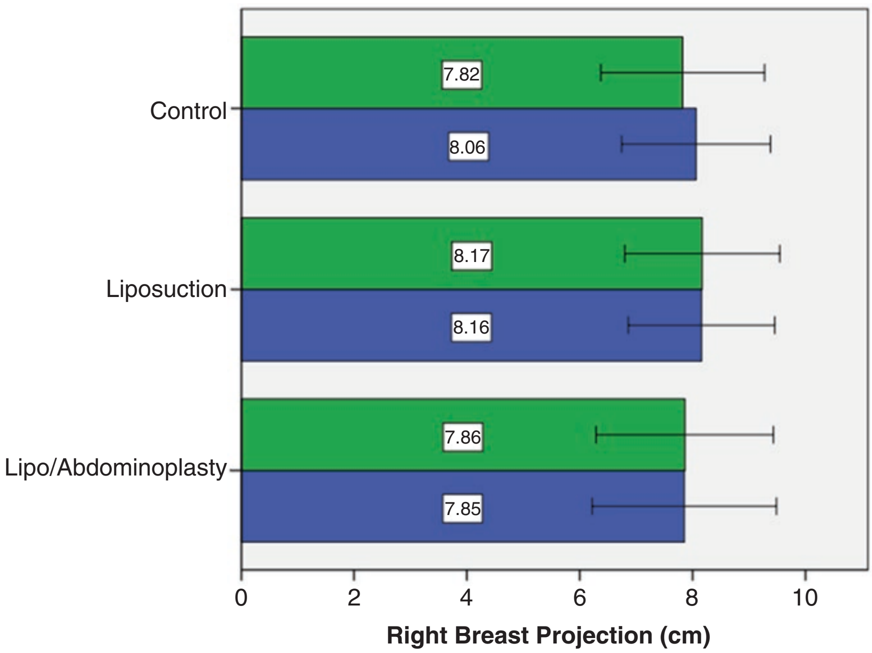

Fig. 2.14 Right breast projection before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction (n = 24), liposuction (n = 41), and liposuction in combination with abdominoplasty (n = 17). Data are presented as means +/− SD [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

There were no significant differences in breast measurements among control patients, with the exception of a slight increment (0.23 cm) in mean postoperative right breast projection ($p < 0.01$). There were no significant changes in breast measurements after either liposuction or liposuction/abdominoplasty (Figs. 2.14 and 2.15). Mean breast area measurements were also unchanged (Fig. 2.16).

> There were no significant changes in breast measurements after either liposuction or liposuction/abdominoplasty. Mean breast area measurements were also unchanged.

Upper body dimensions did not change significantly for control patients after surgery (Figs. 2.17–2.19). Upper abdominal width decreased significantly ($p < 0.01$) after surgery in patients treated with liposuction in combination with abdominoplasty (Fig. 2.19).

A subset of 53 patients who did not have existing breast implants was evaluated separately (data not shown). Similar to the larger group of patients that included women with breast implants, there were no significant changes in any measurements in liposuction patients and a significant ($p < 0.01$) decrease in upper abdominal width after liposuction combined with abdominoplasty.

A subset of 17 women with liposuction volumes exceeding 1500 cc (Figs. 2.11–2.13) also had no significant changes in breast or upper body dimensions after liposuction; a reduction in upper abdominal width ($p < 0.01$) was recorded after liposuction/abdominoplasty. No significant correlations were detected between patient age, follow-up time, and body mass index and change in either breast or upper body dimensions.

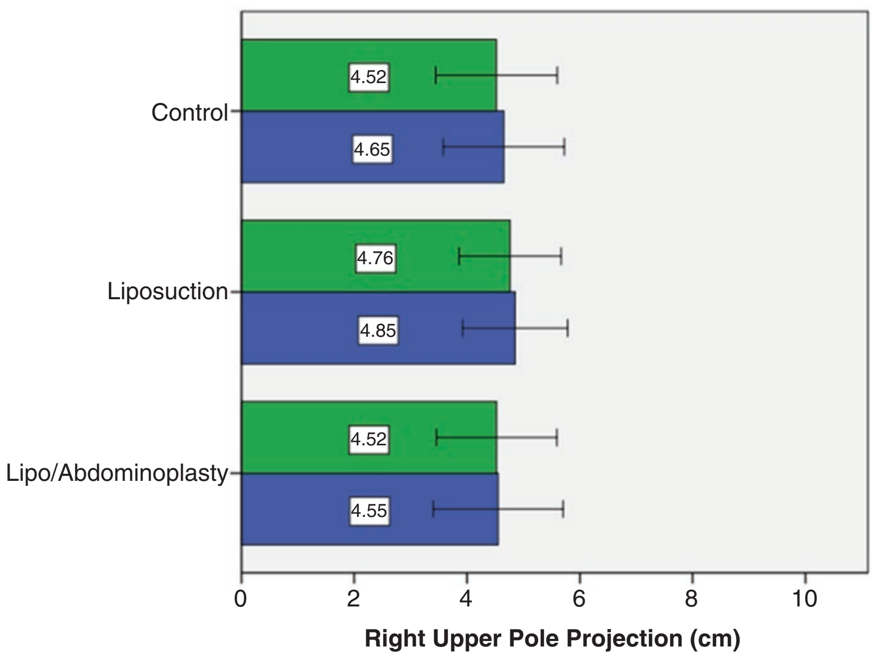

Fig. 2.15 Right upper pole projection before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction ($n = 24$), liposuction ($n = 41$), and liposuction in combination with abdominoplasty ($n = 17$). Data are presented as means +/− SD [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

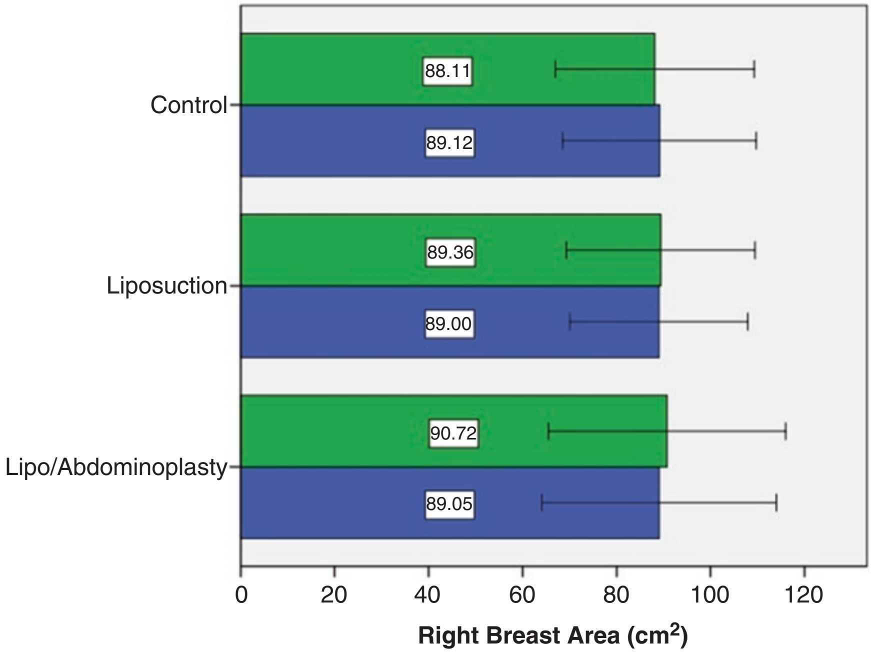

Fig. 2.16 Right breast area before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction ($n = 24$), liposuction ($n = 41$), and liposuction in combination with abdominoplasty ($n = 17$). Data are presented as means +/− SD [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

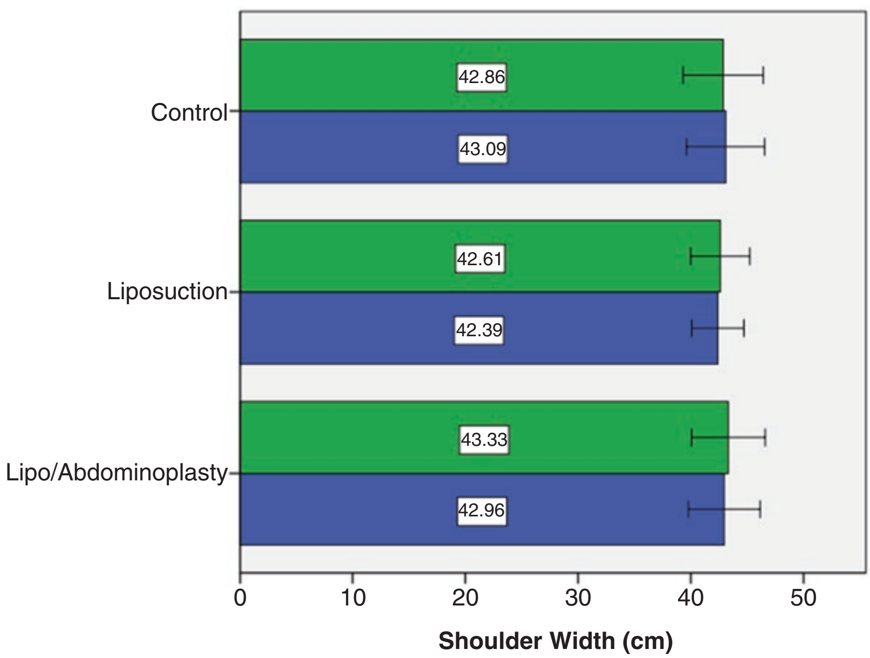

Fig. 2.17 Shoulder width before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction ($n = 24$), liposuction ($n = 41$), and liposuction in combination with abdominoplasty ($n = 17$). Data are presented as means +/− SD. [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

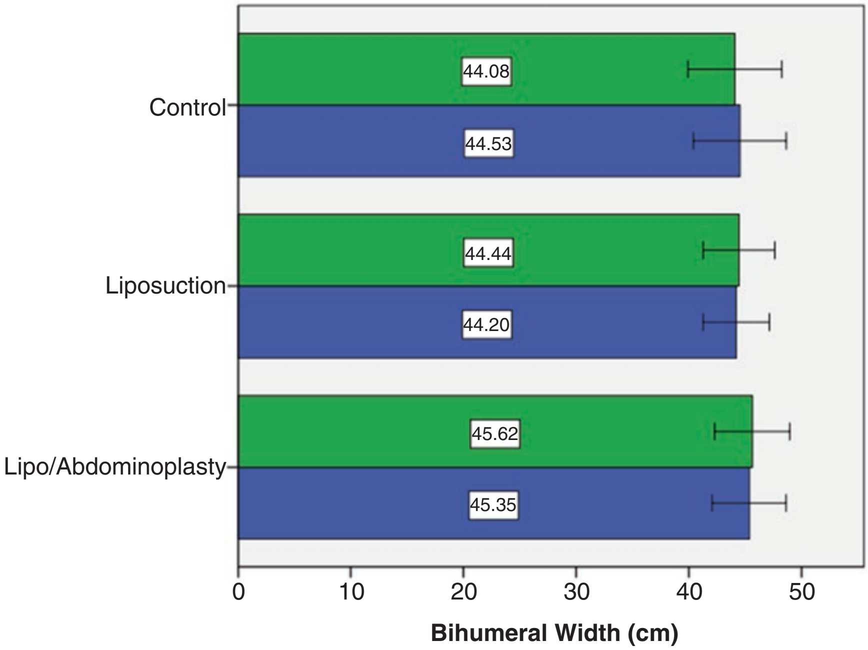

Fig. 2.18 Bihumeral width before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction ($n = 24$) liposuction ($n = 41$) and liposuction in combination with abdominoplasty ($n = 17$). Data are presented as means +/− SD [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

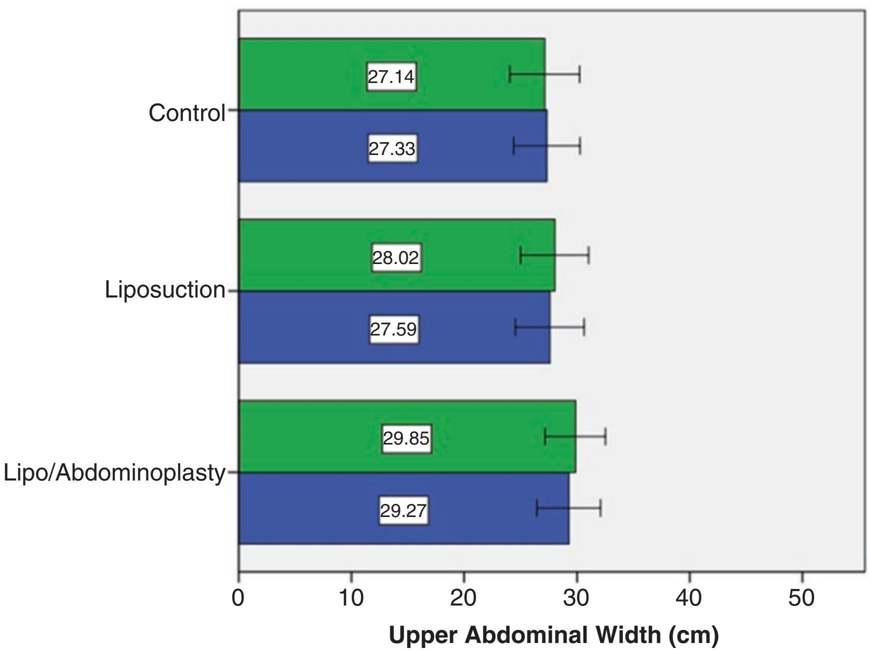

Fig. 2.19 Upper abdominal width before (green) and after surgery (blue) in patients undergoing cosmetic surgery not including liposuction ($n = 24$), liposuction ($n = 41$), and liposuction in combination with abdominoplasty ($n = 17$). Data are presented as means +/− SD [Reprinted from Swanson E. No increase in female breast size or fat redistribution to the upper body after liposuction: a prospective controlled photometric study. Aesthet Surg. J. 2014;34:896–906. With permission from Oxford University Press]

Patient Weight Changes After Liposuction

Caloric neutrality is essential in any study of fat changes after liposuction [4]. If postoperative weights are increased, there is no way to distinguish a theoretical volume expansion caused by fat redistribution from an expected volume increase that would have taken place anyway as a result of additional fat deposition caused by weight gain. Patient weights in this study were rigorously recorded by nurses using the same hospital scales. There was no reliance on patients' estimates, which are notoriously inaccurate. Postoperative changes in mean body weight among control patients and liposuction patients were less than 1 lb (not significant). The mean reduction of 3.91 pounds after abdominoplasty was similar to an average flap weight of 4.15 pounds. The measurement data, therefore, are not influenced by a significant postoperative weight change that might cause an overall increase or decrease in adipocyte size and fat volume. The significant ($p < 0.01$) reduction in upper abdominal width after combined liposuction/abdominoplasty may be explained by more effective fat reduction achieved by combined modalities.

> The measurement data are not influenced by a significant postoperative weight change that might cause an overall increase or decrease in adipocyte size and fat volume.

Previous studies documenting a post-liposuction increase in breast size, with one exception [13], evaluated patients who gained weight after surgery [10–12, 14, 15]. Finzi's survey [13], the only study to report a breast size increase without documented weight gain, relies on patient estimates provided in person or by telephone; patients were not weighed directly.

Possible Hormonal Influence

Although published findings of a breast size increase can be explained by weight gain, several investigators [10–12, 14, 15] postulate a hormonal mechanism for increased breast size after liposuction. Fat cells are known to produce estrogen. In postmenopausal women, adipocytes produce most of the circulating estrogen [14]. Adipocytes also produce androgens. Proponents of a hormonal influence reference a study by Killinger et al. [43], citing site-specific differences in the production of estrone versus androgens from their precursor, androstenedione, in four women and two men. These investigators report that the conversion of androstenedione to estrone was greater in fat cells harvested by liposuction from the upper thigh, buttock, and flank than abdominal fat cells.

According to this hypothesis, if abdominal fat is preferentially removed by liposuction, the relative amount of circulating estrogen is increased, causing breast enlargement [12, 14, 15]. No published studies include hormonal assays to support this theory, so that it remains entirely speculative. Moreover, most patients treated with abdominal liposuction also receive treatment of the flanks [10–15] (sometimes labeled the "hip rolls" [12, 14]) and thighs, tending to even out any possible differences in estrone production by aspirated fat cells. Liposuction/abdominoplasty removes a greater volume of fat from the abdomen than liposuction alone [4]. The lack of a breast size increase in this group provides additional evidence that preferential removal of abdominal subcutaneous fat does not create a hormonal imbalance leading to breast hypertrophy [16].

> The lack of a breast size increase in this group provides additional evidence that preferential removal of abdominal subcutaneous fat does not create a hormonal imbalance leading to breast hypertrophy.

Anderson et al. [44], in their evaluation of 15 women and 14 men, report no effect of either estrone or dihydrotestosterone on adipocyte mass through proliferation of preadipocytes, raising the possibility that differences in plasma levels of these sex hormones are a moot point with respect to fat deposition. In postmenopausal women, estrogen no longer has a major role as a circulating hormone, but rather functions locally in tissue sites where it is formed [45]. Scarborough and Bisaccia [11] report no correlation between subjective change in breast size and supplemental hormone replacement or menstruation. Finzi [13] finds no effect of menopausal status.

Limitations of Existing Studies

All published studies reporting breast enlargement after liposuction [10–15] rely on subjective patient assessments of change in weight, breast size, and bra cup size. None includes objective measurements of the breasts. Of course, reducing the abdominal girth improves the ratio of breast/abdominal projection, which may be interpreted by patients as an increase in breast size [46].

The Measuring Device

Measurements of body and limb circumferences would seem to be appropriate when studying changes in body dimensions [47]. However, these physical measurements have limitations, which are well-known to investigators who have used them. Such clinical measurements are affected by differences in the level of measurement on the trunk or limb, the tension applied to the tape measure, and how level it is held. These factors create variations in repeated measurements. Interobserver error is introduced when different individuals (usually nurses) take the measurements. Photographic measurements are easy and convenient. Taking the photographs requires only 1 or 2 min of patient time and is typically done anyway by plastic surgeons to document results.

Measurement software facilitates matching photographs for size and orientation (Figs. 2.2–2.5) [4, 42]. This method corrects for any differences in magnification or tilt in the before-and-after photographs. Measurements may be made using a cursor on a computer monitor at the investigator's convenience. These factors maximize compliance and therefore inclusion rates. In this study, an inclusion rate of 80.4% was achieved, meeting the benchmark for evidence-based medicine [48] and ensuring that the reliability of the findings is not compromised by missing patient data.

Sample Size

The original report of a post-liposuction breast size increase included five women who gained 5–7 pounds after surgery [10]. A recent study [49] claiming a breast size increase after application of aminophylline cream to the thighs evaluated seven weight-stable patients and did not include a control group. The study by Hernandez et al. [6] claiming fat redistribution assessed 14 nonconsecutive surgical patients. A small sample size increases the likelihood of capturing a cohort of patients who gain weight after surgery. Large sample sizes are essential to avoid type II (false-negative) statistical errors [38].

Exclusion criteria need to be kept to a minimum so as to avoid selection bias [48]. The present study included 29 women who had existing breast implants (i.e., inserted at a previous operation), based on the presumption that breast implants do not change in size in the absence of a complication. Reassuringly, data analyses excluding these patients produced the same findings.

Follow-Up Time

The follow-up time must be long enough to ensure that the temporary effects of tissue swelling do not influence the data. On the other hand, follow-up times should not be so long as to jeopardize the inclusion rate [50]. Elective cosmetic surgery patients are not typically motivated to return in long-term follow-up for research purposes [51]. Previous measurement studies reveal that at 3 months the swelling has subsided and is unlikely to affect measurements [50, 52].

Clinical Relevance

There is no evidence of fat redistribution to female breasts or the upper body after liposuction. Any breast size changes in women after liposuction are likely caused by postoperative weight gain [16].

> There is no evidence of fat redistribution to female breasts or the upper body after liposuction. Any breast size changes in women after liposuction are likely caused by postoperative weight gain.

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3 Liposuction

Abstract

Ideal body proportions call for a low (0.70) waist-to-hip ratio in women. Liposuction remains the gold standard for treatment of body disproportion and provides a lasting improvement in body contours. On average, the fat thickness is reduced 45.6% after liposuction and two-thirds of the swelling is gone in 1 month. It takes about 3 months for the swelling to completely resolve. Today, many patients elect to have buttock fat transfer, reducing the role of thermal systems to dissolve fat cells.

Ultrasound scans are used to detect abdominal wall defects and avoid penetration of the abdominal wall with the cannula. A superwet infusion (1:1 infusion-to-aspirate ratio) is recommended to avoid overhydration. Patients are positioned supine and then turned from side to side to perform the infusion, avoiding prone positioning. The sequence is repeated for liposuction. The number of incisions is minimized. The abdomen is cross-hatched, while the patient is on her side to most effectively treat the upper abdomen. The arms and axillary areas are frequently included. Many patients (30%) undergo simultaneous facial or breast cosmetic surgery. Aspirate volumes rarely exceed 5 L.

Women drop an average of 1.7 dress sizes after liposuction. Men lose, on average, 1.4 in. at the waist. The average time off work after liposuction is 5.7 days. The mean pain rating is 6.1 on a scale of 1–10. Patients feel "back to normal" and return to exercising 1 month after liposuction, on average. Patient satisfaction is 82.5%, and 93.5% of patients would recommend liposuction to others.

> Liposuction remains the gold standard for treatment of body disproportion and provides a lasting improvement in body contours.

E. Swanson, *Evidence-Based Body Contouring Surgery and VTE Prevention*,
https://doi.org/10.1007/978-3-319-71219-2_3

Ideal Body Proportions

Historically, the female form has been somewhat heavy in many cultures, a sign of health and nutrition. Greek statues do not depict women with six-pack abdomens or well-toned biceps. This full form has given way in the last few decades to a lean look, albeit with full breasts and rounded buttocks. This combination is unusual in nature. Few women are naturally endowed with a lean physique and full breasts. Similarly, few men are endowed with the physique of Michelangelo's David, who did not have love handles.

Healthy premenopausal women have waist-to-hip ratios of 0.67–0.80 [1]. Their waist circumferences are 70–80% as large as their hips. A healthy man's waist-to-hip ratio is 0.85–0.95 [1]. Moderate weight gain does not alter these basic male and female shapes, and they are found all over the world among people who vary considerably in height and weight.

> Healthy premenopausal women have waist-to-hip ratios of 0.67–0.80. Their waist circumferences are 70–80% as large as their hips. A healthy man's waist-to-hip ratio is 0.85–0.95.

Men have an innate preference for female bodies with narrow waists and full hips, which signal high fertility, high estrogen, and low testosterone [1]. Interestingly, this preferred waist-to-hip ratio is not limited to Caucasian males but is also true for women and other cultures and races [2, 3].

Cartoon characters and virtual images of females like Jessica Rabbit (*Who Framed Roger Rabbit, 1988*) and Lara Croft (*Lara Croft* movies starring Angelina Jolie, 2001, 2003, and video games) typically have exaggerated proportions. The original Barbie (1959–) had measurements similar to 36-18-33 in a life-sized woman, with a 0.54 waist-to-hip ratio [4].

During the twentieth century, Miss Americas' and Playboy Centerfolds' waist-to-hip ratios ranged from 0.68 to 0.72 [1]. By the end of the twentieth century, the average fashion model was 4 in. taller than the average woman but maintained a 0.70 waist-to-hip ratio, combining a tall, lean body with curves [5]. Even the Columbia Pictures logo, the torch-bearing woman, was slimmed in 1992 [4].

These ideals bear little resemblance to reality. Presently, 70.2% of American adults are overweight, defined as having a body mass index ≥ 25 kg/m^2, and 37.7% are obese, having a body mass index ≥ 30 kg/m^2 [6].

Celebrities have had an enormous impact on the public perception of desirable body proportions. Jennifer Lopez ignited the interest in buttock aesthetics, along with Kim Kardashian. Today, few leading male actors who remove their shirts for an action role do not have a ripped abdomen.

Not surprisingly, liposuction has been the top cosmetic surgical operation for years, although it has been overtaken by breast augmentation in the last 2 years according to statistics provided by the American Society of Plastic Surgeons [7].

Obese Patients

Although liposuction has been used to treat obesity [8], it is now recognized that these patients are not ideal candidates. In very obese patients, the volume of fat and fluid removed may be much larger (>5 L), making fluid management more difficult and increasing risk. Third-space blood loss exceeds 1 L on average in patients with >5 L superwet aspirate volume [9]. Furthermore, the difference in body contours is proportionately less, making the procedure less worthwhile. Also, these patients have not developed good eating habits and exercise regimens, so that they may be more likely to gain weight after surgery, particularly if they are even less active after surgery.

Patients with a "beer belly" are poor candidates for liposuction. These patients have very protuberant abdomens, but there is minimal subcutaneous fat. These patients are understandably disappointed but are sorted out early in the consultation. They are glad to be told candidly that they are not good candidates so they do not waste their time and money having a procedure that is unlikely to help. Professional weight loss counseling is recommended.

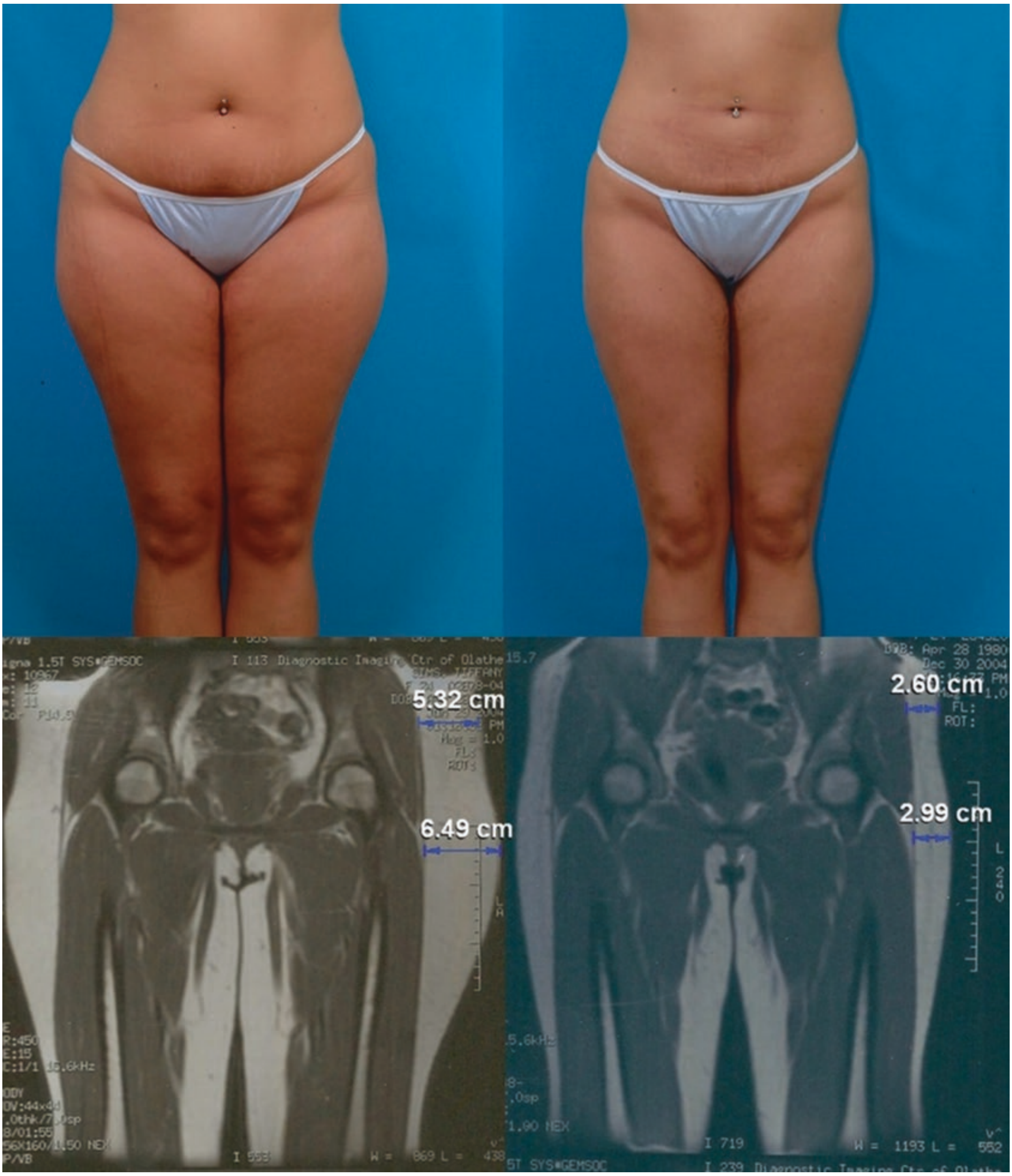

Fig. 3.1 This 24-year-old woman's photographs (*above*) and magnetic resonance imaging scans (*below*) were taken before (*left*) and 6 months after liposuction of her lower body, arms, and axillae and breast augmentation (*right*). The total aspirate volume was 3250 cc. The subcutaneous fat appears white in these coronal, T1-weighted images. Measurements are indicated at the level of the left flank and outer thigh. The thickness of the abdominal fat pad was also measured, using axial slices (not shown)

Efficacy of Liposuction

Liposuction has been used worldwide since the early 1980s. However, its effect on the thickness of the fat layer (Fig. 3.1) was only recently determined using magnetic resonance imaging [9].

On average, the fat thickness is reduced 45.6% after liposuction and two-thirds of the swelling is gone after 1 month [9]. It takes about 3 months for the swelling to completely resolve.

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Coolsculpting

Coolsculpting (Allergan plc, Dublin, Ireland), or cryolipolysis, has recently entered the marketplace as a nonsurgical alternative to liposuction. This device freezes subcutaneous fat. Proponents concede that the effects are not as dramatic as liposuction. Studies using ultrasound have detected a small reduction in the thickness of the lateral thigh fat layer after treatment—1/10″ in 16 weeks [10]. This method is time-consuming and expensive and provides only spot treatments (like LipoDissolve used to do). Investigators generally have financial conflicts. Many owners of these systems report underwhelming results. Unlike liposuction, there is a deficiency of published studies using MRI or photometric analysis to demonstrate its effectiveness [11]. Nonsurgical technologies are discussed in Chap. 11.

Laser and Ultrasonic Liposuction

It is easy for patients to confuse ultrasonic liposuction with laser liposuction. Adding to the confusion is the term "Vaser" liposuction (Solta Medical, Inc., Hayward, CA), which is a type of ultrasonic liposuction.

Ultrasonic liposuction uses a high-frequency sound wave to selectively disrupt fat cells. Laser liposuction systems (e.g., Smartlipo, Cynosure Inc., Westford, MA) use a low-energy laser light beam to break up fat cells. Laser systems are costly and add a price increment to surgery because a non-reusable tip is needed for each patient [12]. Importantly, laser use in liposuction does not selectively target fat cells, which is the principle advantage of ultrasonic assistance.

Studies have failed to show a definite advantage for liposuction devices that incorporate a laser [12, 13]. Prado et al. [12] found greater cellular damage to the fat cells and greater release of triglycerides from laser treatments, compared with liposuction without laser pretreatment, and no improvement in skin retraction [12]. There is no real reduction in blood loss as claimed in a recent publication [14].

The word "laser" has marketing appeal in medicine, and investigators caution against putting commerce before research [12]. Although laser resurfacing of skin turned out to be a winning application of laser technology, fat removal appears to be a better served by ultrasonic technology or traditional liposuction. With recognition of the value of transposing fat cells to other areas of the body and the destructive effects of the laser on adipocytes [12], the trend today is back to nonthermal liposuction that does not compromise the viability of fat cells [14].

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Technical Advances in Liposuction

Since Illouz's landmark publication in 1983 [15], advances in liposuction include the evolution of instruments, energy source, wetting solutions used to pretreat the areas, and anesthesia.

Traditional Liposuction (1982)

Instrument	Cannula, large bore
Energy	Physical
Infusion	None ("dry" liposuction) or small volumes
Results	Spot treatments, small volumes, irregularities, blood loss

Tumescent Technique (1990)

Instrument	Smaller caliber cannulae
Energy	Physical
Infusion	Tumescent: saline, lidocaine, epinephrine
Results	Larger volumes of fat removed, multiple areas, smoother borders, less blood loss

Ultrasonic Liposuction (1995)

Instrument	Ultrasonic generator
Energy	Ultrasound, physical
Infusion	Superwet: saline, lidocaine or bupivacaine, epinephrine
Results	Selective fat cell removal, easier treatment of fibrous areas, possibly less trauma

Ultrasonic liposuction, also called ultrasonic-assisted liposuction, was developed by Zocchi in 1988 [16]. This method was used extensively in Europe and South America for several years, before being introduced in the United States in 1995.

Ultrasonic energy has been used in many areas of medicine since the 1970s. One of its first applications was in eye surgery, to selectively dissolve cataracts. It was subsequently used to remove tumors in neurosurgery. The same principle is applied to fat removal. An ultrasonic probe produces a high-frequency sound wave, which causes fat cells to dissolve. The technique is used in combination with superwet liposuction (Fig. 3.2).

Ultrasonic assistance became popular in the late 1990s. It is less popular today but still used by surgeons, including the author, who find the method helpful, if not essential.

Ultrasonic liposuction has improved results in fibrous areas that may be difficult to treat with traditional liposuction, such as the upper abdomen, flanks, back, and male breasts [17]. Because ultrasonic energy is used to break up the fat cells, less physical force may be required from the plastic surgeon. It makes sense that the less phys-

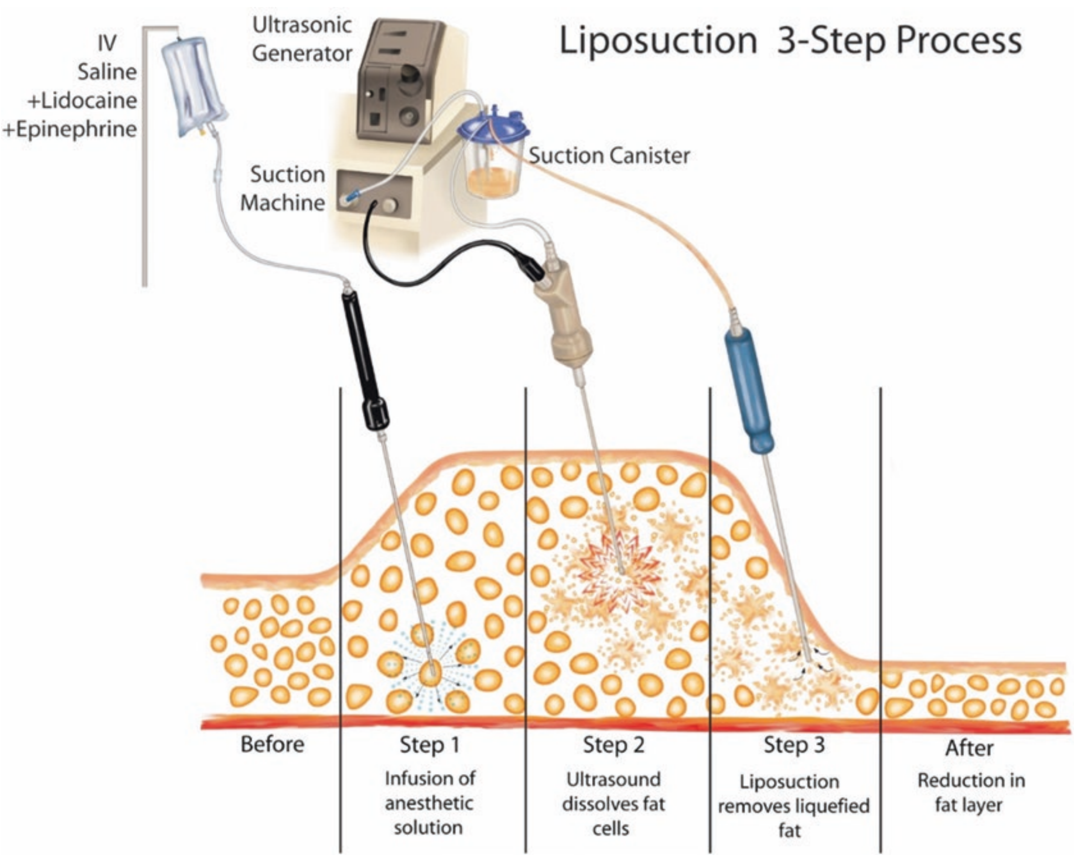

Fig. 3.2 Ultrasonic liposuction consists of three steps. The subcutaneous fat layer is infused with a saline solution containing a local anesthetic and epinephrine. Ultrasonic energy dissolves fat cells. Traditional liposuction is used to aspirate fat

ical force is used, the better the connective tissue under the skin is preserved, along with nerves and blood vessels. Ultrasonic liposuction may allow better skin contraction [18]. It is important to recognize that these are theoretical advantages that have not been clinically proven. A disadvantage is thermal injury to adipocytes used for fat transfer [19]. When performing fat transfer, ultrasound is not used.

The author uses the Lysonix 3000 (Mentor Corp., Santa Barbara, CA.) ultrasonic system. Ultrasound times for each area are kept short, seldom exceeding 2 min, so as to minimize the risk of a seroma.

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Wetting Solution

The author uses normal saline with 500 mg lidocaine (0.05%) and 2 mg epinephrine (1:500,000). This epinephrine concentration doubles the traditional concentration in an effort to maximize vasoconstriction and limit third-space blood loss into the tissues. The usual (superwet) volume of infusion solution is 2–3 L. To avoid epinephrine toxicity (and overhydration), the infusion volume should not exceed 5 L. Normal saline is preferred to Ringer's lactate, which is slightly hypotonic.

Liposuction Systems

Today there are many different cannulae and systems available, including a power-assisted cannula, which reciprocates to reduce surgeon fatigue (PAL Liposuction System, MicroAire, Surgical Instruments LLC, Charlottesville, VA). Wall uses an exploded tip cannula to separate fat as part of his SAFELipo (separation, aspiration, and fat equalization) method [20]. Little evidence supports one method over another. The old adage applies—the hand that holds the liposuction instrument is more relevant to the surgical result than the instrument itself.

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Avoiding Overtreatment

At first, the fat comes out readily. Gradually, the fat stream slows to a trickle. Tissue resistance decreases. The operator keeps a hand on the treated area to assess the change in contour as the fat comes off (which is impossible to do using cryolipolysis).

The experienced surgeon strikes the right balance between maximizing fat removal and avoiding complications. If the surgeon persists in trying to remove another 10% or so of fat, after the fat stream has been reduced to a trickle, this could cause unnecessary tissue trauma and increase the risk of seromas, skin irregularities, or poor skin contraction. It is far better to avoid such problems and return for a touchup if necessary later on.

Donor site contour deformities are particularly relevant now that buttock fat injection has become so popular. Surgeons may be overly aggressive in their effort to obtain as much fat as possible. Any incremental increase in buttock volume does not compensate for a contour deformity elsewhere that may be difficult or impossible to correct.

> Any incremental increase in buttock volume does not compensate for a contour deformity elsewhere that may be difficult or impossible to correct.

Managing Postoperative Weight Gain

Liposuction provides permanent correction of body disproportions. Contrary to rumor, any weight gain after surgery is evenly distributed all over the body. Adipocytes do not return to the treated areas or accumulate instead in untreated areas. This subject, “The Myth of Fat Redistribution,” is explored in Chap. 2.

So, how does a rumor like this get started? One possible explanation is that people rely on how they fit their clothes as a guide to when to cut back on calories. After liposuction, their clothes fit more loosely. Patients may gain weight until they fit clothes like they did before. Only now they are fuller in other parts of the body that were not reduced with liposuction, such as the face and arms.

Patients may return in follow-up and express dissatisfaction with the result. Before any further discussion takes place, these patients are asked to step on the scales.

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Invariably, these disappointed patients weigh more, sometimes 10 lb more, than they did at the time of liposuction. Of course, they should weigh less, not more, because the fat that was removed at surgery weighed several pounds, and sometimes as much as 10 lb. Patients are often surprised when they learn of this weight gain. Postoperative weight gain has compromised the result. In fact, if they had not had liposuction, they would likely be unable to fit into their pants. Patients may gain weight from postoperative inactivity. The usual caloric intake and fewer calories burned produces weight gain.

Fortunately, the outcome can still be a favorable one. Because the number of fat cells is fixed, there is no permanent harm done by temporary swelling of the fat cells. Of course, the patient needs to return to full activity and a proper diet. When the weight returns to normal (the same weight as at the time of surgery or less), the patient will better appreciate the results of liposuction. With good eating habits and gradual weight loss, the result just gets better.

My practice is to take photographs at least 3 months after liposuction. This allows enough time for the swelling to go down fully. Ideally, the patient will weigh the same as she did on the day of surgery, or even a little less, accounting for the volume of fat removed by liposuction. Fat weighs about 2 lb per L. Consequently, removal of 3000 cc of fat by liposuction should produce a 6 lb weight loss when the swelling has gone down. Therefore, to appreciate the results of liposuction without any compromise due to postoperative weight gain, this patient should weigh 6 lb less than on the day of surgery, when the postoperative photographs are taken.

My practice is to take photographs at least 3 months after liposuction. This allows enough time for the swelling to go down fully.

The patient will always fit into her clothes better than she would have without liposuction, regardless of how much she weighs, for the rest of her life because there are fewer fat cells in the treated areas, barring extreme weight gain. (At extreme weight, the fat cells reach the limit of their capacity to expand and will start making new fat cells to hold the additional fat. This subject is discussed in Chap. 4.)

Patients may be skeptical at first. A permanent correction of body disproportion does seem to be too good to be true. But they understand the concept when they are informed that fat cell numbers are genetically determined and the numbers do not change during ordinary weight gain or loss.

Health Benefits of Liposuction?

Patients sometimes ask if there are any long-term health risks associated with liposuction. For example, how does liposuction affect cholesterol levels? Liposuction has no effect on cholesterol levels [21]. This finding is not surprising because fat cells do not manufacture cholesterol. However, adipocytes do contain triglycerides. People with high triglyceride levels experience a 43% drop in triglyceride levels, on average [21]. A surprising and unexpected finding is that the white blood cell count drops 11% on average after liposuction [21]. Although there are no studies to indicate that these favorable changes are associated with health benefits, there is evidence that high triglyceride levels and high white blood cell counts are unhealthy, so the news is welcome. This subject is discussed in detail in Chap. 4.

Accredited Surgical Facilities

Today body contouring surgery, including liposuction, is done primarily in ambulatory surgery centers and in office operating suites. All members of the American Society of Plastic Surgeons performing outpatient surgery under general anesthesia must use facilities that are state-licensed, Medicare-certified, or accredited by a national- or state-recognized accrediting agency, such as the American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF), the Accreditation Association for Ambulatory Health Care (AAAHC), the Canadian Association for Accreditation of Ambulatory Surgery Facilities (CAAASF), or The Joint Commission (TJC) [22]. The American Society for Aesthetic Plastic Surgery also mandates accredited surgical facilities [23].

> All members of the American Society of Plastic Surgeons performing outpatient surgery under general anesthesia must use facilities that are state-licensed, Medicare-certified, or accredited by a national- or state-recognized accrediting agency.

Anesthesia

With recent attention to enhanced recovery after surgery (ERAS), the form of anesthesia has taken on an increased importance. This subject merits its own section and is discussed in detail in Chap. 5.

In my practice, having a licensed ambulatory surgery center on site facilitates performing even small cases such as liposuction touchups under a short intravenous anesthetic at a nominal cost. "SAFE" (spontaneous breathing, avoid gas, face up, extremities mobile) anesthesia provides an ideal balance of patient comfort, safety, and a short stay in the recovery room [24]. Avoidance of muscle paralysis is an important factor in preventing venous thromboembolism (Chap. 12) [25].

Patients naturally are nervous about the prospect of anesthesia. During my patient consultations, I list the priorities, which start with patient safety as the top priority for which there is no compromise, followed by surgeon expertise and cost. The discussion of safety includes the type of anesthesia and how total intravenous anesthesia differs from general endotracheal anesthesia. Prospective patients are very receptive to these discussions, especially those with a medical or nursing background. In the back of their minds, they worry about the risk. Such discussions may relieve some of the apprehensions of patients who may otherwise elect to undergo inferior and just as costly nonoperative alternatives.

> The discussion of safety includes the type of anesthesia and how total intravenous anesthesia differs from general endotracheal anesthesia.

A laryngeal mask airway (LMA) is used to maintain the airway. A propofol infusion (Fig. 3.3) is supplemented by fentanyl. Patients breathe spontaneously. No muscle relaxation is administered. Patients are never turned prone.

Because large areas of the body are exposed, hypothermia is a concern. The most effective way to avoid hypothermia is to keep the room warm (75 °F), even though this temperature is a little uncomfortable for operating personnel. Warm blankets and fluids are essential. It may be possible to use a Bair Hugger (Arizant Inc., Eden Prairie, MN) for at least part of the case, depending on how much of the patient is exposed, and in the recovery room.

Superwet Infusion

The superwet infusion is a modification of tumescent liposuction, in which fluids are infused in approximately a 1:1 ratio with the aspirate volume. A superwet infusion provides a liquid medium to facilitate liposuction but avoids overhydration. Fluid balance during liposuction is discussed in detail in Chap. 5.

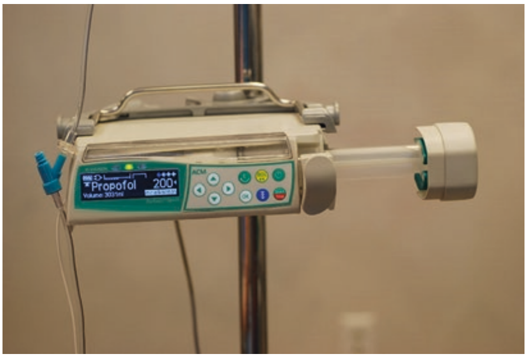

Fig. 3.3 Propofol infusion pump

Preoperative Marking

Preoperative marking is performed immediately before surgery (Fig. 3.4). "Lower body liposuction" consists of liposuction of the abdomen, flanks, thighs, and knees and is performed in 71% of women presenting for liposuction [26]. Almost all men have the abdomen and flanks treated, often including the breasts, with few men requiring treatment of the thighs or arms.

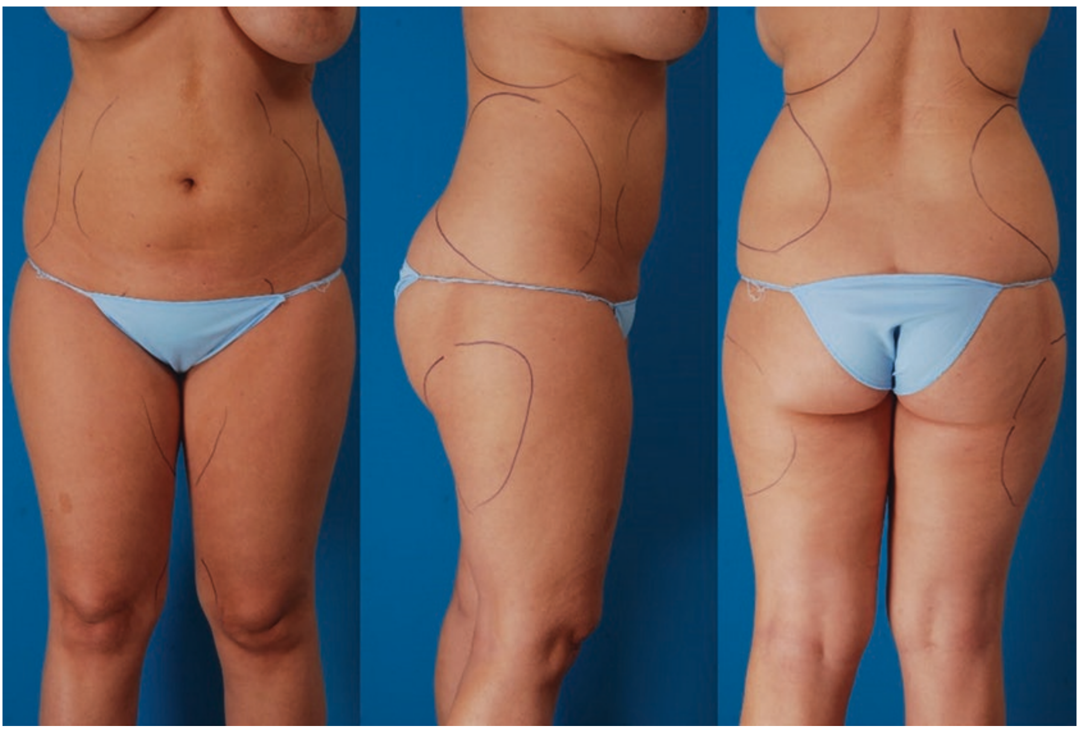

Fig. 3.4 Preoperative marking in a 29-year-old woman before liposuction of the lower body, arms, and axillae. Frontal (*left*), lateral (*center*), and posterior (*right*) views are shown. The patient had a previous liposuction treatment of her lower abdomen performed elsewhere, leaving her with a mild contour deformity. The markings highlight treatment areas. Liposuction extends beyond the marking borders. This patient's intraoperative and postoperative photographs are provided in Figs. 3.5, 3.10, 3.11, 3.12, and 3.13

Fig. 3.5 The patient is prepped by the nurse using dilute chlorhexidine solution

Simultaneous Cosmetic Procedures

Combination procedures are performed routinely. In the author's practice, 39% of liposuction patients undergo a simultaneous abdominoplasty (90% of abdominoplasty patients are also treated with liposuction, Chap. 6). Thirty percent of liposuction patients undergo simultaneous cosmetic procedures of the face or breasts [26].

Standing Prep

All women having body contouring surgery of the lower body are prepped circumferentially by the nurse using dilute, warmed chlorhexidine solution (Fig. 3.5).

Positioning in Surgery

Neuropathies can develop from unrelieved pressure. It is advantageous to move patients during surgery. Liposuction patients start supine on the operating table (Fig. 3.6) but are then moved to one side and then the other (Fig. 3.7) as the anesthetic solution is infused. The infusion is completed before liposuction is undertaken. This turning routine is repeated when liposuction is performed, so that the patient undergoes two cycles of supine/side-to-side positioning. Patients are never prone, and a pelvic bolster is therefore unnecessary. This sequence ensures that there is no prolonged pressure while the patient is in one position. The intraoperative movement of the lower extremities (the "E" representing "extremities mobile" in SAFE anesthesia) may also help to avoid venous stasis.

Liposuction patients start supine on the operating table (Fig. 3.6) but are then moved to one side and then the other (Fig. 3.7) as the anesthetic solution is infused. The infusion is completed before liposuction is undertaken. This turning routine is repeated when liposuction is performed.

No Prone Positioning

The prone position is the anesthetist's least favorite position. The airway is more difficult to manage, and endotracheal intubation (usually with paralysis and mechanical ventilation) is needed. There is a period of inactivity, about 20 min, in the operating room while the patient is turned from faceup to facedown on the operating table. The patient must be reprepped and redraped, compromising sterility and possibly accounting for high infection rates during body lift surgery (Chap. 7). A basic ethical litmus test is, would the

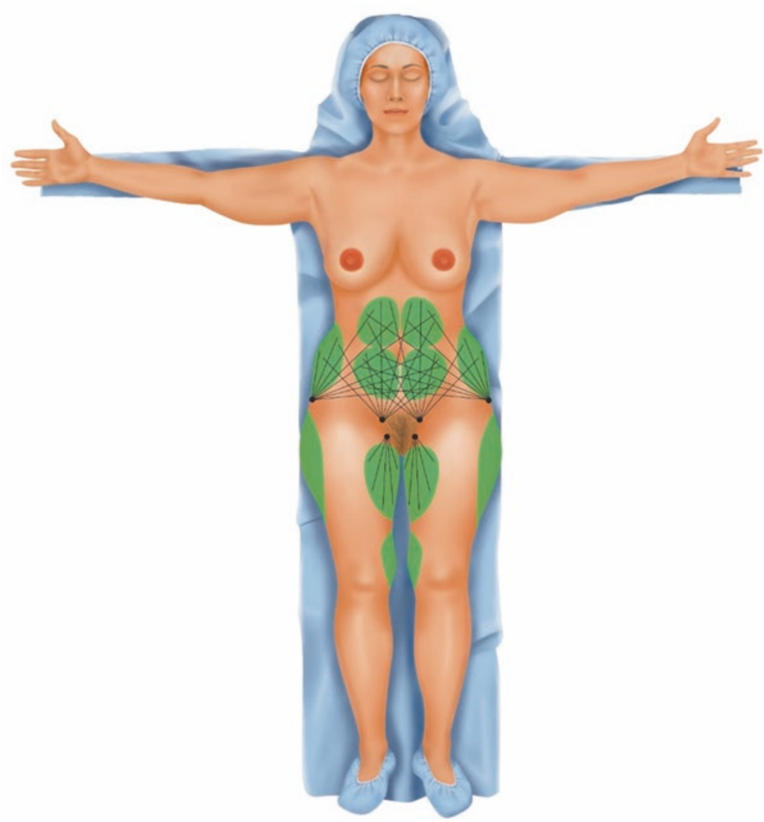

Fig. 3.6 Positioning in surgery and incisions used for liposuction. The patient is positioned supine on the operating table. The abdomen and inner thighs are infused in this position. An umbilical incision is not used. Cross-hatching from the hip incisions is done once the patient is turned on her side, not while she is in the supine position. [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

Fig. 3.7 After infusion of the abdomen and inner thighs, the patient is turned onto her left side. The outer and posterior thigh, flank, arm, and axilla (including the scapular area), left medial knee, and left medial calf may all be accessed. The abdomen is also re-treated from this lateral approach using the same hip incision (shown in Fig. 3.11). [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

surgeon allow himself or herself to undergo intubation, paralysis, mechanical ventilation, and prone positioning for cosmetic liposuction? The author would not.

The traditional criticism of supine/side positioning is that the two sides (except for the inner thighs) cannot be visually inspected simultaneously to ensure symmetry, which is true. However, with experience, this problem is mitigated by recognizing volume asymmetry preoperatively and by checking aspirate volumes as each area is treated.

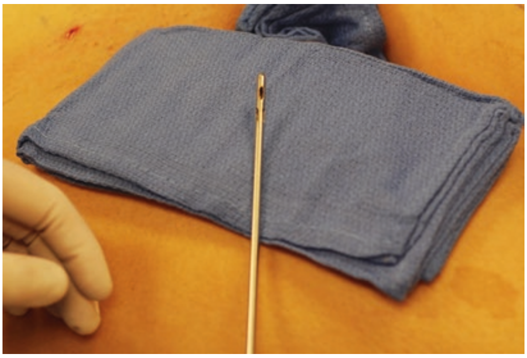

Fig. 3.8 Liposuction cannula used for fat aspiration. A 3-hole Las Vegas blunt tip cannula is preferred. A 4-mm cannula is used primarily. A 5-mm cannula is used for larger fat deposits

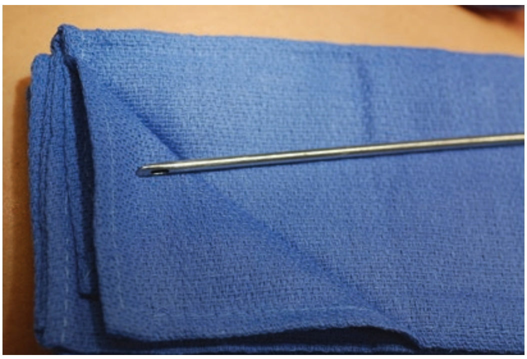

Fig. 3.9 The single-hole spatula tip is used for smaller fat deposits and finer contouring

Liposuction Cannulae

A multitude of cannulae styles are available. A blunt tip reduces trauma. The author prefers a 4-mm 3-hole "Las Vegas" style cannula (Fig. 3.8) and uses it in almost all patients. A 5-mm version is used in patients with larger fat deposits. A larger caliber allows faster fat removal, but a finer caliber (Fig. 3.9) is preferred after the fat layer has been debulked so as to avoid contour deformities.

Operative Sequence

The incisions and operative sequence are depicted in Figs. 3.10 and 3.11. The abdomen is accessed using an incision on either side of the pubic area, located well within the bikini line. The pubic area is frequently treated using these incisions as well. The author avoids umbilical incisions except in abdominoplasty cases, which require an incision around the umbilicus anyway. It is important to be aware of umbilical hernias and avoid them. Preoperative ultrasound scans of the abdomen are helpful in alerting the surgeon to any abdominal wall defects (Chap. 13).

> It is important to be aware of umbilical hernias and avoid them. Preoperative ultrasound scans of the abdomen are helpful in alerting the surgeon to any abdominal wall defects.

As a rule, the fewest possible incisions should be used when performing liposuction (Figs. 3.6 and 3.7). The access incisions for the inner thighs are hidden in the groin crease on either side. The outer thigh may be treated using the hip incision, which also provides access to the flank. An incision on the lower lateral buttock (not the gluteal fold) allows cross-hatching of the posterior and inner thigh using a curved cannula. The knee incision is located on the medial side of the knee and serves dual purpose when the medial calf is treated. Similarly, only one axillary incision is needed to treat both the upper arm and axilla/scapular areas. Directing the cannula away from the axilla is a safety consideration. A preaxillary fat deposit may be reached from the same incision. Occasionally an incision is made very superficially over the lateral aspect of the knee (to avoid injuring the common peroneal nerve) to access the lateral calf. The cannulae are typically 30 cm long, so that incisions placed midway along the length of the thigh, leg, or upper arm are unnecessary.

> Directing the cannula away from the axilla is a safety consideration. A preaxillary fat deposit may be reached from the same incision.

Fig. 3.10 Intraoperative photographs showing superwet infusion. The sequence starts with the abdomen (*above*, *left*), proceeding to the inner thighs (*above*, *center*, *and right*). The patient is turned onto her left side for treatment of the outer thigh (*center*, *left*), flank (*center*), right arm (*center*, *right*), axilla (*below*, *left*) including the anterior axillary area (*below*, *center*), and finally the contralateral medial knee (*below*, *right*)

The upper abdomen may be cross-hatched with strokes directed parallel to the costal margin (a safety consideration), while the patient is on her side, improving the contour of the upper abdomen (Fig. 3.11).

> The upper abdomen may be cross-hatched with strokes directed parallel to the costal margin (a safety consideration), while the patient is on her side, improving the contour of the upper abdomen.

Aspirate Volume

A superwet infusion followed by liposuction yields an aspirate with little infranatant fluid (Fig. 3.12), typically 12.5% of the total aspirate volume [27]. The infranatant fluid is very dilute, with a hematocrit (lipocrit) of <2% [27]. This observation has led plastic surgeons to underestimate blood loss from liposuction. Notably, about 90% of the infusion solution administered by a superwet method stays in the patient (not 30% as previously calculated for a tumescent method [27]). Consequently, patients require only mainte-

Fig. 3.11 Ultrasound treatment starts with the abdomen, which was the first site that was infused with the wetting solution (*above*, *left*). A syringe is used to drip saline on the cannula so as to avoid excessive heat at the infusion site. After ultrasound, liposuction is performed (*above*, *center*). The treatment proceeds with ultrasound followed by liposuction of the inner thighs (*above*, *right*; *center*, *left*; *and center*). A curved cannula is used to treat the upper inner thigh (*center*). After turning the patient on her side, the outer thigh is treated next (*center*, *right*), using the curved cannula to treat the proximal posterior thigh (*below*, *left*). The flank is treated next (*below*, *center*). The abdomen is cross-hatched while the patient is on her side to obtain maximum contouring of the upper abdomen (*below*, *right*)

nance fluid requirements during liposuction so as to avoid overhydration. Superwet aspirate volumes >5 L are seldom needed in patients who are not very obese (Fig. 3.13). Aspirate volumes >5 L are associated with an estimated blood loss >1 L (see Chap. 5). Almost all of this blood loss is into the tissues, not external, but its effect on the patient's hematocrit is no different [27]. Symptomatic anemia is best avoided.

Female Liposuction: Abdomen and Flanks

Examples of women treated with liposuction of the abdomen and flanks are shown in Figs. 3.14, 3.15, 3.16, 3.17, 3.18, and 3.19. Volumes indicate total aspirate volumes, including the infranatant fluid. The patients are arranged in order of increasing aspirate volumes.

Fig. 3.12 The suction canister with a small volume of infranatant fluid

Fig. 3.13 This 29-year-old woman's intraoperative photographs are shown in Figs. 3.10, 3.11, and 3.12. She is seen 6 weeks after surgery. The bruising has cleared, although she still has postoperative swelling, which typically requires 3 months to resolve

Fig. 3.14 This 39-year-old woman is seen before (*left*) and 4 months after ultrasonic liposuction of the abdomen and flanks (*right*). Volume, 1000 cc

Female Liposuction of Lower Body

Photographs of women treated with liposuction of the lower body are shown in Figs. 3.20, 3.21, 3.22, 3.23, 3.24, 3.25, 3.26, 3.27, and 3.28, arranged in order of liposuction aspirate volumes.

Long-Term Follow-up

An example of long-term follow-up is provided in Fig. 3.29.

Male Liposuction

Examples of men treated with liposuction of the abdomen and flanks are provided in Figs. 3.30, 3.31, 3.32, 3.33, 3.34, and 3.35.

Repair of Umbilical Hernia in Men

In women, it is common to repair an umbilical hernia at the time of abdominoplasty. Affected men may be treated using a periumbilical inci-

Fig. 3.15 This 24-year-old woman is seen before (*left*) and 3 months after (*right*) ultrasonic liposuction of the abdomen and flanks. Volume, 1300 cc

Fig. 3.16 This 31-year-old Hispanic woman underwent ultrasonic liposuction of the abdomen and flanks. She is seen before (*left*) and 6.5 months after surgery (*right*). Volume, 1500 cc

Fig. 3.17 This 32-year-old woman is shown before (*left*) and 8 months after (3 months after touchup) ultrasonic liposuction of the abdomen, flanks, inner thighs, and arms (*right*). Her torso appears longer and her buttock appearance is improved. She had a touchup liposuction of the abdomen, flanks, and inner thighs. Volumes, 1475 cc; touchup, 600 cc

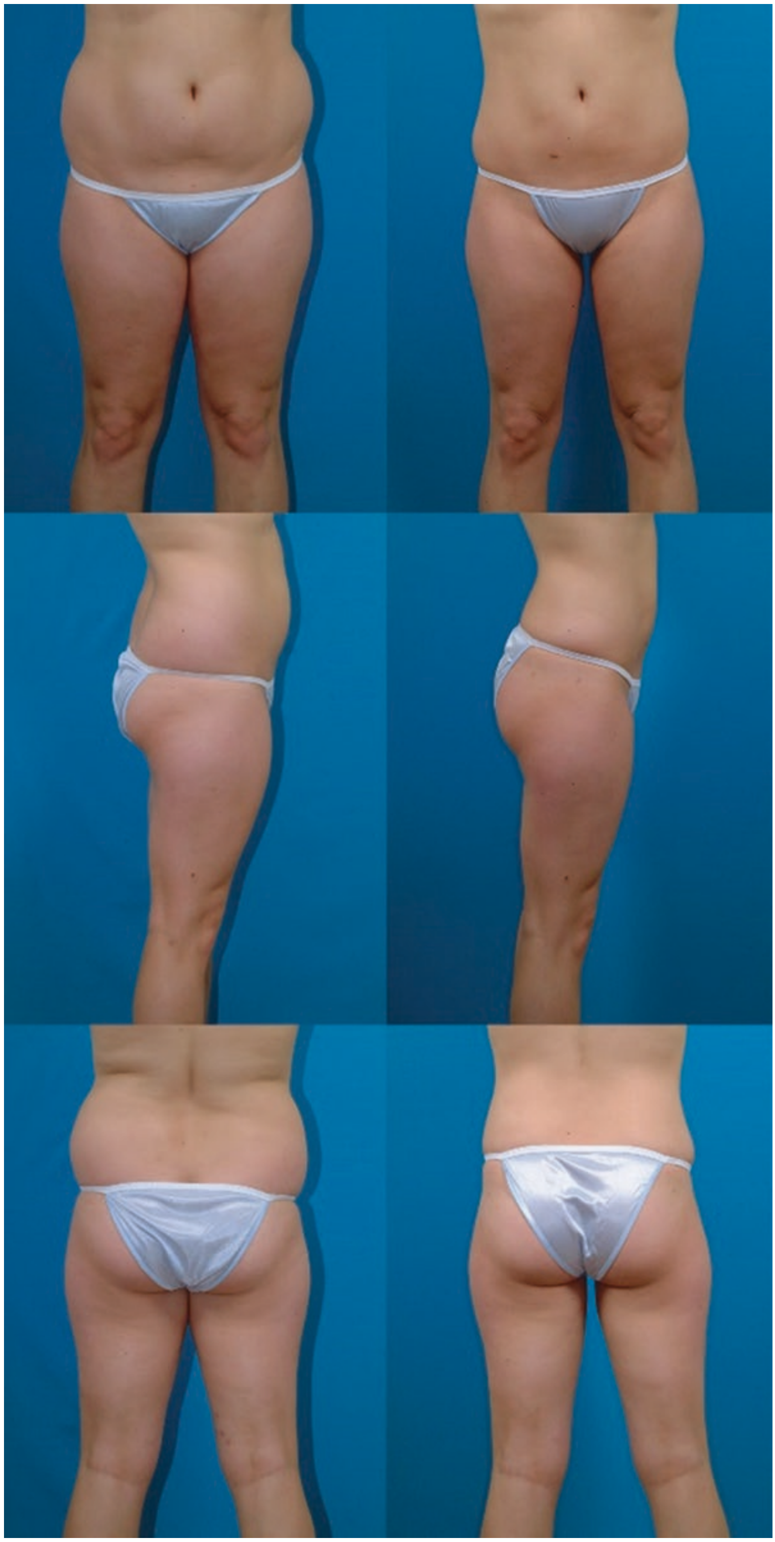

Fig. 3.18 This 31-year-old nulliparous woman with an “apple” body type is seen before (*left*) and 1 year after ultrasonic liposuction of the abdomen, flanks, arms, and axillae (*right*). Volume, 2400 cc

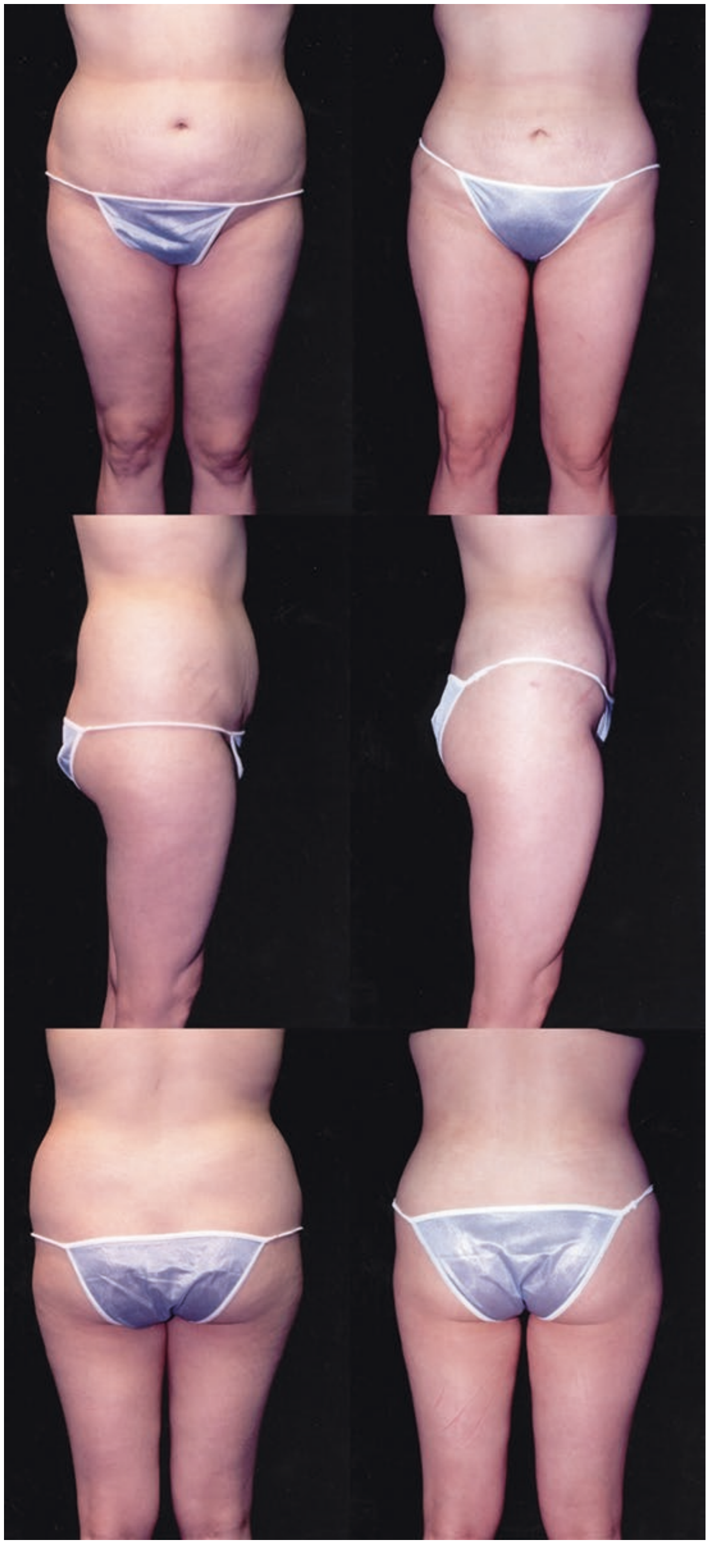

Fig. 3.19 This 23-year-old woman had a "muffin top" deformity (*left*). Her shape is improved 9 months after ultrasonic liposuction of the abdomen, flanks, inner thighs, and arms and 3 months after a touchup liposuction of the abdomen and flanks (*right*). Despite skin laxity and extensive stretch marks of the abdomen, her skin has contracted well. Volume, 3150 cc. Touchup, 625 cc

Fig. 3.20 This 27-year-old woman is shown before (*left*) and 9 months after (5 months after touchup) ultrasonic liposuction of the lower body (*right*). She had a simultaneous breast augmentation. Volumes, 1800 cc. Touchup, 700 cc. Her scars are shown in Figs. 3.21, 3.22, and 3.23

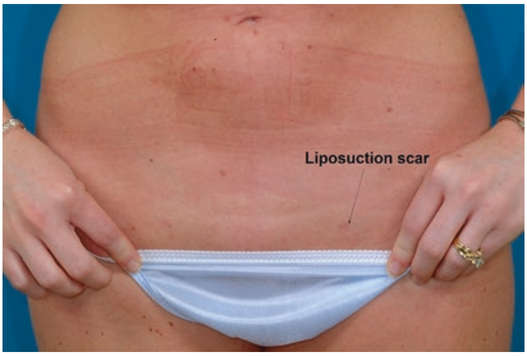

Fig. 3.21 Scar in left suprapubic area

Fig. 3.22 Left hip scar

sion, often at the time of simultaneous abdominal liposuction (Fig. 3.34).

Abdominal Definition

With the importance of abdominal muscle definition in our culture, it is not surprising that patients seek to develop their six-packs, or eight-packs. The anatomy of the tendinous intersections that define the rectus abdominus muscle is genetically endowed and highly variable. Some patients may not have this favorable anatomy and be limited to a four-pack or even a two-pack.

Traditionally, liposuction has been used to reduce the thickness of the subcutaneous fat layer, making underlying muscle definition more visible (Fig. 3.35). Some operators have performed selective liposuction more aggressively over the fascial bands that define the rectus abdominus, in an effort to maximize the patient's six-

Fig. 3.23 Scar on left lower buttock

pack [28]. However, more aggressive defatting increases the seroma rate to about 18% [28]. Although short-term results can be impressive, subsequent weight gain might produce an unnatural "waffle" appearance.

Arm Liposuction

The arms are a favorable area for liposuction and are probably undertreated by plastic surgeons. Liposuction of the arms does not seem to add much to the amount of postoperative discomfort and treats an area that is visible and responds well to treatment, so it is common for me to treat the arms at the same time as liposuction of the lower body, or occasionally on their own.

Most women are understandably concerned about what will happen to the skin after the fat is suctioned. The skin tone may be no better, but it is unlikely to be made worse by judicious liposuction. It is always possible to come back and perform brachioplasties if needed. If the brachioplasty scar can be avoided, so much the better.

Liposuction of the Axilla

In consultation, women often grab a roll of fat just lateral to their breasts, commonly called the bra fat. It can bulge around the bra strap, which is not considered attractive. Even though this area is located below the axilla, it is included in the area called the axilla, or sometimes the "scapular" area.

Fig. 3.24 This 21-year-old woman underwent ultrasonic liposuction of the lower body. She is seen before (*left*) and 2 months after surgery (*right*). Volume, 2700 cc

There is often a crease between this bra fat roll and the love handle. By treating the extra fat in the roll above and below this crease, the crease may be softened or sometimes eliminated (Fig. 3.18).

Because of the difference in fat distribution in men, very few men require liposuction of the arms, although I frequently treat the axillary areas (from a lateral decubitus position) when I perform liposuction on male breasts.

Clinical Examples: Liposuction of Arms

Examples of women treated with liposuction of the arms are provided in Figs. 3.36, 3.37, 3.38, 3.39, 3.40, 3.41, and 3.42.

Fig. 3.25 This 43-year-old woman is seen before (*left*) and 16 months after (*right*) ultrasonic liposuction of the lower body, arms, and axillae. She had four children. Her skin tone is noticeably improved after surgery. Volume, 3250 cc

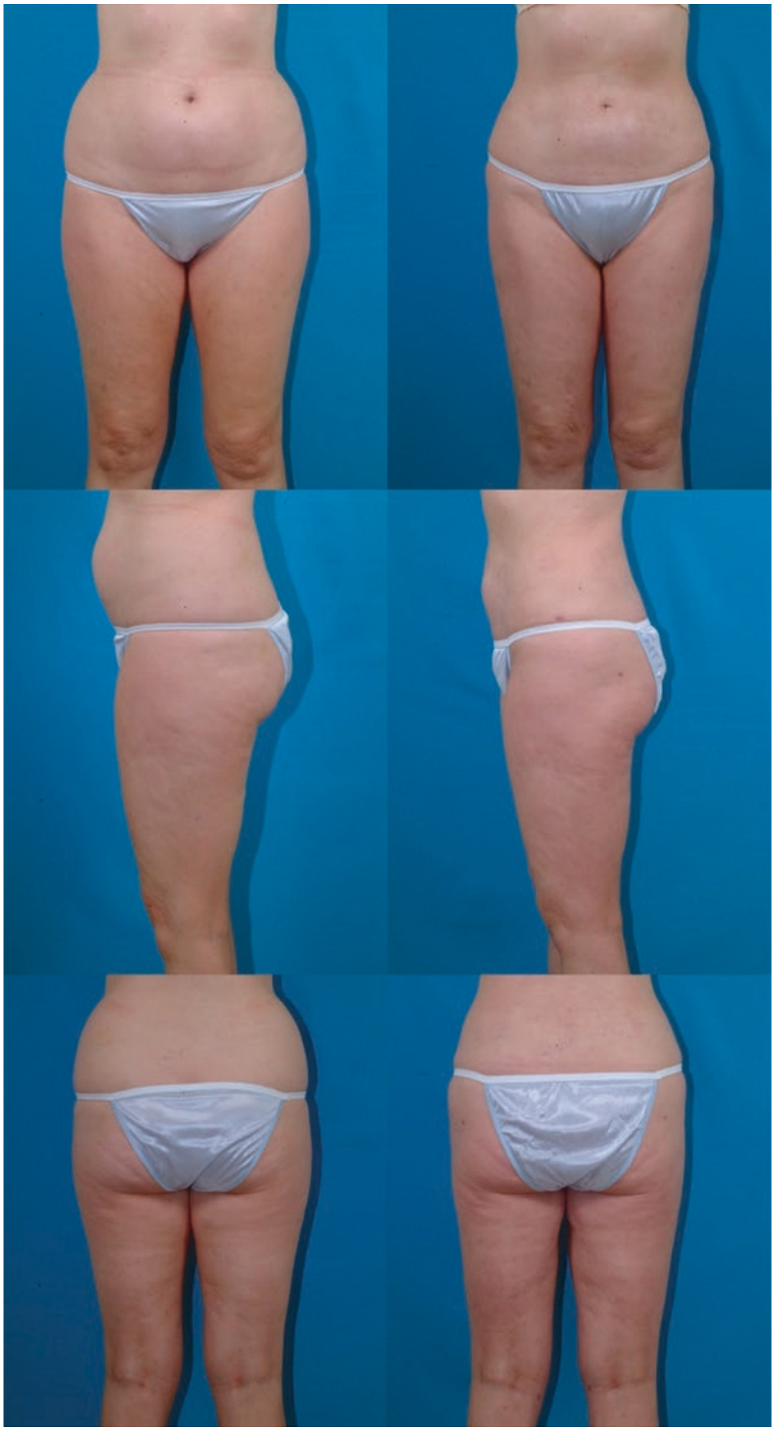

Fig. 3.26 This nulliparous 54-year-old woman is seen before (*left*) and 3 months after ultrasonic liposuction of the lower body, arms, and axillae (*right*). Volume, 3800 cc

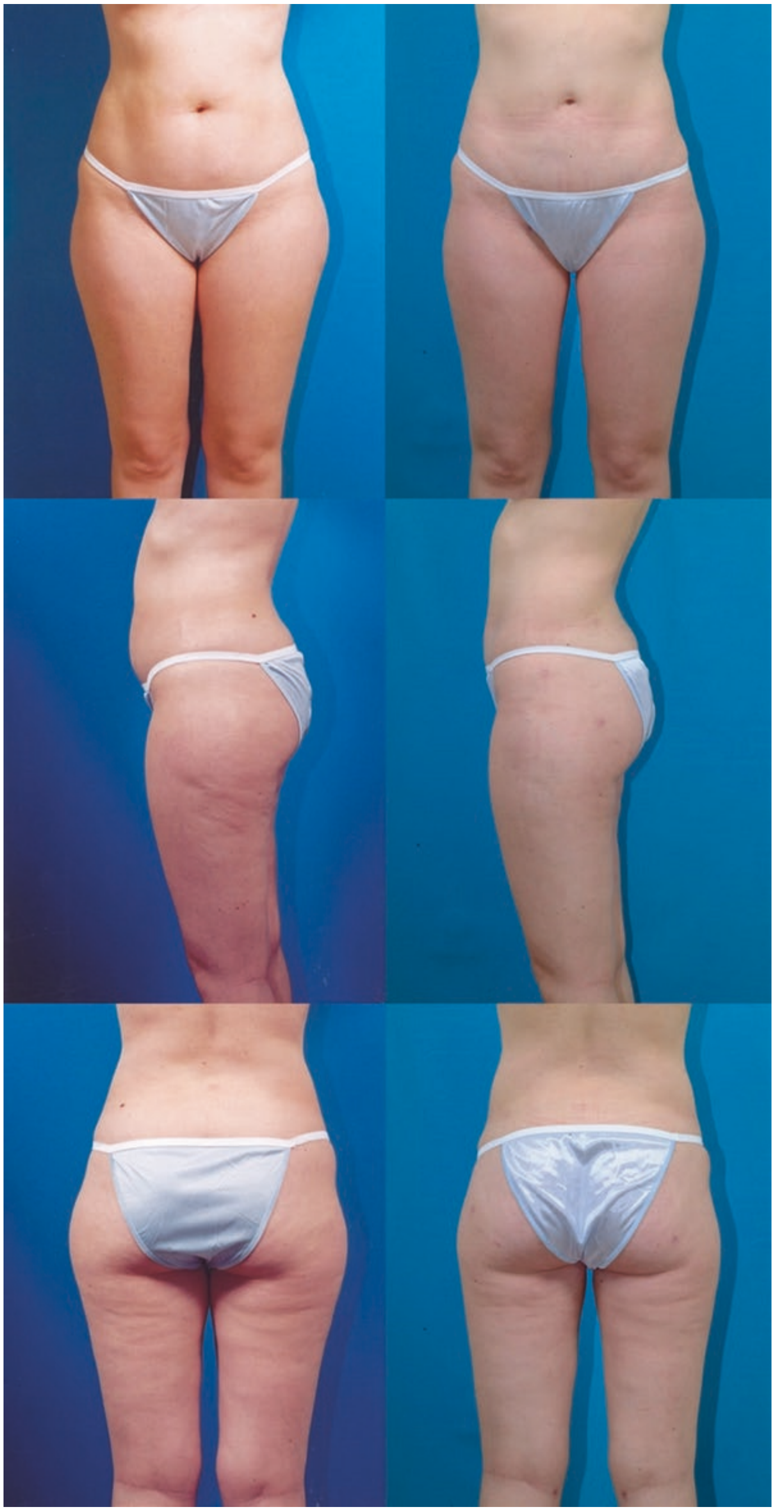

Fig. 3.27 This 28-year-old woman underwent liposuction of the lower body followed by a touchup of the lower body 11 months later and breast augmentation. She is seen before (*left*) and 1 year after her original procedure (*right*). Volume, 3650 cc. Touchup, 1150 cc

Fig. 3.28 This 26-year-old African-American woman is seen before (*left*) and 11 months after (5 months after touchup) ultrasonic liposuction of the lower body, followed by a touchup liposuction of the abdomen, flanks, inner thighs, and right posterior thigh (*right*). Volume, 4225 cc. Touchup, 950 cc

Fig. 3.29 This 34-year-old woman is seen before (*left*), 1.5 years after (*center*), and 8 years after (*right*) liposuction of the lower body and calves with a simultaneous breast augmentation. She had no touchups. Volume, 5325 cc

Liposuction of Arms: Patients Over 50

Older patients often demonstrate a satisfactory skin response after liposuction (Figs. 3.40, 3.41, and 3.42).

Compression Garment

At the end of the operation, while the patient is still in the operating room, a compression garment is applied. This garment is either a simple Velcro binder that goes around the abdomen and flanks, commonly used in men, or a girdle that extends from the level of the upper abdomen down to the thighs and ends either above or just below the knees. The compression garment is worn for 1 month, although it is not mandatory and alternatives may be worn such as spandex or pantyhose if the patient finds the garment uncomfortable. Patients are counseled that the garment does not "smooth out" the contours. In fact, the garment does not affect the ultimate result because the swelling will resolve regardless, but it does limit swelling and help the swelling to resolve more quickly.

The garment does not affect the ultimate result because the swelling will resolve regardless, but it does limit swelling and help the swelling to resolve more quickly.

No compression garment is used for the arms. However, some patients wear a snug athletic shirt that has sleeves to provide some gentle compression. Compression garments should not fit too tightly in the groin, particularly when there is swelling from liposuction of the inner thighs. The garment can be cut if the fabric is too tight. The zippers do not have to be fully zipped up on either side, especially in shorter patients.

Fig. 3.30 This 45-year-old man is seen before (*left*) and 6 months after (*right*) ultrasonic liposuction of the abdomen and flanks. Volume, 900 cc

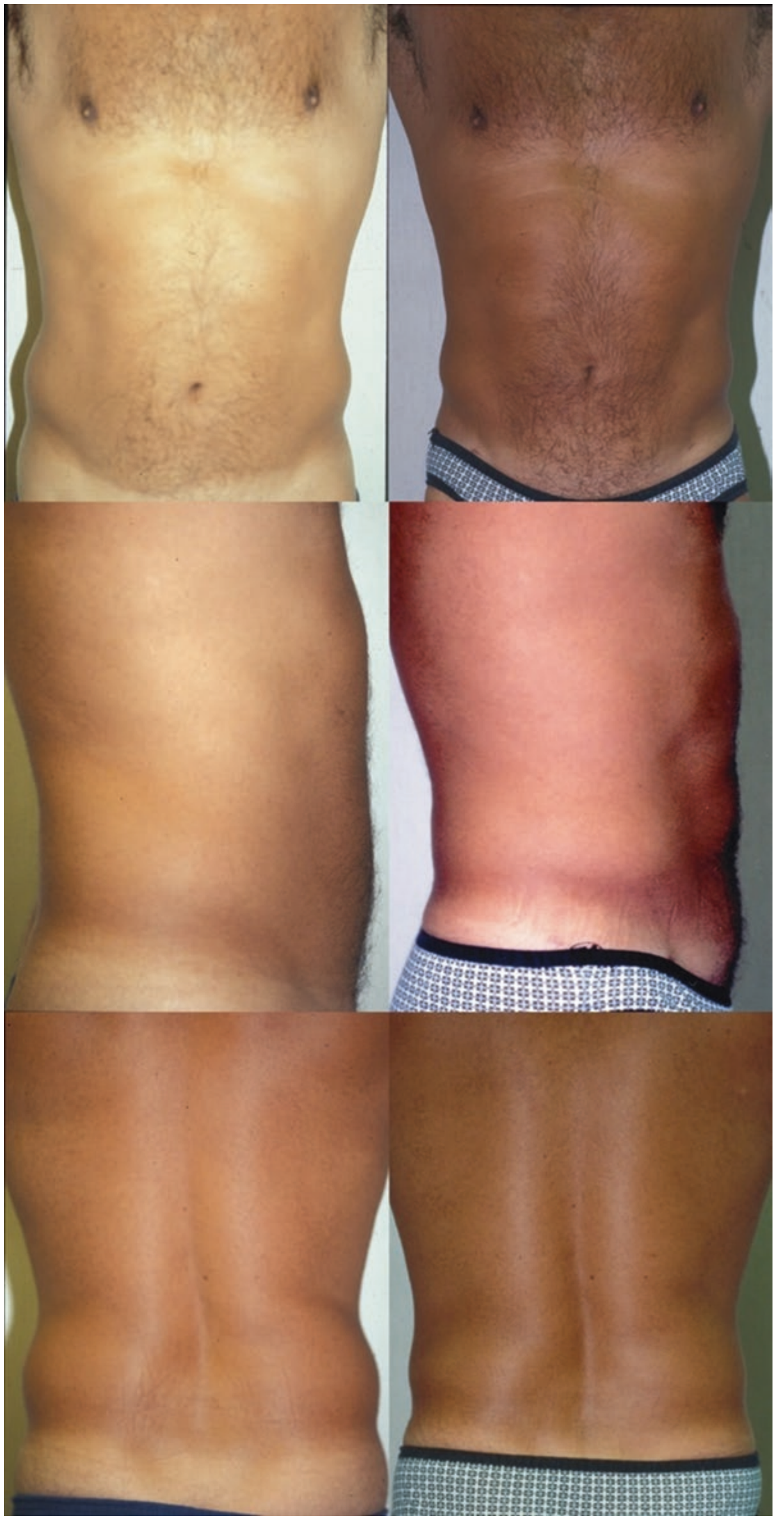

Fig. 3.31 This 39-year-old man exercised daily and had only 8% body fat, but was unable to develop muscle definition and had persistent love handles (*left*). Six weeks after liposuction, his muscle definition is already visible (*right*). Volume, 925 cc

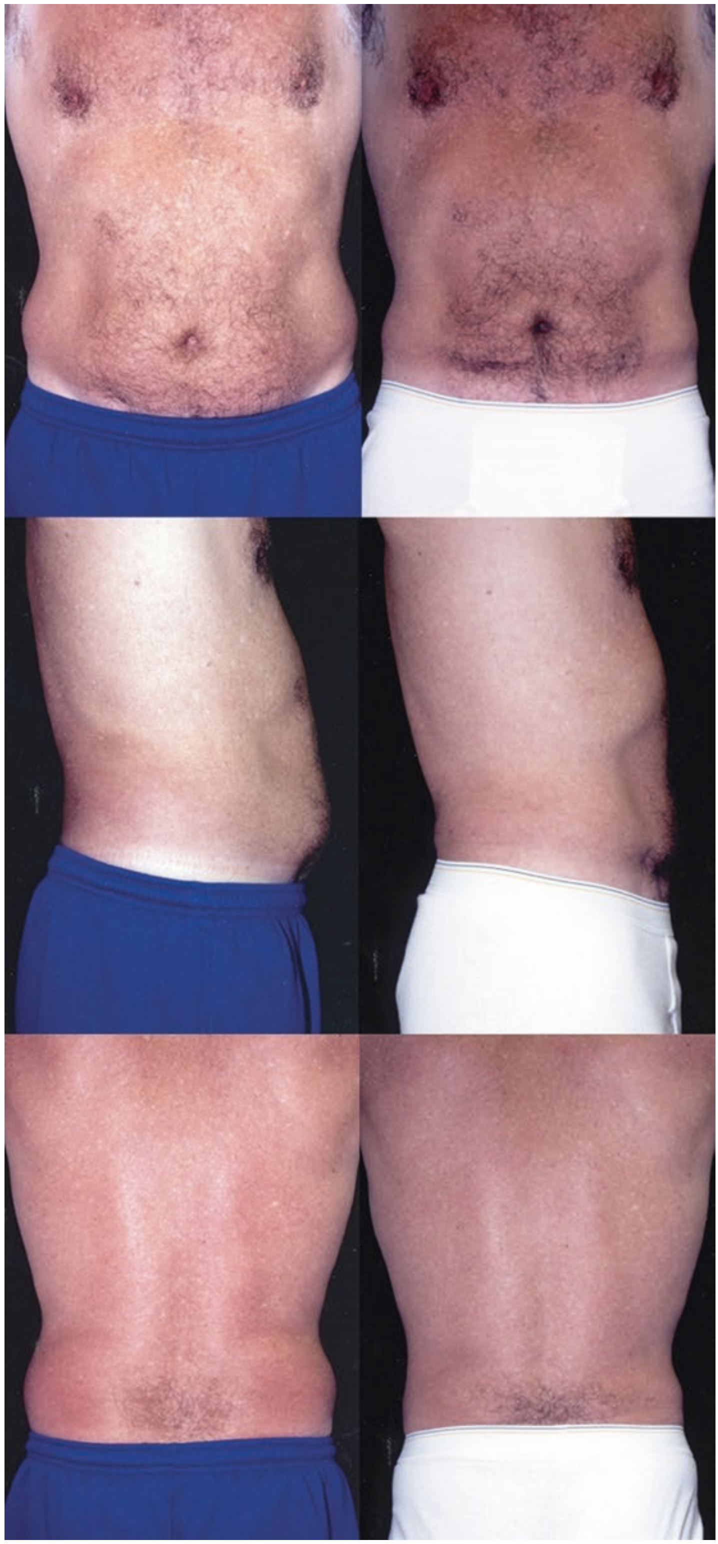

Fig. 3.32 This 54-year-old man is seen before (*left*) and 2 months after (*right*) ultrasonic liposuction of the abdomen and flanks. He reported dropping from a 36″ waist size to a 33″ waist circumference. Volume, 1825 cc

Fig. 3.33 This 45-year-old man had lost weight recently and demonstrated the expected loss of abdominal skin tone (*left*). Four months after liposuction, his skin tone appears to be improved (*right*). Volume, 1925 cc

Fig. 3.34 This 38-year-old man's umbilical hernia had been present for at least a decade and caused him intermittent discomfort. It was repaired at the time of liposuction of the abdomen and flanks. He is seen before (*left*) and 3 months after surgery (*right*). Volume, 1650 cc

Fig. 3.35 This 24-year-old bodybuilder could not achieve his desired muscle definition (*left*). After ultrasonic liposuction of the abdomen and flanks and a touchup 7 months later, he was encouraged by the appearance of his six-pack, photographed 3 months after the touchup (*center*). He won his category in a bodybuilding competition just 2 weeks later (*right*). Volume, 850 cc. Touchup, 750 cc

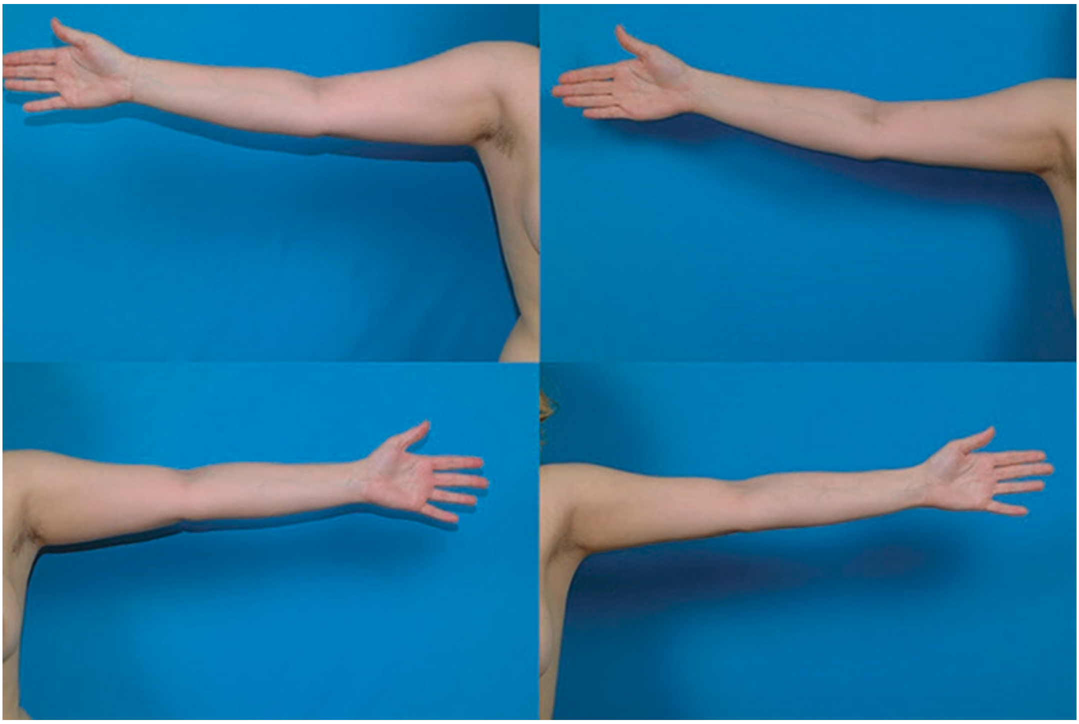

Fig. 3.36 This 22-year-old woman is seen before (*left*) and 1 year after (*right*) ultrasonic liposuction of the arms and axillae. Volumes: right arm, 100 cc; left arm, 125 cc

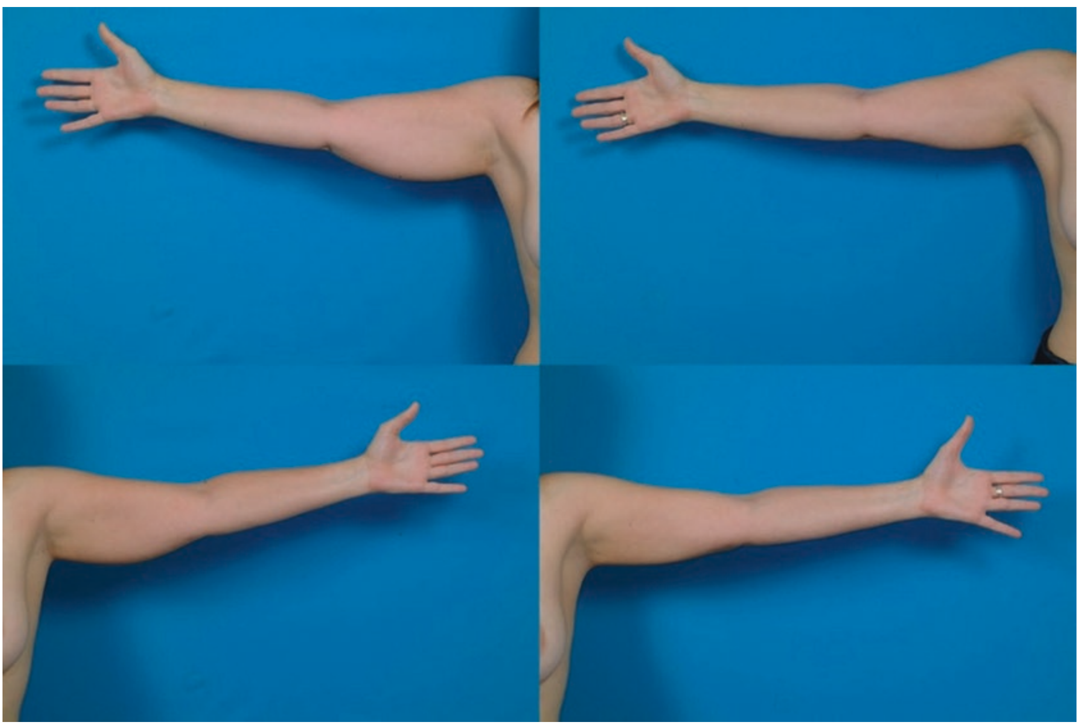

Fig. 3.37 This 32-year-old actress had a role coming up in which she would be sleeveless. She is seen before (*left*) and 3 months after (*right*) ultrasonic liposuction of the arms and axillae. Volumes: right arm, 275 cc; left arm, 250 cc

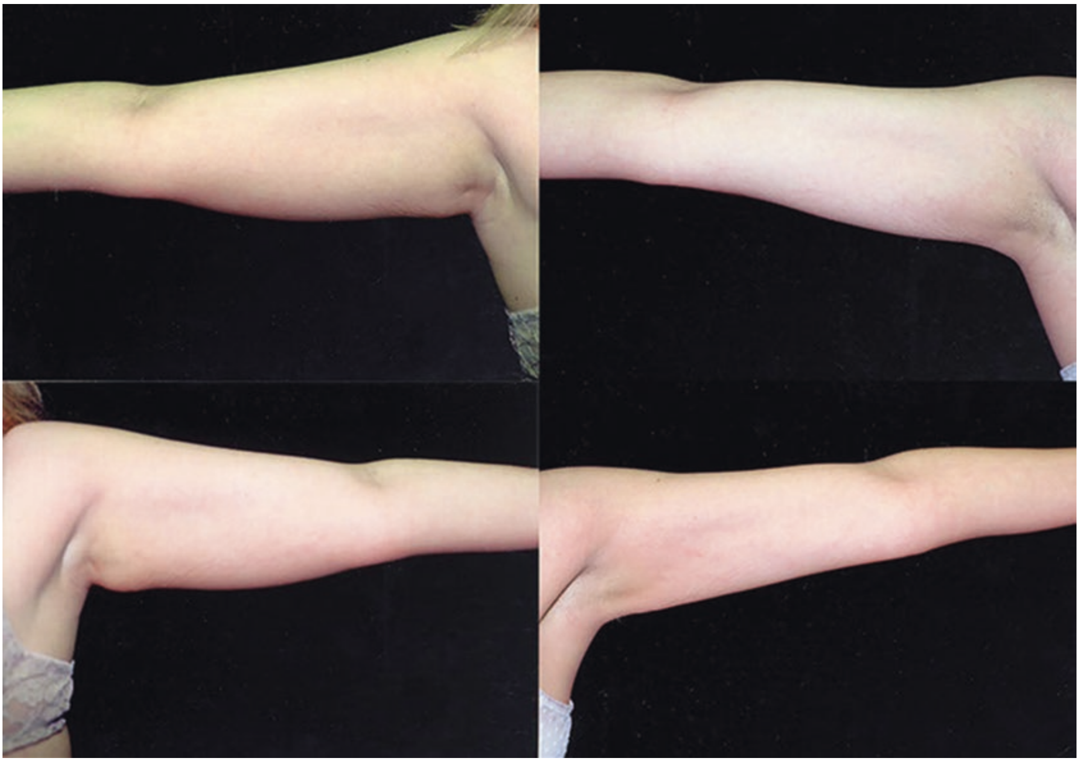

Fig. 3.38 This 34-year-old woman is shown before (*left*) and 3 months after (*right*) ultrasonic liposuction of the arms. Previously she would not wear sleeveless tops. Volumes: right arm, 150 cc; left arm, 175 cc

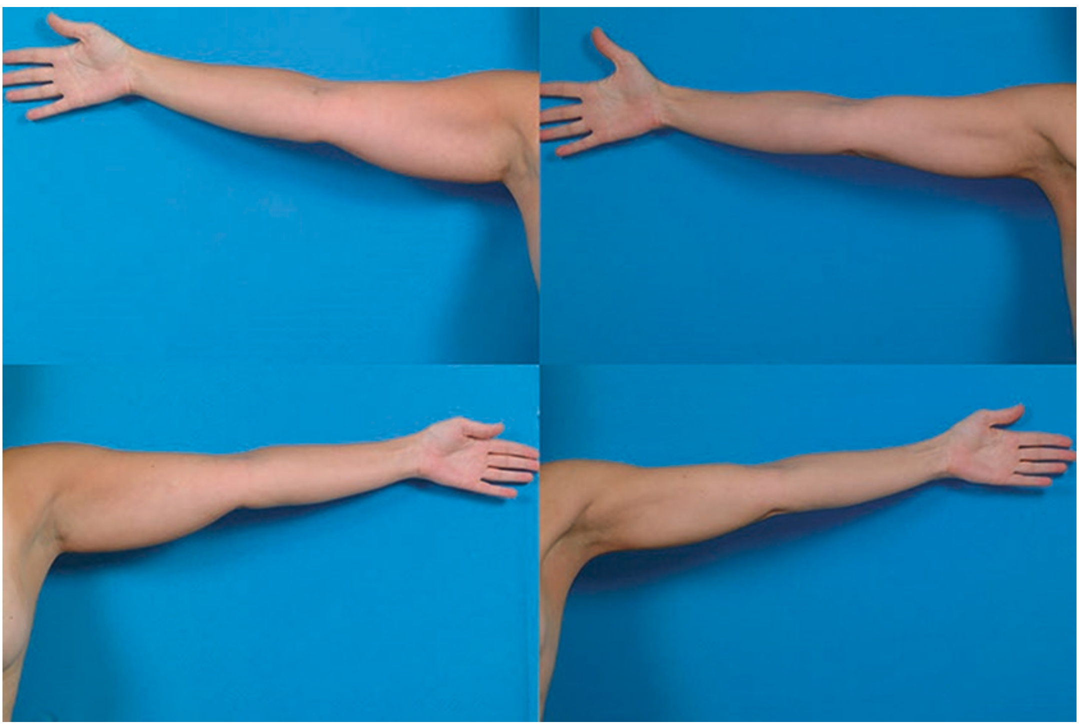

Fig. 3.39 This 39-year-old woman is seen before (*left*) and 1 year after (8 months after touchup) ultrasonic liposuction of the arms and axillae, performed simultaneously with lower body liposuction. Volumes: right arm, 100 cc; left arm, 125 cc. Touchups, 25 cc, 25 cc

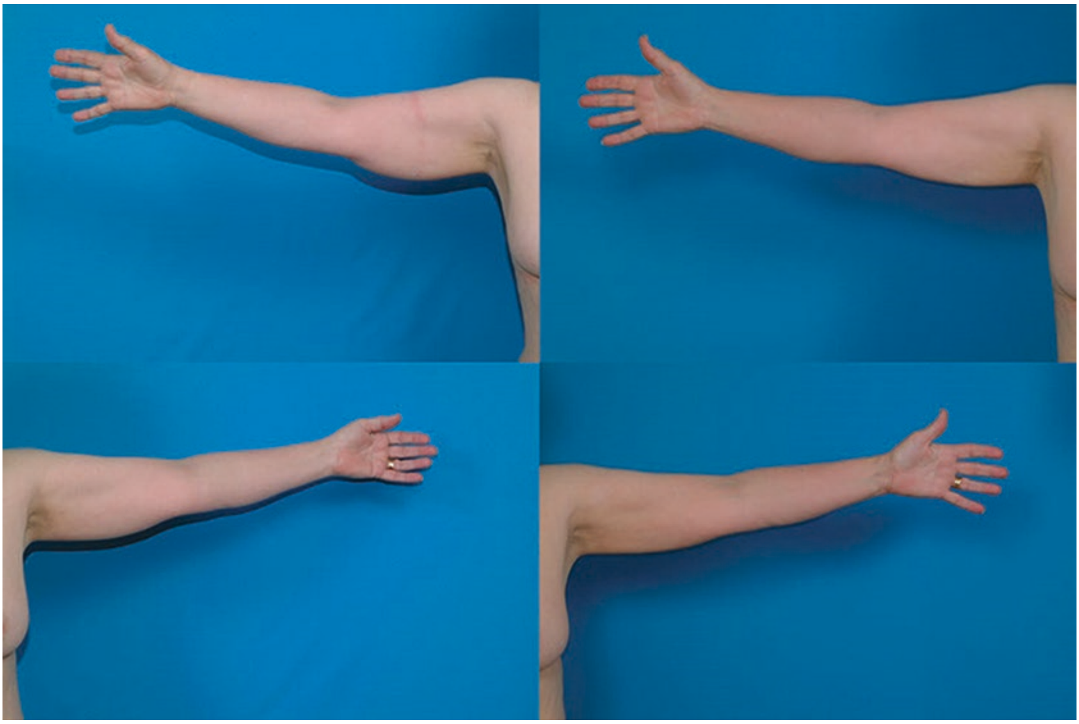

Fig. 3.40 This 58-year-old woman is seen before (*left*) and 1 year after ultrasonic liposuction of the arms and axillae, performed at the time of a lower body liposuction (*right*). Volumes: right arm, 100 cc; left arm, 125 cc

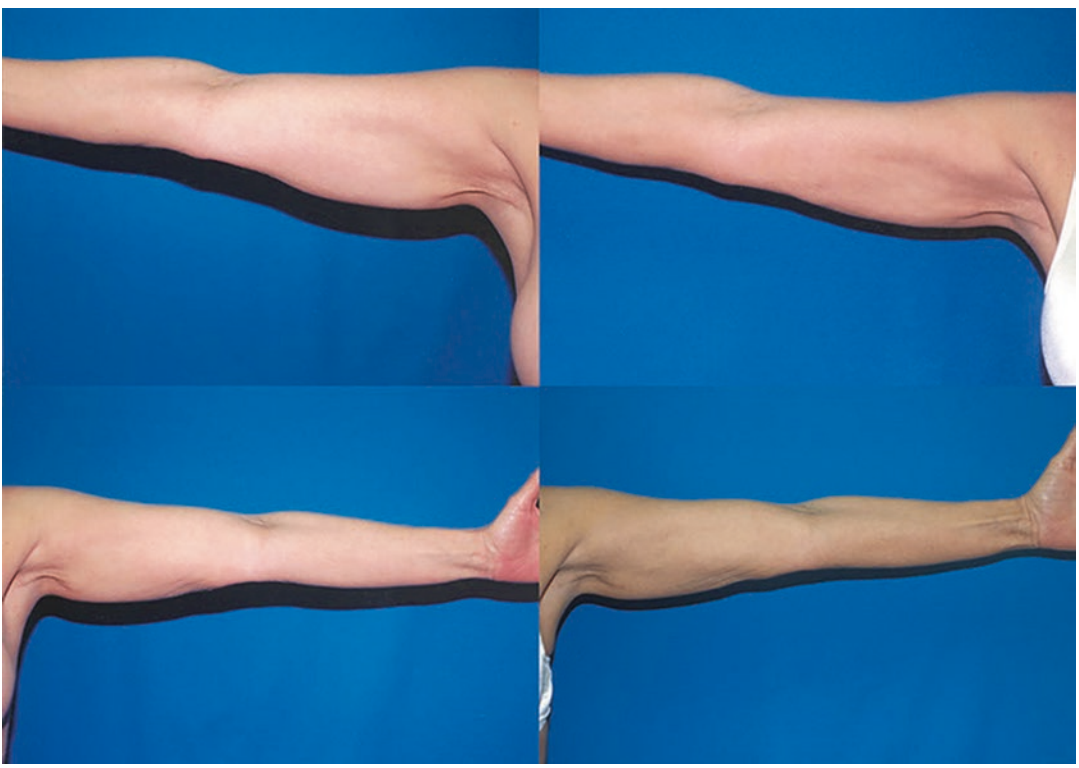

Fig. 3.41 This 61-year-old woman is seen before (*left*) and 3 months after (*right*) ultrasonic liposuction of the lower body and arms. Volumes: right arm, 200 cc; left arm, 150 cc

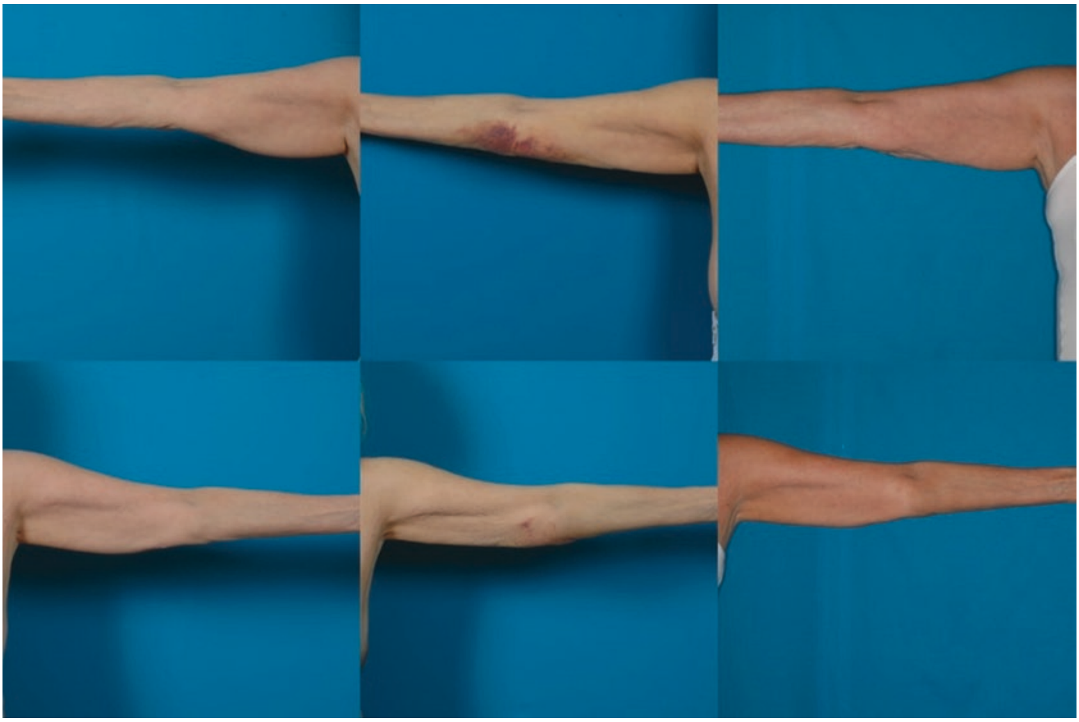

Fig. 3.42 This 66-year-old former model was at ideal body weight and had never been overweight. She is seen before (*left*), 8 days after (*center*), and 5.5 months after (*right*) ultrasonic liposuction of the arms and axillae. Her skin responded well despite her age. The improvement is visible even 8 days after surgery (*center*). Volumes: right arm, 165 cc; left arm, 140 cc

Numbness

Numbness in the treated areas may last up to 2 months. There may also be areas of hypersensitivity.

Swelling

Most patients notice a reduction in contours immediately after having liposuction. However, swelling develops during the first few days and can occasionally make treated areas temporarily look fuller than they were before surgery, particularly in lean patients. Although swelling is variable from patient to patient, typically two-thirds of the swelling is gone in 1 month [9]. Full resolution of swelling takes about 3 months. This fact is important for patients to know, because they may otherwise be disappointed at their 1-month follow-up appointment, thinking that they are now seeing their final result, when in fact they still have a significant degree of swelling. "Lymphatic massage" is recommended by some operators; whether it is helpful is unknown.

The legs and ankles may swell more a week after surgery because of the effects of gravity and increased activity. Bruising may extend all the way down to the toes but usually disappears within 1 month [26]. Of course, elevating the legs is helpful. If one lower extremity swells conspicuously more than the other, a deep venous thrombosis should be considered and a Doppler ultrasound performed.

Time Off Work

The average time off work after liposuction is 5.7 days [26]. Most women take 1 week off work, or 2 weeks if their job requires vigorous physical activity. Men usually recover quickly because fewer areas are treated; men are often back to an office job in 3 or 4 days. If the job is very physical, men are advised to take 2 weeks off work.

Exercising

Patients are instructed to wait 2 weeks before resuming most exercises. Patients are cautioned that if they exercise too soon, they will experience more swelling and will hurt more afterward—not while they are working out, but later. Walking is encouraged instead, even a few miles. Using an elliptical trainer or exercise bike should be deferred until about 3 weeks after surgery. All exercises may be resumed 4 weeks after surgery. Patients are instructed to start gradually, doing a light workout, perhaps 50% of their usual, and then see how they feel later in the evening. If there is no soreness or increased swelling, their exercise routine can be advanced.

Patient-Reported Outcomes

Patient satisfaction and the effect of surgery on quality of life are the most important determinants of a successful cosmetic operation [29–31]. Prospective studies with high response rates are preferred [32, 33]. Otherwise, it is impossible to know whether the experience of the majority of patients is similar to that of the minority of respondents sampled [32]. Large sample sizes increase statistical power and improve reliability [34]. In-person interviews reward the researcher with a much higher response rate than mailed surveys and often more thoughtful and complete responses [26].

In order to learn more about the recovery experience and patient assessment, an outcome study was undertaken by the author and published in 2012 [26]. In-person interviews were conducted with 360 consenting patients who attended a follow-up appointment at least 1 month after surgery. These patients were among 551 consecutive patients treated with liposuction and/or abdominoplasty. The response rate was 65.3% [26].

Patient Discomfort

Considerable variability exists between individuals in their pain evaluations. The range of pain ratings after liposuction was 1–10 (1 representing no pain and 10 the worst possible pain) for both sexes. The mean pain rating for liposuction was 6.1, compared with 7.5 for abdominoplasty either on its own or combined with liposuction (Fig. 3.43) [26]. Liposuction patients find the surgery less painful than they anticipated compared with abdominoplasty patients, who are more likely to find the surgery more painful than expected ($p = 0.001$).

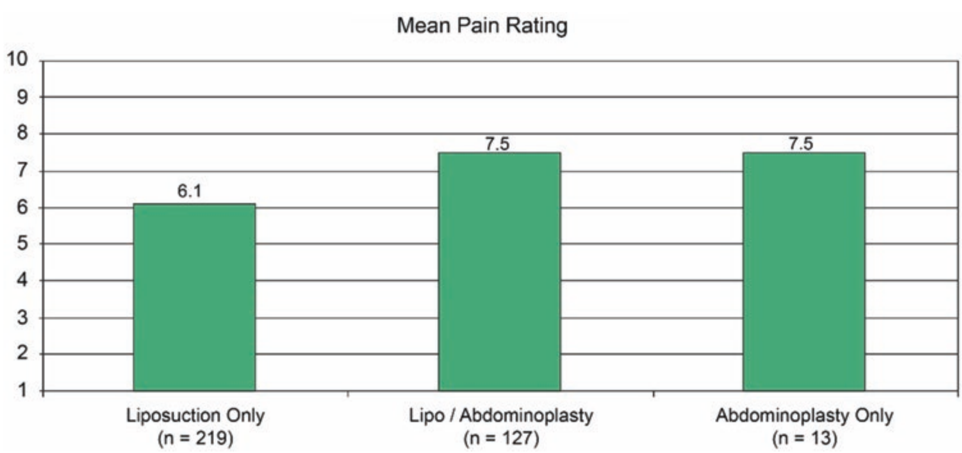

Fig. 3.43 Pain rating: scale of 1 (no pain) to 10 (most severe pain) [Reprinted from Swanson E. Prospective outcome study of 360 patients treated with liposuction, lipoabdominoplasty, and abdominoplasty. Plast Reconstr Surg. 2012;129:965–978; discussion 979–980. With permission from Wolters Kluwer Health, Inc.]

Fig. 3.44 Result rating: scale of 1 (worst) to 10 (best) [Reprinted from Swanson E. Prospective outcome study of 360 patients treated with liposuction, lipoabdominoplasty, and abdominoplasty. Plast Reconstr Surg. 2012;129:965–978; discussion 979–980. With permission from Wolters Kluwer Health, Inc.]

The duration of prescription painkiller use after liposuction was 4.3 days, corresponding to a return to driving. The average time off work after liposuction was 5.7 days. Patients felt they were "back to normal" and returned to exercising 1 month after liposuction, on average [26].

Bruising typically cleared in 1 month. Numbness lasted for about 2.5 months [26]. Men reported less pain and shorter recovery times than women after liposuction, with similar result ratings [26].

Patient Satisfaction

Women reported dropping an average of 1.7 dress sizes (e.g., a drop from a size 14 to a size 10 would be two dress sizes) after liposuction. Men reported losing, on average, 1.4 in. at the waist [26]. The average result rating after liposuction was 7.8 on a scale of 1 (worst) to 10 (best), less than the ratings for patients treated with abdominoplasty alone or in combination with liposuction ($p < 0.001$) (Fig. 3.44). The 82.5% of liposuction patients whose results met or exceeded their expectations is similar to other series quoting patient satisfaction rates of 76–85% [35–41]. The 93.5% of patients who would repeat liposuction compares to rates of about 80% in other series [37, 42]. The 97.3% of patients who said they would recommend liposuction to others compares favorably with other series reporting rates of 75–86% [37, 39, 42].

Touchup Liposuction

About half of all patients reported than the amount of liposuction was "not enough" [26]. Such a finding is unlikely to surprise most plastic surgeons, who encounter few patients who, even after liposuction, think they are as lean as they would like to be (although 82.5% of liposuction patients also reported that their expectations were met).

Study patients were predominantly nonobese (79.4% had body mass indices <30 kg/m^2), and liposuction volumes averaged 2420 cc for liposuction alone and 2007 cc when combined with abdominoplasty—not modest amounts, particularly considering that touchups (9.6%) were included in the series. Magnetic resonance imaging in three study patients determined that the average reduction in fat thickness was 45.6% [9], a substantial reduction. Surgeons are well-aware that excessive liposuction compromises skin resilience. Reassuringly, especially in view of the frequency of this problem early in the history of liposuction, only 5.7% of liposuction patients reported worse skin tone after liposuction. Patients understand that it is preferable for them to return later for additional liposuction rather than sacrificing skin tone with overaggressive liposuction. Although liposuction is not usually promoted as a remedy for cellulite, 64.9% of liposuction patients reported an improvement in this condition [26].

> Only 5.7% of liposuction patients reported worse skin tone after liposuction. Patients understand that it is preferable for them to return later for additional liposuction rather than sacrificing skin tone with overaggressive liposuction.

The author's revision policy is financially favorable for patients. Patients undergoing touchup liposuction are charged for the surgery center and anesthesia only. There is no surgical fee. Approximately 10% of liposuction patients take advantage of this policy. At least 3 or 4 months are allowed for the swelling to resolve before a touchup liposuction is undertaken.

Liposuction volumes are typically less at the time of a touchup, and patient recovery is much faster, even when the same areas are re-treated. Because the cost is much less and the recovery time is short, patient satisfaction is high.

Psychological Benefits

The finding of improved self-esteem in 82.6% and improved quality of life in 65.8% of liposuction patients attests to the psychological significance of the preoperative condition and also to the efficacy of the treatment [26]. Goyen [42] found that 74.8% of patients reported an increase in self-esteem and 80.5% had greater self-confidence after liposuction. Lari et al. [43] reported a 75% improvement in emotional well-being after liposuction.

Patients often look toward surgery as a motivator. The study findings suggest that patients do experience a psychological boost, with 88.8% of liposuction patients saying they were more motivated to stay in shape after surgery [26].

> Patients often look toward surgery as a motivator. The study findings suggest that patients do experience a psychological boost, with 88.8% of liposuction patients saying they were more motivated to stay in shape after surgery.

Complications

Complications were tabulated in a series of 551 consecutive body contouring patients that included 384 liposuction patients [44]. The overall complication rate after liposuction was 4.2%. There were no cases of venous thromboembolism. One patient was admitted to hospital overnight for suspected negative pressure pulmonary edema. No patient required a blood transfusion and there were no cases of overhydration.

Infection

The absence of infection after ultrasonic liposuction in 384 patients is notable and a favorable experience shared by others [18, 45].

Seromas

Seromas after liposuction were also absent in the author's series [44], likely because ultrasound times were limited to a few minutes for most areas. Scar dissatisfaction was 2.3% [26]. One patient required a scar revision [44].

Burns

Burns may occur from friction at the liposuction site. When using ultrasound, skin protectors should be used, or the cannula should be cooled with saline applied by syringe. The cannula is kept moving and short ultrasound times are used.

Skin Excess

Patients with skin redundancy are usually better served with an excisional procedure, particularly when the scar is well-hidden (e.g., abdominoplasty). However, there are areas where the scars from a skin excisional procedure are more obvious, such as the arms and inner thighs. In these areas, liposuction may be helpful in reducing bulk and providing modest skin contraction, accepting that an excisional procedure may ultimately be required.

> Liposuction may be helpful in reducing bulk and providing modest skin contraction, accepting that an excisional procedure may ultimately be required.

Overhydration

A tumescent technique (3:1 infusion-to-aspirate ratio) is unnecessary and can lead to patient overhydration and possible pulmonary edema. A superwet infusion (1:1 infusion-to-aspirate ratio) suffices. Infusions should be limited to <5 L.

Anemia

Aspirate volumes should rarely exceed 5 L so as to avoid postoperative anemia. Proper fluid maintenance is essential (discussed in Chap. 5).

Asymmetry

During liposuction, measurements of the amount of fluid injected, ultrasound time, and the aspirate volume removed are reported to the operating surgeon. Existing asymmetrical fat distribution is common, so it is not unusual to remove more volume from one side than the other. Skeletal asymmetry should be pointed out to the patient before surgery. Nevertheless, asymmetry may need to be addressed at the time of a touchup procedure.

Overtreatment

Overtreatment (Fig. 3.45) is much more difficult to correct than undertreatment. It is not difficult to return to do more liposuction. However, if too much fat is removed, restoring normal contours is a challenge and may be impossible. Fat injection can be used to fill in defects.

Visceral Perforation

Zakine et al. [46] reported 19 cases of intra-abdominal penetration of the liposuction cannula, including three deaths. This problem is signaled by unusual pain and intestinal obstruction. Abdominal radiography reveals intraperitoneal gas or liquid. The ileum is most frequently perforated, often in the umbilical region. Previous abdominal surgery and the presence of a hernia at the umbilicus increase the risk. For this reason, an umbilical incision for liposuction is avoided (except for abdominoplasty cases in whom an incision just above the umbilicus is made to access the upper abdomen in patients who have been prescreened with ultrasound). The narrower infusion cannula may more easily penetrate the abdomen than larger liposuction cannulae.

The infusion should be done by the surgeon and not delegated to another member of the team. Liposuction and abdominoplasty patients are screened with ultrasound preoperatively to detect abdominal wall defects or unexpected anatomy.

Venous Thromboembolism

This problem is discussed in Chap. 12.

Fig. 3.45 This 40-year-old man had excess adiposity of the abdomen and flanks and gynecomastia. He is seen before (*left*) and 3 months after (*right*) ultrasonic liposuction of the abdomen, flanks, breasts, and axillae and direct breast tissue excision using a periareolar incision. A contour irregularity of the right lower back is visible on the posterior view (*below*, *right*). Volume, 2200 cc

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Metabolic Effects of Liposuction

4

Abstract

The metabolic effect of liposuction has been poorly understood. In the absence of reliable data, some investigators speculate that liposuction may cause a metabolic imbalance, causing the body to gain weight to compensate for lost fat cells. The possibility that removing subcutaneous fat may cause a deleterious increase in the relative proportion of the "bad" visceral fat volume has been considered.

In order to investigate the metabolic effect of liposuction and liposuction combined with abdominoplasty, the author undertook a laboratory study of 322 predominantly nonobese patients, with sequential measurements of lipid levels, fasting blood glucose, and leukocyte counts. Patient weights were also recorded to ensure caloric neutrality during the study.

There were no significant differences in cholesterol levels after surgery. Fasting blood sugars were unchanged. However, there was a highly significant mean 43% reduction in triglyceride levels 3 months after liposuction in patients with elevated preoperative triglyceride levels ($p < 0.001$). Surprisingly, mean white blood cell counts decreased 11% after liposuction, also a highly significant change ($p < 0.001$).

Adipocytes do not manufacture cholesterol but do synthesize triglycerides. The reduction in triglycerides in patients with elevated preoperative levels (≥150 mg/dL) is likely caused a postsurgical reduction in subcutaneous fat cell volume. Subcutaneous fat may be no less metabolically relevant than visceral fat, challenging the concept of a metabolic syndrome.

Excessive triglyceride levels are associated with serious health problems such as diabetes, coronary artery disease, and stroke. Elevated white blood cell counts have also been linked to health problems. Adipocytes induce production of inflammatory cytokines, which may contribute to coronary artery disease and type II diabetes. Although the long-term health benefits of these changes, if any, are unknown, patients may be reassured that any metabolic effect of removing extra subcutaneous fat seems to be favorable.

E. Swanson, *Evidence-Based Body Contouring Surgery and VTE Prevention*,
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Introduction

Some investigators suggest that liposuction induces a metabolic imbalance, causing the body to gain weight to compensate for the fat that has been removed [1, 2]. However, the author's measurement studies [3, 4] and other clinical studies [5, 6] reveal no compensatory weight gain 3–12 months after liposuction. Indeed, there is no reliable evidence to suggest that liposuction causes a positive caloric state to drive the fat volume back to its original level [4].

Because the total number of fat cells is tightly controlled in adulthood, whether that number is normal or increased by excessive production during childhood [7], it makes sense that a surgical reduction will not alter this regulatory control and that the fat cell number will reach a new plateau, balanced by adipocyte production and loss. Indeed, the evidence suggests that the "lipostat" [8]—a theoretical homeostatic system thought to maintain fat deposits at a constant level—is reset after liposuction.

Some investigators hypothesize that subcutaneous fat removal may cause untoward effects by upsetting the balance of visceral and subcutaneous fat volumes [2, 9]. Recent research, discussed in this chapter, reveals that removal of excess subcutaneous fat can have favorable metabolic and inflammatory consequences and that excess subcutaneous fat may be just as important, and potentially unhealthy, as excess visceral fat [3].

Triglyceride Levels

Triglyceride levels ≥150 mg/dL are considered a risk factor for metabolic syndrome [10, 11], increasing the risk of type II diabetes, coronary artery disease, stroke, and peripheral vascular disease [12, 13]. A relationship between obesity and elevated triglyceride levels has been established [13]. Liposuction is known to permanently reduce the number of subcutaneous fat cells [14]. Abdominoplasty also removes subcutaneous fat. Theoretically, such a fat reduction might be expected to reduce the level of circulating triglycerides, which are produced by adipocytes. To investigate this possibility, the author undertook a study to determine whether liposuction and abdominoplasty have any effect on lipid levels in predominantly healthy patients with a range of body mass indices (BMIs) [3].

Over a 2-year period, a prospective study was undertaken among 322 consecutive patients who underwent liposuction ($n = 229$), abdominoplasty with liposuction ($n = 87$), and abdominoplasty without liposuction ($n = 6$). Ninety-seven patients (30%) had simultaneous cosmetic surgery to other body areas. Secondary liposuction patients ($n = 53$) were also considered, a subset of the liposuction-only ($n = 229$) group. This group included any patient that had been treated previously with liposuction, either by the author or another surgeon.

Blood Tests

All blood tests were performed by the same laboratory, Quest Diagnostics Incorporated (Madison, NJ). The cost of these tests was borne by the author's practice. Preoperative fasting blood tests were drawn immediately before surgery. Follow-up fasting blood tests were scheduled at the time of regular appointments 1 month and 3 months after surgery. No specific dietary instructions were provided. Patients were instructed to resume exercising 2 weeks after liposuction and 1 month after abdominoplasty. They were told that a combination of dietary indiscretion and inactivity could cause a postoperative weight gain and should be avoided.

Surgery

The Lysonix 3000 (Mentor Corp., Irvine, CA) ultrasonic system and a superwet technique were used in all cases. All surgery was performed by the author. Surgical details are provided in Chap. 3. Among the 264 women treated with liposuction, 170 (64.4%) had lower body liposuction, which included the abdomen, flanks, buttocks, thighs, and knees.

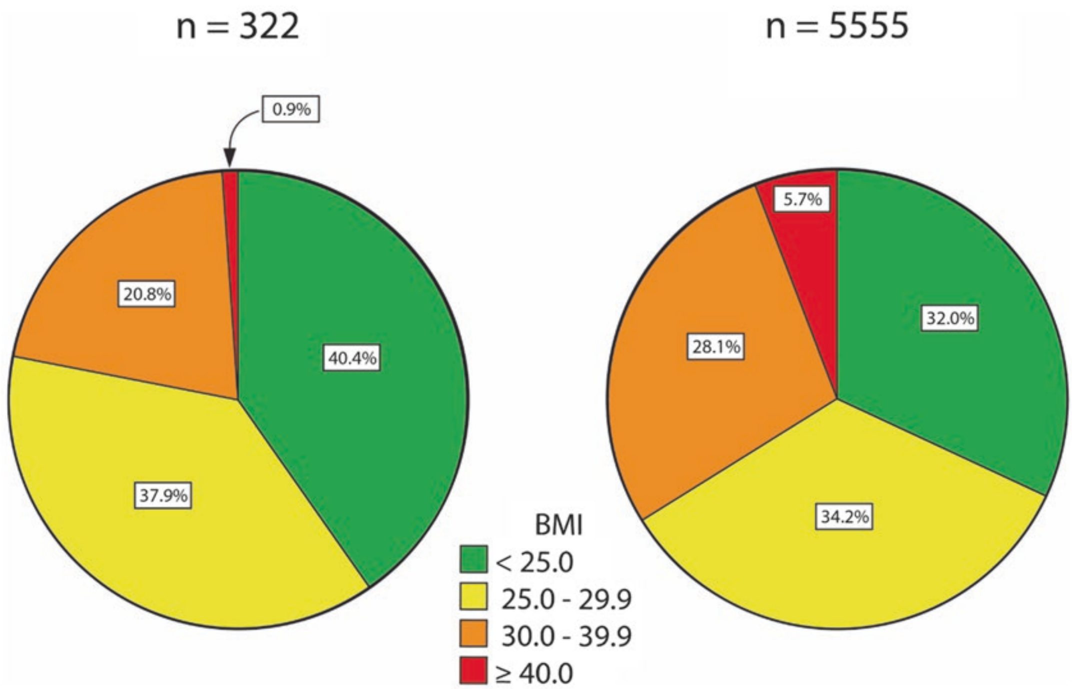


Fig. 4.1 Distribution of body mass indices of (*left*) study patients and (*right*) the adult American population in 2007–2008. The study population consisted of fewer obese (BMI ≥ 30.0) and morbidly obese (BMI ≥40.0) people than the general population ($p < 0.001$) [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

Body Mass Index

The distribution of BMIs and a comparison to the US adult population [15] are provided in Fig. 4.1. The prevalence of obesity (BMI ≥30.0 kg/m^2) and morbid obesity (BMI ≥40.0 kg/m^2) in patients was significantly lower than the adult American population ($p < 0.001$).

The mean BMI for men in this study was 28.9 kg/m^2, significantly higher than the mean BMI for women, 26.2 kg/m^2 ($p < 0.001$). The mean aspirate volume for secondary liposuction patients was significantly lower (1357 cc) than for primary liposuction patients (2499 cc, $p < 0.001$).

Lipid Levels

There were 152 liposuction patients with triglyceride values available at all three measurement times, for an inclusion rate of 66% (Fig. 4.2). Some follow-up blood tests could not be drawn because the patients had not fasted, and some blood tests could not be analyzed by the lab for technical reasons (e.g., an insufficiently separated blood sample). To determine whether the 152-patient group was self-selected (by patients choosing to keep both their follow-up appointments), making the data susceptible to sampling bias [16], this group was compared to the 77 patients for whom all three data points were unavailable. There were no significant differences in mean age, gender, BMI, aspirate volume, or change in weight after surgery between groups.

For liposuction patients, the mean fasting preoperative triglyceride level decreased 39.0 mg/dL (−26%) at 3 months ($p < 0.001$). This group included both primary and secondary (including touch-up) liposuction cases. The triglyceride levels for primary liposuction cases ($n = 117$) decreased from a mean level of 157.02 mg/dL,

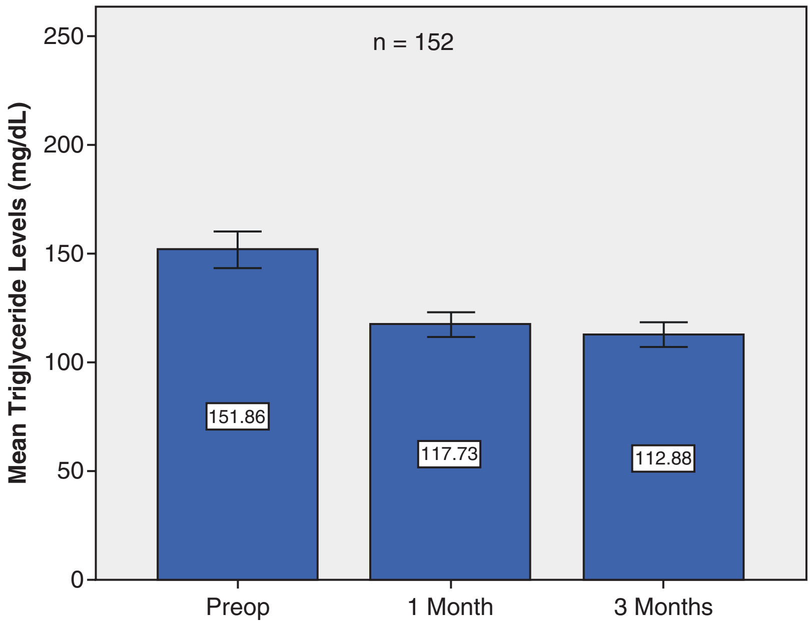


Fig. 4.2 Triglyceride levels before and after liposuction. Both 1-month and 3-month mean triglyceride levels are significantly lower than the mean preoperative level ($p < 0.001$) [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

preoperatively, to 113.10 at 3 months, a reduction of 43.9 mg/dL (−28%, $p < 0.001$).

Women treated with liposuction had a lower preoperative mean triglyceride level (144.5 mg/dL) than men (180.6 mg/dL). The mean 3-month postoperative triglyceride level was also lower for women, 108.1 mg/dL, versus 131.6 mg/dL for men, although these differences, and the magnitude of the reductions, were not significantly different between genders.

For liposuction-only patients with aspirate volumes of at least 3000 cc (Fig. 4.3), the triglyceride level decreased from a mean level of 185.60 mg/dL before surgery to 117.06 mg/dL 3 months after surgery, a decrease of 68.54 mg/dL (−37%, $n = 35$, $p < 0.01$).

Nonobese liposuction patients showed a greater reduction in triglyceride levels (−28%, $n = 125$) than obese patients (−13%, $n = 27$), although the difference was not statistically significant. There was no significant difference in triglyceride reduction comparing patients treated with liposuction of the abdomen and flanks ($n = 74$) to patients treated with lower body liposuction ($n = 78$). There were no significant differences for any parameters tested for secondary liposuction patients.

No significant change was detected in total cholesterol, low-density lipoprotein (LDL), or high-density lipoprotein (HDL) levels 3 months after surgery for any group (Figs. 4.4–4.6), including the subset of liposuction-only patients with aspirate volumes of 3000 cc or more.

Patients with High Triglyceride Levels

Over one-third of the liposuction patients (37%) had preoperative triglyceride levels ≥150 mg/dL. After liposuction, this proportion decreased to 18% ($n = 152$, $p < 0.001$). The percentage of women with at-risk levels decreased from 31% to 12% ($n = 121$, $p < 0.001$). Men experienced a similar reduction, from 58% to 39%, although this difference did not reach statistical significance ($n = 31$).

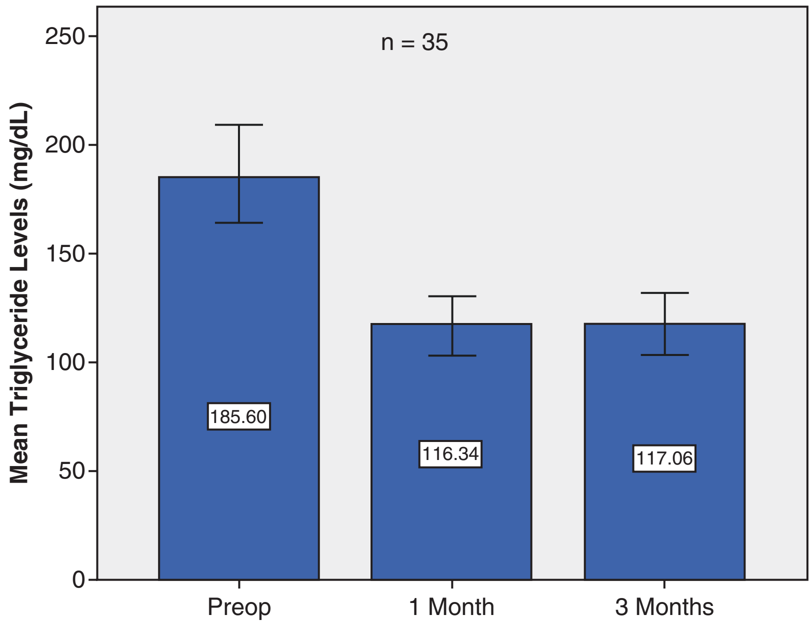
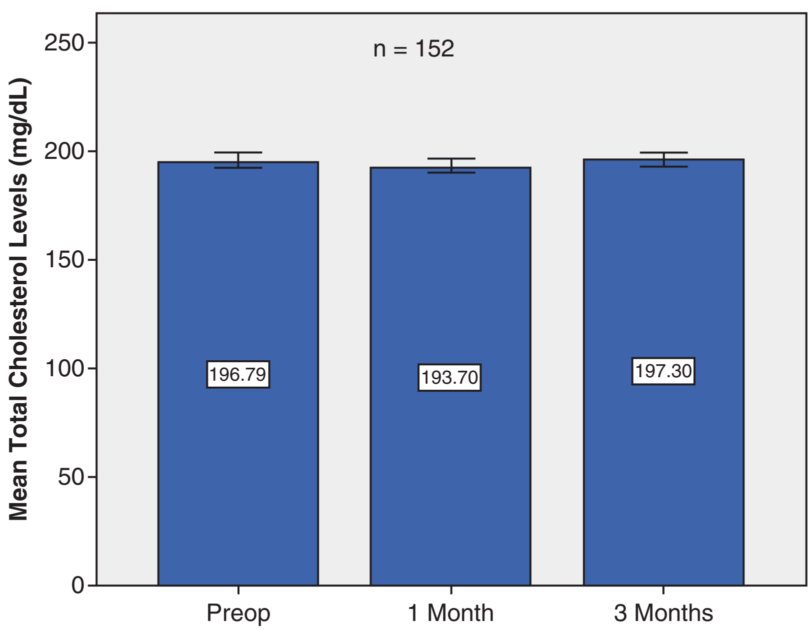


Fig. 4.3 Triglyceride levels in liposuction patients with aspirate volumes ≥3000 cc. Both 1-month and 3-month mean triglyceride levels are significantly lower than the mean preoperative level ($p < 0.01$). The mean reduction 3 months after liposuction is 37% [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

Fig. 4.4 Total cholesterol levels before and after liposuction. There is no significant change at any of the three times [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128: 182e–197e. With permission from Wolters Kluwer Health, Inc.]



Among patients with preoperative triglyceride levels ≥150 mg/dL (Fig. 4.7), the triglyceride level decreased from a mean preoperative level of 255.48 to 145.52 mg/dL 3 months after liposuction, a reduction of 43% ($p < 0.001$). The triglyceride level decreased 30% in patients treated with

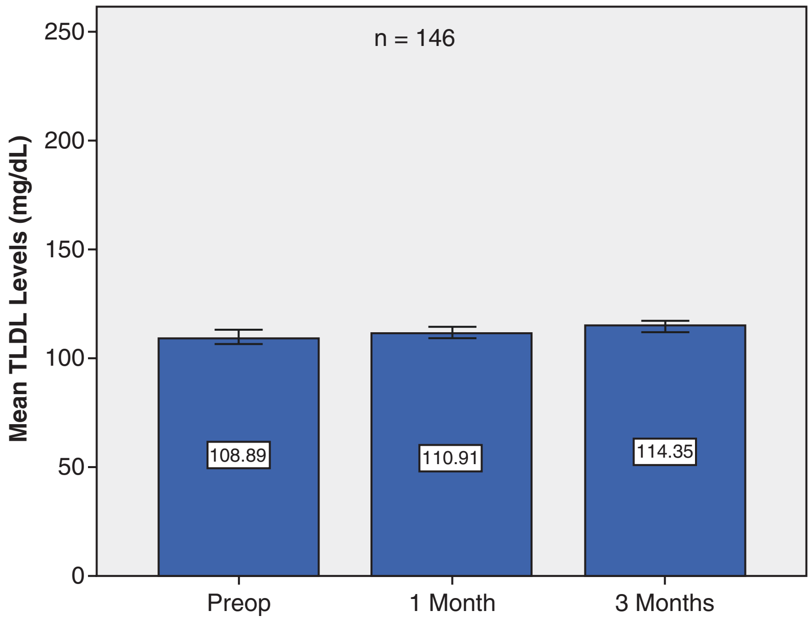


Fig. 4.5 Low-density lipoprotein (LDL) levels before and after liposuction. There is no significant change at any of the three times [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128: 182e–197e. With permission from Wolters Kluwer Health, Inc.]

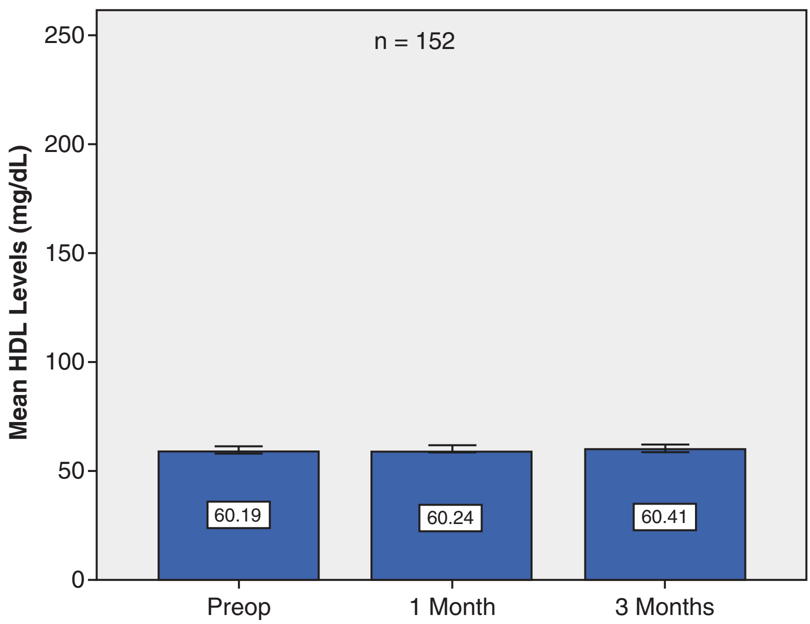


Fig. 4.6 High-density lipoprotein (HDL) levels before and after liposuction. There is no significant change at any of the three times [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128: 182e–197e. With permission from Wolters Kluwer Health, Inc.]

liposuction and abdominoplasty ($p < 0.05$). After surgery, the triglyceride level decreased to within normal range in 63% of liposuction patients ($n = 56$) and 43% of liposuction/abdominoplasty patients ($n = 21$) with elevated (≥150 mg/dL) preoperative levels. There was no significant change in triglyceride levels for patients with normal preoperative values.

> After surgery, the triglyceride level decreased to within normal range in 63% of liposuction patients ($n = 56$) and 43% of liposuction/abdominoplasty patients ($n = 21$) with elevated (≥150 mg/dL) preoperative levels.

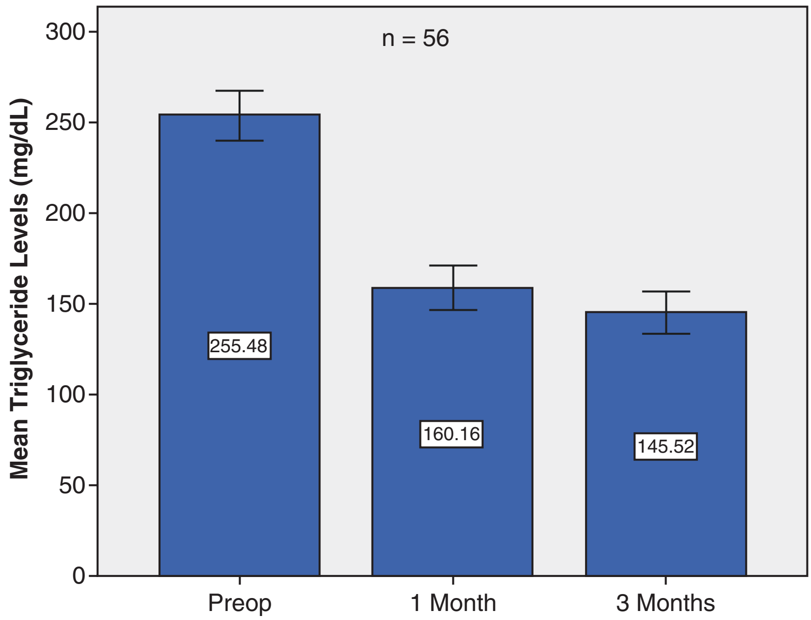


Fig. 4.7 Triglyceride levels in liposuction patients with preoperative levels ≥150 mg/dL. Both 1-month and 3-month mean triglyceride levels are significantly lower than the mean preoperative level ($p < 0.001$). The mean decrease 3 months after liposuction is 43% [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

The at-risk group with triglyceride levels ≥150 mg/dL contained a greater proportion of men than women ($p < 0.001$). There was no significant difference in age, change in weight, change in BMI, prevalence of obesity, or aspirate volume in patients with elevated preoperative triglyceride levels compared with patients with normal preoperative levels. There was no correlation between change in BMI and change in triglyceride level. There was no significant difference in weight, BMI, or treatment areas after adjustment for gender [3].

White Blood Cell Count

The mean preoperative leukocyte count for all nonobese patients ($n = 250$) was 6.98 thous/mcL, versus 8.05 thous/mcL for obese ($n = 69$) patients ($p < 0.001$). The mean white blood cell count decreased from 7.03 to 6.25 thous/mcL (−11%, $p < 0.001$) 3 months after liposuction (Fig. 4.8). The leukocyte count dropped from 7.22 to 6.33 thous/mcL (−12%, $p < 0.001$) 3 months after liposuction/abdominoplasty. Reductions in white blood cell count were similar for obese (7.84–7.00 thous/mcL, $p < 0.01$) and nonobese (6.98–6.18 thous/mcL, $p < 0.001$) liposuction patients.

> The white blood cell count decreased from 7034 to 6247 (−11%) 3 months after liposuction.

Previous Studies of Lipid Levels After Liposuction

Several previous studies have examined changes in lipid levels in small groups (9–15 patients) of predominantly obese female patients [5, 17–20]. Two of these studies found no significant changes

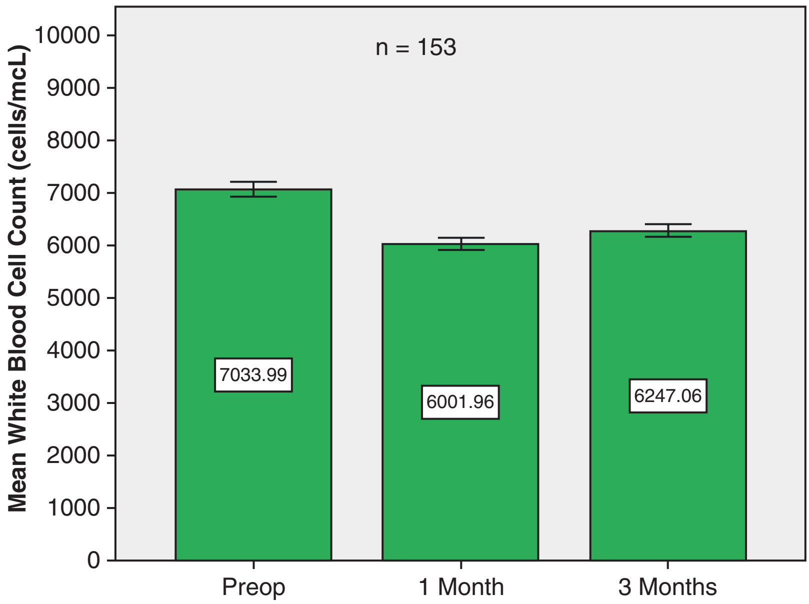


Fig. 4.8 White blood cell counts before and after liposuction. Both the 1-month and 3-month mean leukocyte counts are significantly lower than the preoperative counts ($p < 0.001$). The mean reduction 3 months after liposuction is 11% [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

in lipid levels after liposuction in obese patients [5, 20]. One experimental study found a reduction in cholesterol and triglyceride levels in an obesity-prone strain of rats after excisional lipectomies [21]. Two studies of nonobese patients were limited by follow-up periods of ≤3 weeks [22, 23]. Ybarra et al. [24] reported a reduction in triglyceride levels and an increase in cholesterol levels in 20 normal and overweight patients 4 months after abdominal liposuction. By contrast, Robles-Cervantes et al. [25] found no significant change in lipid values in 19 nonobese women 1 month after abdominal liposuction. None of these studies examined more than 20 patients, and only 2 men were included [24].

In several studies, only the abdomen was treated with liposuction [20, 24, 25], limiting the amount of subcutaneous fat reduction as a percentage of total fat volume. This limited treatment area and the increased total fat stores of obese patients likely explain why a reduction in triglyceride levels was previously undetected despite large aspirate volumes [20]. Furthermore, previous studies [5, 17–20, 22–25] examined such small groups of patients that the statistical power [16] was very limited, allowing for a type II statistical error (i.e., the finding of no difference when a real difference actually exists).

Follow-Up

The 3-month follow-up period was intended to eliminate any possible influence of postsurgical inflammation [20]. There was no significant difference in the (reduced) white blood cell counts between 1 and 3 months, suggesting that any systemic signs of inflammation from surgery had resolved by 1 month. Similarly, there were no significant differences in lipid values between the 1-month and 3-month follow-up appointments, indicating that lipid values had also reached a plateau 1 month after surgery. The finding that the reduction in triglyceride levels and leukocyte counts are both present as early as 1 month after surgery is consistent with their relationship to *adipocyte* mass, irrespective of swelling. These favorable metabolic and inflammatory changes precede the cosmetic benefits that are fully apparent only when the swelling has subsided.

These favorable metabolic and inflammatory changes precede the cosmetic benefits that are fully apparent only when the swelling has subsided.

Aspirate Volumes

The finding that liposuction patients who had aspirate volumes ≥3000 cc experienced a greater reduction in triglyceride levels than those with lesser aspirate volumes suggests that triglyceride levels are related to total body fat stores, such that a greater reduction in body fat relative to the total fat volume causes a greater reduction of circulating triglycerides. It is therefore not surprising that secondary liposuction patients, with lower aspirate volumes, did not demonstrate a significant lowering of triglyceride levels.

Interestingly, nonobese liposuction patients showed a greater reduction in triglyceride levels than obese patients, although this difference did not reach significance. Indeed, the benefit incurred from liposuction may be greater in nonobese patients than obese patients, likely because the reduction in fat volume is *proportionately* greater even if aspirate volumes are less.

The benefit incurred from liposuction may be greater in nonobese patients than obese patients, likely because the reduction in fat volume is *proportionately* greater even if aspirate volumes are less.

Calculation of Fat Reduction

The measured 26% reduction in triglyceride level after liposuction alone is similar to the calculated reduction using an estimate of the number of body areas treated and the relative fat contribution of each area [26, 27]. For "subcutaneous fat accessed," an estimate of two-thirds is used, recognizing that 66% of the women in this study had as a minimum the fat-rich lower body treated. This calculation uses a 45% reduction of subcutaneous fat, which is the average reduction of fat thickness after liposuction [14] (Fig. 4.9):

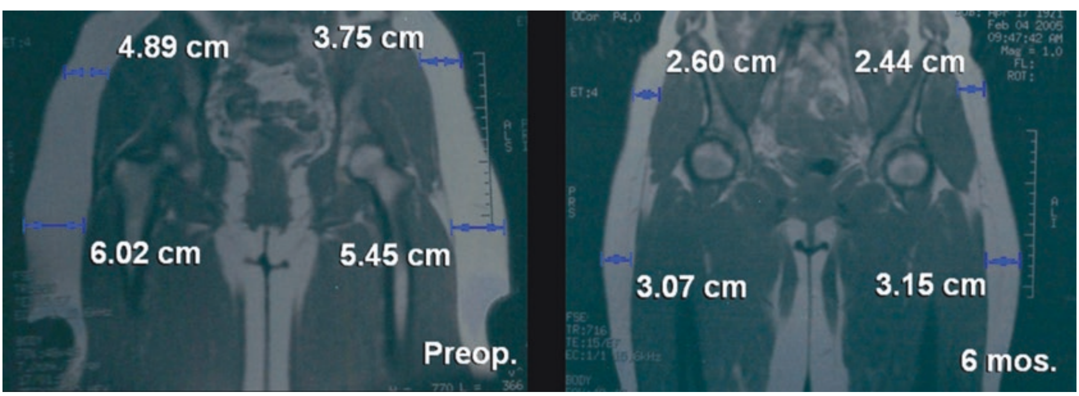


Fig. 4.9 Coronal MRI scans of a 33-year-old woman with a BMI of 27.5 kg/m^2 (*left*) before and (*right*) 6 months after ultrasonic liposuction of the lower body, arms, and axillae. The total aspirate volume was 3000 cc. The reduction in subcutaneous fat is indicated at the flanks and outer thighs [Reprinted from Swanson E. Prospective clinical study reveals significant reduction in triglyceride level and white blood cell count after liposuction and abdominoplasty and no change in cholesterol levels. Plast Reconstr Surg. 2011;128:182e–197e. With permission from Wolters Kluwer Health, Inc.]

Fat Reduction:

88% subcutaneous fat/total fat [26–28] × 45% reduction of subcutaneous fat [14] × 66% subcutaneous fat accessed = 26% reduction in total fat.

Diet

Fat cells synthesize triglycerides, but not cholesterol. Cholesterol levels are well-known to be affected by diet [13]. The observation that cholesterol values remained almost identical before and after surgery (Figs. 4.4–4.6) reflects the consistency of patients' diets and confirms that the reduction in triglyceride levels, which may also be affected by diet [13, 29], is unrelated to any dietary changes after surgery. Dieting reduces both visceral and subcutaneous fat [30–32]. In this study, weight changes were minimal and attributable to the physical loss of fat cells.

> Fat cells synthesize triglycerides, but not cholesterol.

Body Weight

This study detected a modest, but significant, weight reduction after both liposuction (−2.2 lbs) and liposuction/abdominoplasty (−4.2 lbs). Although weight reduction alone is known to improve lipid profiles [33], the modest degree of weight loss (−1.3%) and the magnitude of triglyceride decrease after liposuction (−26%) suggest that the reduction in triglyceride level is more directly linked to the change in fat mass than it is to weight loss or change in BMI.

Subcutaneous Versus Visceral Fat

Computed tomography and MRI studies reveal that the subcutaneous fat volume comprises about 90% and visceral fat 10% of the total body fat volume in women [26–28]. In men, the relative fat makeup is about 80% subcutaneous fat and 20% visceral fat [26, 28]. Women have higher total and subcutaneous fat volumes than men [27, 34, 35], particularly in the buttocks and thighs [27, 34]. Liposuction reduces the subcutaneous fat volume without affecting visceral fat [9].

It has been suggested that a selective reduction in subcutaneous fat might have a detrimental effect on lipids by increasing the relative proportion of visceral fat [9, 36]. The results of this study indicate that subcutaneous fat reduction is favorable.

"Metabolic Syndrome"

For decades, visceral fat has been considered more metabolically important than subcutaneous fat and more directly linked to type II diabetes and cardiovascular disease [10, 11]. The portal theory postulates that visceral fat adversely affects metabolism by releasing high concentrations of fatty acids into the portal venous system, which are absorbed by the liver [37]. However, this concept has been challenged [30, 38]. Tiikkainen et al. [30] found that liver fat content is related more strongly to dietary fat than endogenous fat stores in obese women. Abate et al. [38] reported that hepatic insulin sensitivity was no more strongly correlated with intraperitoneal (visceral) fat mass than total body fat mass, suggesting that intraperitoneal fat does not uniquely increase insulin resistance. Catheterization studies show that fatty acids released by the splanchnic bed contribute only about 10% of total free fatty acids delivered to the liver [39, 40]. About 75% of free fatty acids derive from systemic non-visceral fat sources [40]. Even in "upper body obesity" (i.e., waist-to-hip ratio > 0.85), subcutaneous fat appears to deliver more free fatty acids to the circulation than visceral fat [41, 42].

In obese patients, subcutaneous fat accounts for 75% of the total abdominal fat versus 25% for visceral fat [30, 31, 43]. Total abdominal fat measured on CT and MRI scans, and specifically subcutaneous fat volume, correlates better than intraperitoneal fat to insulin resistance [38, 43]. Abate et al. [38] found that the abdominal subcutaneous fat mass measures about twice the intraperitoneal fat mass in men, challenging the conventional wisdom that middle-aged men carry most of their excess body fat inside the abdomen.

Indeed, metabolic syndrome may not, in fact, be a syndrome, but rather a collection of physical findings with no known common pathophysiology (e.g., increased insulin resistance) that links these factors [44, 45]. Regardless of the validity of this syndrome, there is evidence that a high triglyceride level is an independent risk factor for cardiovascular disease [46, 47].

> Metabolic syndrome may not, in fact, be a syndrome, but rather a collection of physical findings with no known common pathophysiology.

Previous studies provide conflicting results as to the effect of liposuction or lipectomy on insulin levels, with some studies showing no change [20–22, 24] and others finding a reduction [5] or improved insulin sensitivity [19]. Measurement of insulin levels is known to be prone to errors and inconsistency, with varying methodology, widely variable levels even among nondiabetics, and a lack of accepted criteria for interpretation of results [44]. Insulin levels are not a recommended screening test for metabolic syndrome [13]. An elevated fasting glucose level is a reliable and recommended indicator of insulin resistance and incident diabetes [13, 45, 48]. Therefore, this test was used to detect signs of impaired glucose metabolism among study participants. Fasting glucose levels stayed remarkably constant after surgery, indicating that the decrease in triglyceride levels is not related to reduced insulin resistance. In their study of obese rats, Liszka et al. [21] also documented a dramatic reduction in triglyceride levels after lipectomy, without a consistent change in glucose or insulin levels.

> Fasting glucose levels stayed remarkably constant after surgery.

Subcutaneous Fat Distribution

The absence of a significant difference in triglyceride reduction comparing patients by treatment areas suggests that the overall volume of subcutaneous fat is metabolically relevant, rather than its anatomic location. This finding is not surprising in view of the lack of consistent evidence of anatomic differences in the lipid metabolism of subcutaneous fat cells [38].

> The absence of a significant difference in triglyceride reduction comparing patients by treatment areas suggests that the overall volume of subcutaneous fat is metabolically relevant, rather than its anatomic location.

White Blood Cell Count and Inflammatory Status

The reduction in leukocyte count was a serendipitous discovery and only detected because it is part of the complete blood count that was performed to evaluate changes in hemoglobin and hematocrit [3]. This fact explains why other inflammatory markers were not examined but would be of interest in future studies.

Obese patients (BMI $\geq$30 kg/m^2) had higher preoperative leukocyte counts than nonobese patients ($p < 0.001$). The unexpected decrease in white blood cell count after surgery may be a sign of reduced systemic inflammation caused by fat depletion. Adipose tissue is known to produce tumor necrosis factor α and interleukin-6 [49, 50], two proteins that stimulate lipolysis and fatty acid release, increasing hepatic synthesis of C-reactive protein, and increasing systemic inflammation [50–53]. Weight loss is known to reduce circulating markers of inflammation [54]. Liposuction and dermolipectomy in obese women have been found to reduce multiple inflammatory markers [55, 56].

> The unexpected decrease in white blood cell count after surgery may be a sign of reduced systemic inflammation caused by fat depletion.

Bulló et al. [57], in a study of abdominal subcutaneous fat obtained from surgery, found that adipocytes induce production of inflammatory cytokines, causing a chronic low-grade systemic inflammatory state, which may contribute to cardiovascular disease and type II diabetes. Patients with higher C-reactive protein levels, which were positively correlated to VLDL cholesterol and triglyceride levels, had significantly elevated leukocyte counts. Patients with obesity-related metabolic disorders (diabetes, dyslipidemia, and hypertension) were also found to have significantly higher leukocyte counts.

Meta-analyses of 19 prospective studies show that patients with leukocyte counts in the upper tertile (mean 8.4 thous/mcL) have a significantly greater risk of coronary artery disease than those with levels in the lower tertile (mean 5.6 thous/mcL), independent of other known risk factors [58]. Indeed, leukocyte counts in the upper third of the "normal" range may portend serious health risks. Leukocytosis may be more than just a marker of a chronic inflammatory state; there are a number of known mechanisms by which leukocytosis may directly contribute to vascular disease [59, 60].

Other Parameters

Weight loss is known to reduce blood pressure [61]. Giese et al. [5] documented a reduction in blood pressure and weight after liposuction. This benefit in pulse and blood pressure may reflect reduced cardiac work, although preoperative elevation caused by anxiety before surgery must also be considered. Similar to the author's study [3], Giese et al. [5] also reported a slight drop in hematocrit levels 1 month after surgery and then restoration 4 months after surgery.

The slight postoperative increase in carbon dioxide may be a sign of mild hyperventilation caused by preoperative anxiety. The marginal rise in the creatinine level may reflect an increase in the relative proportion of lean muscle mass [62, 63]. The slight elevation in potassium level 1 month after liposuction is probably caused by hemolysis of some of the postoperative blood samples.

Clinical Relevance

Liposuction is usually recommended to treat body disproportion, not obesity [64]. Notably, despite the fact that the study patients were leaner than the general population, the mean preoperative triglyceride level was at the threshold level, 150.46 mg/dL ($n = 317$). High triglyceride levels bear directly on serious and common medical problems – cardiovascular disease and type II diabetes—that can severely affect quality of life and life expectancy [12, 13]. The decrease in triglyceride level after liposuction and liposuction/abdominoplasty was significant only for those patients with elevated preoperative levels, the same patients who are likely to benefit most from a reduction. The magnitude of the triglyceride reduction (−43% for liposuction patients with elevated levels) is dramatic and possibly therapeutic. By comparison, bezafibrate, a medication prescribed to patients with high triglyceride levels, causes a 21% reduction [65].

The reduction in white count signals a reduction in systemic inflammation, which may also be clinically important in view of the known relationship between inflammation and atherothrombotic disease [50, 58–60, 66–68]. It is interesting to speculate whether these findings may influence our thinking about "normal" white cell counts, in the same way that the normal ranges for LDL cholesterol and triglyceride levels have been revised downward (160–100 mg/dL and 200–150 mg/dL, respectively) based on evidence of health risk at what were previously considered safe levels [13]. A problem for investigators has been the absence of a therapy that can safely lower the leukocyte count [59]. Whether liposuction can provide a therapeutic benefit awaits further study.

It is interesting to speculate whether these findings may influence our thinking about "normal" white cell counts, in the same way that the normal ranges for LDL cholesterol and triglyceride levels have been revised downward.

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SAFE Anesthesia and Minimizing Blood Loss

5

Abstract

Enhanced recovery after surgery (ERAS) has received recent attention. Surgery has traditionally relied on the anesthesia provider to mask the pain centrally, with little regard for peripheral anesthesia at the tissue level.

General endotracheal anesthesia remains the most commonly used type of anesthesia for large body contouring cases. However, general anesthesia with muscle relaxation may be implicated in the formation of deep venous thromboses. Instead the author recommends SAFE (spontaneous breathing, avoid gas, face up, and extremities mobile) anesthesia. Total intravenous anesthesia maintains mean arterial blood pressure. Avoiding paralysis preserves the calf muscle pump. Other advantages derive from avoiding anesthetic gas, such as reducing the risk of postoperative nausea. Recovery times are quicker. Prone positioning, which adds unnecessary risks and operating time for patient positioning, may be eliminated.

Bupivacaine is a much longer-acting anesthetic than lidocaine, but it has been regarded with caution because of cardiac toxicity. The author evaluated plasma levels of this anesthetic when administered in a dilute form into the abdominal subcutaneous tissue before abdominoplasty. Plasma levels rose slowly, and a wide margin of safety was maintained. A bupivacaine infusion, using the body's fat cells as a slow-release mechanism, offers a superior alternative to regional nerve blocks.

Evaluation of hematocrits after liposuction reveals substantial third-space blood loss into the tissues. Aspirate volumes >5 L are associated with an estimated blood loss of >1 L. The prudent surgeon will anticipate blood loss and avoid postoperative anemia. Simply using a superwet method rather than tumescent infusions makes patient overhydration unlikely.

The goal of surgery and anesthesia should be to minimize the physiological, metabolic, and hemodynamic impact of surgery so as to optimize safety and enhance the recovery.

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Introduction

Recent articles analyze patients enrolled in the CosmetAssure (Birmingham, AL) insurance database [1, 2]. As recognized by the authors, a limitation of the CosmetAssure database is that it identifies only complications leading to reoperation, readmission, or a visit to the emergency room [1, 2]. Winocour et al. [2] provide a breakdown of 2506 major complications after cosmetic surgery.

An alarming number of patients ($n = 64$) were admitted for fluid overload, pulmonary dysfunction ($n = 148$), and hypotension ($n = 47$) [2]. The authors sought to identify risk factors for complications and the importance of board certification, but the true value of the study was to identify this large number of cosmetic surgery patients requiring unplanned hospital care after surgery. The data reveal safety deficiencies in fluid management, anticipated blood loss, and anesthesia. Fluid overload is an avoidable complication. There is no advantage in using large-volume tumescent infusions; superwet (1:1 infusion/aspirate volume) infusions suffice (Chap. 3).

> There is no advantage in using large-volume tumescent infusions; superwet infusions suffice.

A knowledge of anticipated blood loss (historically underestimated) and fluid shifts is essential to prevent postoperative anemia. Allowing spontaneous breathing during surgery reduces the risk of respiratory problems. Bleeding risk may be decreased by avoiding routine anticoagulation. Such considerations are likely to make unplanned hospital admissions and blood transfusion rare events. Eliminating >250 unnecessary hospital admissions is in everyone's interest [3]. This chapter and Chap. 12, discussing venous thromboembolism prevention, explore adaptations in our surgical and anesthesia management to improve patient safety.

The tumescent liposuction technique uses doses of lidocaine—35 mg/kg—once thought to be toxic but found to be safe when administered in a dilute form into the subcutaneous fat [4–10]. Adding epinephrine significantly reduces blood loss [11, 12].

Bupivacaine has been used for decades in plastic surgery [13]. However, recent reviews question its safety [7–9]. Until recently [10], bupivacaine levels had not been measured in cosmetic surgery patients. Similarly, few studies examined plasma epinephrine levels after liposuction and/or abdominoplasty [11, 12] and none in conjunction with bupivacaine.

Previously, blood loss has been estimated using the small amount of blood present in the liposuction aspirate. In view of this knowledge deficiency, the author measured hematocrits to determine actual blood loss using the same patient database that was also used to evaluate lipid levels and other parameters 1 month and 3 months after surgery [13]. The results were surprising.

Study of Anesthetic Levels and Blood Loss

Over a 2-year period, 322 consecutive patients who underwent liposuction and/or abdominoplasty were evaluated [10]. Lidocaine, bupivacaine, and epinephrine levels were measured intraoperatively in a subset of 76 consecutive patients during the first 6 months of the study. Among these 76 patients, a subset of 39 consecutive patients underwent additional hourly intraoperative blood tests and tests at the time of their follow-up appointment the day after surgery. No patient declined to participate. A follow-up study examined 12 consecutive patients to determine plasma levels of lidocaine and its active metabolite, monoethylglycinexylidide (MEGX), and bupivacaine during the 24-hour period after infusion.

Laboratory Tests

Plasma lidocaine levels were measured using the fluorescent polarization immunoassay technique by MedTox Laboratories Inc. (New Brighton, MN). Lidocaine/MEGX levels for the follow-up study and all bupivacaine plasma levels were determined using gas chromatography by National Medical Services (Willow Grove, PA). Epinephrine levels were measured using high-performance quantitative liquid chromatography by ARUP Laboratories (Salt Lake City, Utah).

Self-Funding

The cost of all blood tests was borne by the author's practice, with no outside funding. A single bupivacaine plasma level costs $70. The cost of this study was approximately $70,000, including hotel costs for patients who underwent hourly blood draws after surgery. The author believes that the expense was justified to obtain critical safety information that has been lacking. The absence of a corporate sponsor avoids commercial bias. (This topic is discussed in Chap. 1.)

Surgery

Liposuction was performed using the Lysonix 3000 ultrasonic system (Mentor Corp., Santa Barbara, CA). Surgical details are provided in Chap. 3. All patients were treated by the author as outpatients in a state-licensed ambulatory surgery center. A total intravenous anesthetic (TIVA) was administered in all cases (Fig. 5.1). This anesthetic is part of SAFE anesthesia [14], discussed later in this chapter. The composition of the wetting solutions and local anesthetic is illustrated in Fig. 5.2.

Blood Loss Calculation

Blood loss was calculated using the formula:

$$\text{Estimated Blood Loss} = \frac{\text{Preop.hematocrit} - \text{Postop.hematocrit}}{\text{Preop.hematocrit}} \times \text{Total Blood Volume.}$$

Total blood volume was estimated to be 65 cc/kg in women and 70 cc/kg in men [15]. This formula was adjusted for obesity. For patients with body mass indices ≥30 kg/m^2, a value of 55 cc/kg was used for women and 60 cc/kg for men [16]. In calculating the contribution of combination procedures, an adjustment was made to control for aspirate volume. Samples for measurement of hematocrit and glucose were drawn from the infranatant at least 1 h after liposuction to allow settling. The hourly intraoperative glucose level preceding the start of liposuction was used to calculate the "glucose ratio" (infranatant/plasma glucose) [10].

Complications

There were no pulmonary emboli and no deaths. There were two hospital admissions, one for treatment of a deep venous thrombosis and another for treatment of an infection. No patient showed signs of fluid overload, and none required fluid resuscitation beyond maintenance [10].

> No patient showed signs of fluid overload, and none required fluid resuscitation beyond maintenance.

Heart Rate and Blood Pressure

Mean heart rates and blood pressures did not fluctuate significantly during surgery. In the post-anesthesia care unit, no patient developed symptoms or signs of local anesthetic (metallic taste, perioral numbness, lightheadedness, restlessness, drowsiness, tinnitus) [8, 9, 11, 17] or epinephrine toxicity (anxiety, restlessness, tremor, weakness, headache, pallor, palpitations) [12].

Mean times	Anesthesia (CRNA or anesthesiologist)	Surgery	Mean estimated blood loss
−30 min	IV maintenance fluids started; cefazolin, 1 g; famotidine (Pepcid*), 20 mg	Preoperative marking	
−5 min		Standing preparation with chlorhexidine	
−3 min	ECG leads, pulse oximeter, BP cuff; preoxygenation		
−1 min	Midazolam/metoclopramide (2 mg/10 mg); fentanyl, 50–100 μg	Sequential compression devices	
0	Propofol bolus, 180–200 mg; start propofol infusion 160–200 μg/kg/min; laryngeal mask airway; CO_2 monitoring		
2 min	Dexamethazone, 8 mg	Re-preparation of chest; inject breasts with local anesthetic†, 150 cc	
7 min		Start breast augmentation (50 min)	42 cc
15 min	Fentanyl, 50 μg (dosing variable, as needed)‡		
1 hr		Start lidocaine 0.05%/1:500,000 epinephrine infusion of lower body all areas except abdomen, <4 liters (15 min); sequence is inner thighs, right outer/posterior thigh, left knee, left outer/posterior thigh, and right knee	
1 hr 15 min		Start liposuction (1 hr 30 min); sequence is inner thighs, right outer/posterior thigh, left knee, interrupted by abdominal infusion (below)	589 cc
2 hr 15 min	Fentanyl, 50 μg	Infuse abdomen ≤1 liter of bupivacaine 0.025%/1:500,000 epinephrine solution at time of patient position change from left side to right (5 min)	
2 hr 20 min		Finish liposuction of left outer/posterior thigh, right knee, abdomen	
2 hr 45 min		Start abdominoplasty (1 hr 30 min)	290 cc
4 hr	Seratonin 5-HT3 receptor antagonist§; ketorolac, 30 mg (liposuction patients only)		
4 hr 15 min		Finish abdominoplasty (straight catheter); apply garments	
4 hr 30 min	Admitted to postanesthesia care unit (1 hr)	Straight catheter as needed	Total blood loss, 921 cc
5 hr 30 min	Discharged from postanesthesia care unit		

CRNA, Certified Registered Nurse Anesthetist; IV, intravenous; ECG, electrocardiography; BP, blood pressure.
*Johnson & Johnson–Merck, Fort Washington, Pa.
†The local anesthetic solution consists of 50 cc of bupivacaine 0.5% with 1:200,000 epinephrine, 50 cc of lidocaine 1% with 1:100,000 epinephrine, and 100 cc of saline, resulting in a concentration of lidocaine 0.25%, bupivacaine 0.125%, and epinephrine 1:300,000.
‡Fentanyl dosing is variable, depending on intraoperative stimulation and patient sensitivity.
§Ondansetron, 4mg; dolasetron, 12.5 mg; or granisetron, 0.1 mg for nausea prophylaxis. Scopolamine transdermal patches, 1.5 mg, are applied preoperatively for patients with a history of motion sickness.

Fig. 5.1 Sequence of anesthesia and surgery for patients undergoing breast augmentation, liposuction of lower body, and abdominoplasty [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

Anesthetic and Epinephrine Levels

The maximum dose of lidocaine was 37.7 mg/kg. The maximum dose of bupivacaine was 9.2 mg/kg. The maximum epinephrine dose was 10 mg (0.13 mg/kg). Lidocaine levels peaked 8–18 h after infusion (Fig. 5.3). Bupivacaine plasma levels were slower to rise than lidocaine, peaking at 20 h (Fig. 5.3). Epinephrine levels reached a maximum level between 2 and 4 h.

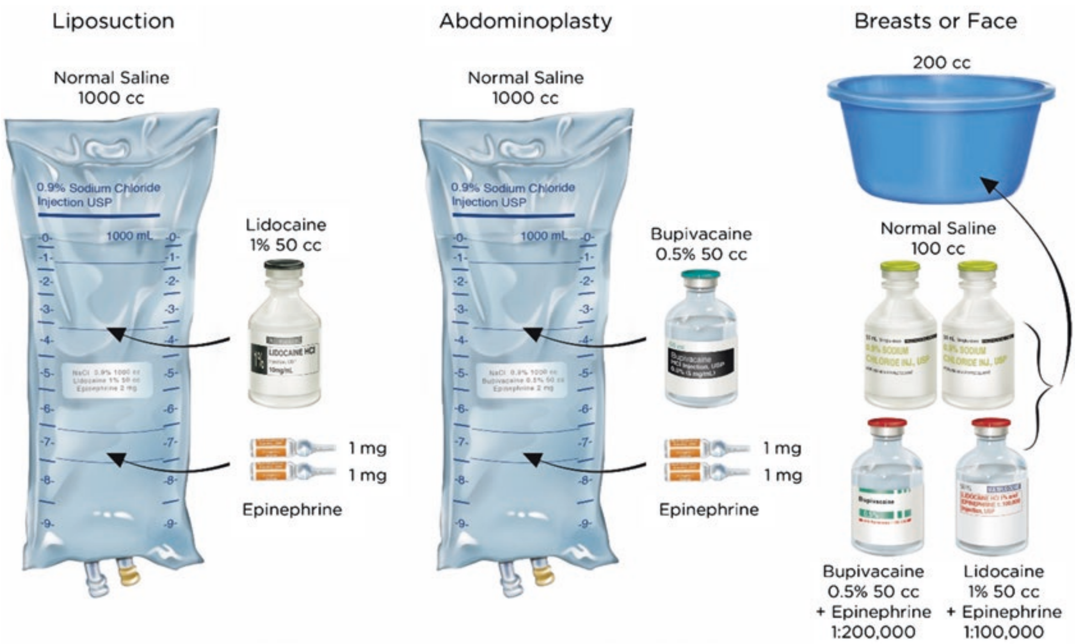

Fig. 5.2 Local anesthetic and epinephrine concentrations. (*Left*) The liposuction wetting solution consists of 1 liter of normal saline, to which 50 cc of 1% lidocaine solution (Hospira Inc., Lake Forest, IL) (500 mg) and 2 cc of 1:1000 epinephrine are added, providing an epinephrine concentration of 1:526,000. (*Center*) The abdominoplasty infusion contains 1 L of normal saline plus 50 cc of 0.5% bupivacaine (Hospira Inc.) (250 mg) and 2 cc of 1:1000 epinephrine (American Regent, Inc., Shirley, NY), for an epinephrine concentration of 1:526,000. Labels are applied to the IV bags immediately after preparation. (*Right*) The local anesthetic solution for combined procedures (e.g., breast surgery, facelift) consists of 50 cc of bupivacaine 0.5% with 1:200,000 epinephrine (Sensorcaine, APP Pharmaceuticals, Schaumburg, IL), 50 cc of lidocaine 1% with 1:100,000 epinephrine, and 100 cc saline, resulting in a concentration of lidocaine of 0.25%, bupivacaine 0.125%, and epinephrine 1:300,000 [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

Estimated Blood Loss

Hemoglobin levels decreased 1.9 g on average the day after liposuction ($p < 0.001$). Estimated blood loss from liposuction correlated significantly ($r = 0.65$, $p < 0.001$) with aspirate volume (Fig. 5.4). Abdominoplasty added 290 cc of blood loss, on average (Fig. 5.5), when performed with liposuction, controlling for aspirate volume [10].

> Abdominoplasty added 290 cc of blood loss, on average.

Other Parameters

Hepatic enzyme, glucose, albumin, protein, calcium, chloride, carbon dioxide, red blood cell morphology, platelet, and intraoperative leukocyte data, including differentials, were also measured and tabulated. White blood cell counts and cholesterol and triglyceride levels in these patients are published separately [13] and discussed in Chap. 4.

Infranatant Composition

The mean infranatant volume was 12.5% of the aspirate volume (Fig. 5.6). The mean glucose ratio was 16.9% (range, 8–28%), indicating that the infranatant consisted of 83.1% infiltrate (the supranatants consisting of disrupted fat cells and triglycerides) [18]. The mean proportion of wetting solution in the aspirate was 10.4% (83.1 × 0.125).

> The mean proportion of wetting solution in the aspirate was 10.4%.

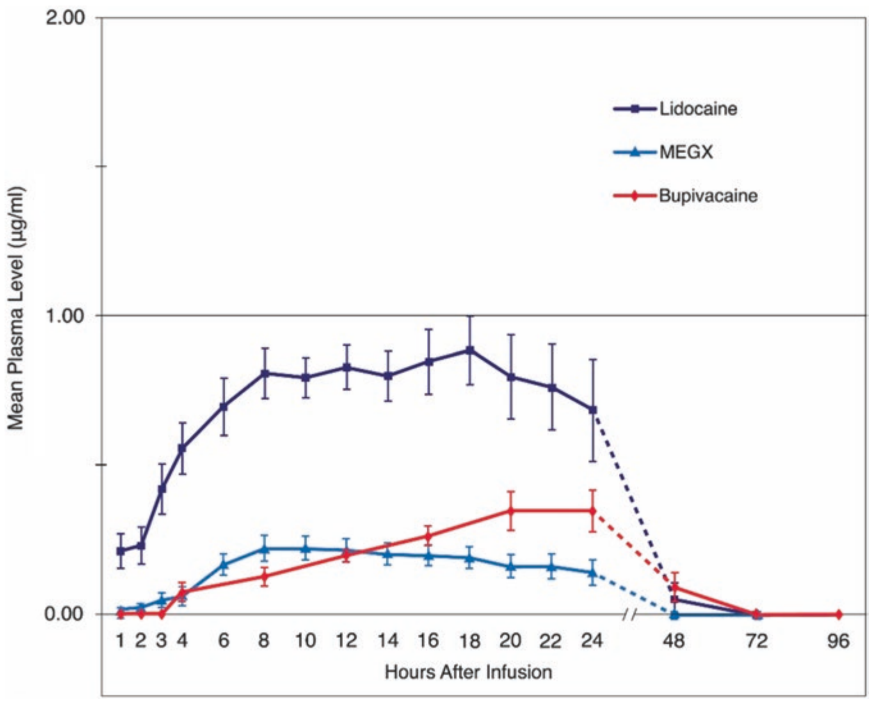

Fig. 5.3 Follow-up study of lidocaine and monoethylglycinexylidide (MEGX) levels in 12 consecutive liposuction ($n = 3$) and lipoabdominoplasty ($n = 9$) patients whose levels were measured after infusion, hourly for the first 4 h, every 2 h from 4 to 24 h, and at 48, 72, and 96 h post-infusion. Bupivacaine levels were also measured in the nine abdominoplasty patients who received bupivacaine. Data are presented as means ± SEM. Note the change in the time scale of the graph after 24 h [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

Lidocaine

Lidocaine doses exceeding 35 mg/kg have been used safely in liposuction for decades [4, 15, 19]. In this study using a superwet technique [20], the maximum plasma lidocaine level was 2.10 μg/mL. The maximum MEGX level was 0.53 μg/mL, and the maximum combined lidocaine/MEGX level was 2.44 μg/mL—below the 3 μg/mL toxic threshold [17]. Epinephrine delays peak lidocaine levels by causing vasoconstriction [4, 11, 18, 21–23]. MEGX has a relative toxicity similar to lidocaine [24]. The very low MEGX levels, which averaged about one-fifth the lidocaine levels, indicate delayed absorption and metabolism of lidocaine by the liver. The lidocaine peak interval, from 8 to 18 h post-infusion, is similar to the findings of previous studies [4, 11, 21, 24]. Most previous studies have evaluated sequential lidocaine levels in 12 or fewer nonconsecutive patients [4, 11, 19, 21, 24]. One study evaluated 32 patients but only at one time 12 h post-infusion [15]. The author's study [10], which evaluated hourly intraoperative plasma levels in 39 consecutive patients and both hourly intraoperative and 2-hourly postoperative levels for the first 24 h in another 12 consecutive patients, confirms the safety of lidocaine doses up to 37.7 mg/kg.

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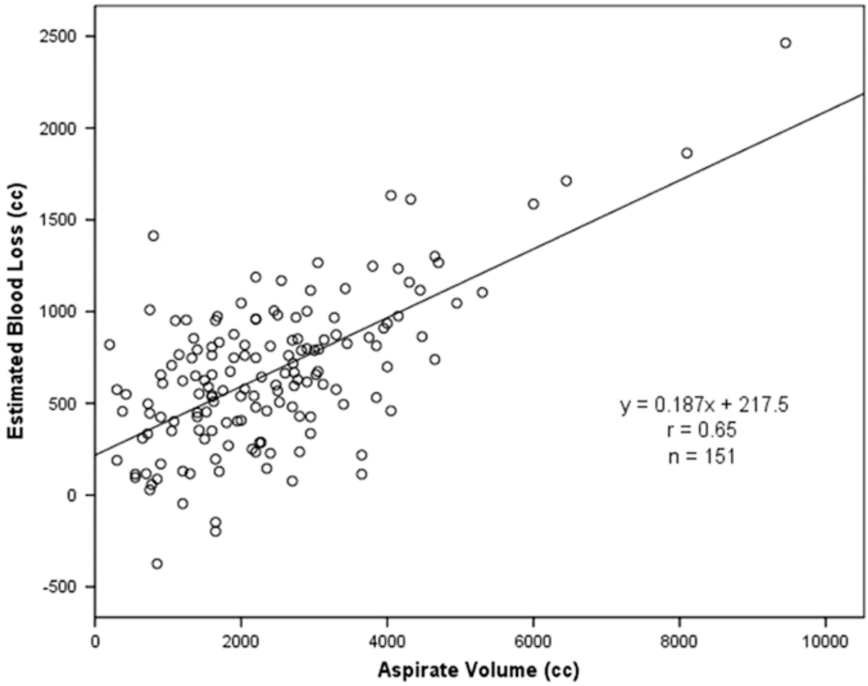

Fig. 5.4 Estimated blood loss calculated from hematocrit levels drawn before and 1 day after surgery versus aspirate volumes. Negative values reflect small daily fluctuations in hematocrit, causing fictitious negative calculations of blood loss in four patients with small aspirate volumes. Using this regression, a blood loss of 1153 cc is expected for a patient with 5 L of aspirate (0.187 × 5000 cc + 217.5). Infusion alone appears to cause a 217.5 cc blood loss [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

Bupivacaine

Similar to lidocaine, bupivacaine is an amide local anesthetic, metabolized in the liver. However, it does not have an active metabolite. Bupivacaine has been administered (1) by subcutaneous injection, (2) as an irrigation solution in surgery, (3) in pain pumps, or (4) as a component of wetting solutions in rhinoplasty [6], facelifts [25], breast augmentation [26–28], breast reduction [29], breast reconstruction [30], liposuction [13, 31–34], and abdominoplasty [13, 34–39]. Despite its widespread use in plastic surgery, there have been concerns about bupivacaine's safety [8, 40, 41]. Bupivacaine gained a poor reputation in the 1980s after severe toxic reactions and deaths occurred after suspected concentrated intravascular injections [42, 43]. Bupivacaine can be especially toxic when a bolus reaches the systemic circulation, causing cardiac toxicity, which is difficult to reverse [44]. However, full recovery has been reported using an intravenous injection of a lipid emulsion, Intralipid 20% (Baxter Healthcare Corp., Deerfield, IL) [45, 46].

However, full recovery has been reported using an intravenous injection of a lipid emulsion, Intralipid 20% (Baxter Healthcare Corp., Deerfield, IL).

Remarkably, unlike lidocaine [47], there have been no reports of bupivacaine-related toxicity or deaths when bupivacaine is diffused in dilute form into the subcutaneous fat [32]. No plastic surgeons reported toxicity when infusing bupivacaine in this manner in a recent national survey of members of the American Society of Plastic Surgeons [48]. In

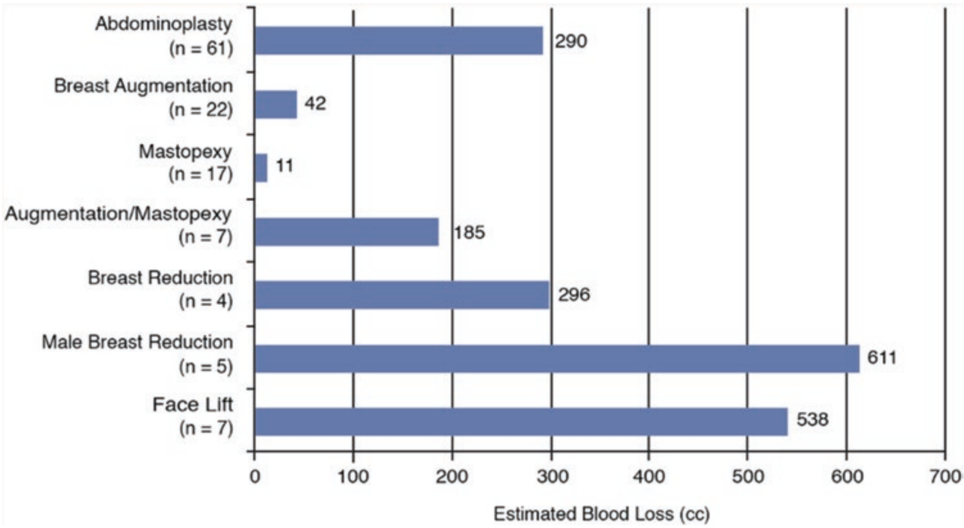

Fig. 5.5 Estimated additional blood loss from specific combination procedures performed with liposuction, controlled for aspirate volume. "Male breast reduction" refers to excisional surgery in combination with breast liposuction to treat gynecomastia. "Facelift" includes facelift patients treated simultaneously with laser skin resurfacing (*n* = 6), fat injection (*n* = 6), endoscopic forehead lift (*n* = 5), submental lipectomy (*n* = 5), blepharoplasties (*n* = 5), chin/jowl augmentation (*n* = 4), rhinoplasty (*n* = 2), and buccal fat pad resection (*n* = 1) [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

one study of patients treated with bupivacaine axillary blocks, no clinical toxicity was reported after subcutaneous infusions of up to 629 mg, despite peak concentrations within 60 min of injection and a maximum recorded plasma level of 3.33 μg/mL—the lower end of the toxic range [49].

The maximum bupivacaine level of 0.81 μg/mL in the author's study [10] suggests a comfortable margin of safety and confirms a marked dampening effect of epinephrine on bupivacaine levels [44]. The 550 mg maximum dose administered in this study is much higher than the presently recommended maximum dose of 225 mg or 400 mg over 24 h [44].

> Remarkably, unlike lidocaine, there have been no reports of bupivacaine-related toxicity or deaths when bupivacaine is diffused in dilute form into the subcutaneous fat. The maximum bupivacaine level of 0.81 μg/mL suggests a comfortable margin of safety.

Subcutaneous infusion using a blunt cannula may have a protective function by inflating the tissues [4, 15, 50, 51], reducing the risk of intravascular injection, and enhancing the effect of the local anesthetic [52]. The absence of detectable intraoperative (the levels were detected postoperatively) plasma levels of bupivacaine in abdominoplasty patients, who typically received 250 mg (0.025%) of bupivacaine with their wetting solution and its persistence in the plasma up to 2 days after surgery (Fig. 5.3), reveals profoundly delayed absorption of this anesthetic agent when it is administered in dilute form in the presence of 1:500,000 epinephrine [10].

Postoperative Analgesia

Postoperative pain control is gaining attention as an issue for plastic surgeons as part of ERAS (enhanced recovery after surgery). Long ignored, pain management is now a subject of panels at national meetings [53]. With the present epi-

Fig. 5.6 The proportion of wetting solution in the aspirate is determined by comparing the infranatant glucose level with the hourly intraoperative plasma glucose level ("glucose ratio") preceding the start of liposuction. The infranatant consists mainly (83.1%) of the wetting solution. This fluid represents only 10.4% of the total aspirate volume because of the high percentage (87.5%) of supranatant fat removed using the superwet technique. A calculation using mean infusion and aspirate volumes for liposuction patients yields a mean volume of 243.7 cc (9.8%) of the wetting solution withdrawn by liposuction and 2255 cc (90.2%) remaining in the patient's interstitial space. The thin red line at the bottom of the canister represents red blood cells (1.76% of the infranatant fluid) [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

demic in opioid abuse, this issue takes on even more importance [54].

Abdominoplasty is known to be painful. The mean duration of prescription painkiller use for lipoabdominoplasty patients, 8.3 days, is about double the time period for liposuction alone [10]. Oral analgesics frequently cause unwanted side effects, particularly nausea and vomiting. Pain pumps have been tried but with negligible benefit [27]. Near-catastrophic administration of a bolus of bupivacaine has been reported [46].

A safe, long-acting local anesthetic has obvious appeal. Bupivacaine is known to act about four times as long as lidocaine [17, 55]. Local anesthetic injection into the rectus sheath [36, 37, 39] is unnecessary; infusion of the abdominal tis-

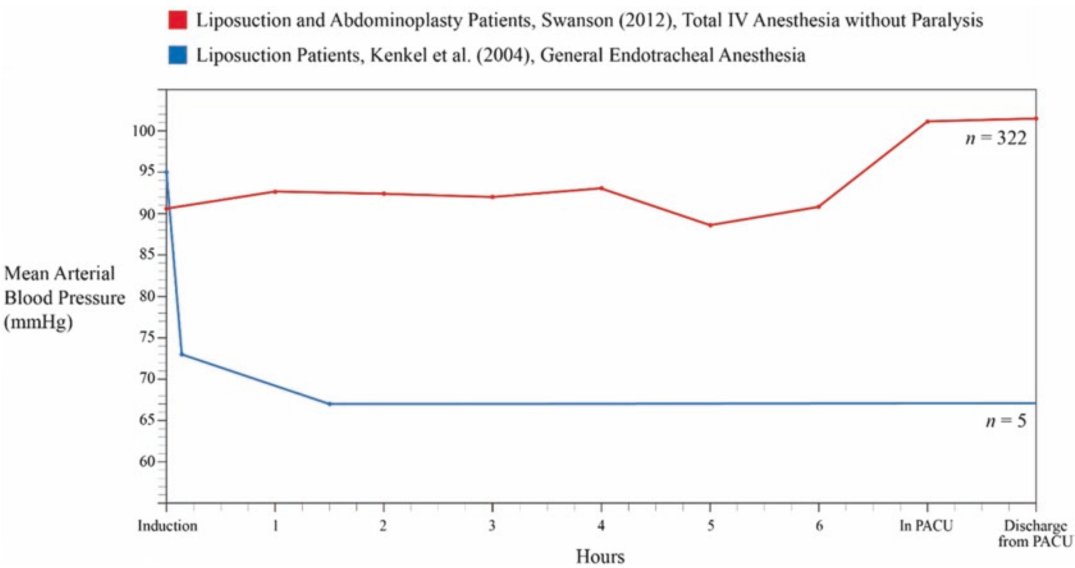

Fig. 5.7 Two forms of anesthesia are compared. A total intravenous anesthetic was administered to 322 consecutive patients undergoing liposuction and/or abdominoplasty (red) [10]. There was no drop in mean arterial pressure during surgery. When patients arrived in the post-anesthesia care unit and on discharge, their mean arterial pressure was close to their preoperative level. This finding contrasts with a 30% decrease in mean arterial pressure in a sample of five inpatients undergoing large-volume liposuction under general endotracheal anesthesia with muscle paralysis in another institution (blue) [57]. The mean arterial pressure did not return to normal in the postanesthesia unit

sues is sufficient [56]. Intercostal (rib) blocks [38, 39] invite potential complications such as pneumothorax, hematomas [39], inadvertent intravascular injection, and carry a 10% failure rate [38].

Total Intravenous Anesthesia

Intraoperative blood pressures (Fig. 5.7) reveal no evidence of negative inotropy, which can occur with inhalational anesthesia [57]. Avoidance of cardiovascular depression is a safety advantage, especially when local anesthetics and epinephrine are administered. Halogenated anesthetics are known to sensitize the myocardium to the effects of epinephrine [8, 58].

Reducing the use of narcotics and benzodiazepines decreases the risk of nausea and shortens the recovery time. The mean length of stay in the recovery room for all patients in the author's series was 50.7 min (range, 20–159 min) [10], much shorter than reported stays for patients treated with conscious sedation using midazolam and fentanyl (mean 235 min; range, 95–520 min) [59].

Traditional low maximum dose recommendations limit effective local anesthesia for large body areas and have led to a historic overreliance on general anesthesia to mask painful stimuli ("central masking") [10, 60]. Pain is best prevented preemptively [32] at its source in the tissues ("peripheral blocking"). Local anesthesia in sufficient doses (Fig. 5.2) reduces the afferent pain load on the central nervous system. Anesthesia is ideally a joint responsibility; the surgeon provides anesthesia at the tissue level, while the anesthetist titrates just enough propofol to mask the injections and any unblocked intraoperative stimulation centrally and maintain unconsciousness [10].

> Traditional low maximum dose recommendations limit effective local anesthesia for large body areas, and have led to an historic overreliance on general anesthesia to mask painful stimuli ("central masking").

Eliminating muscle relaxants may reduce the risk of deep venous thrombosis [9, 10, 14, 56] and pulmonary embolism [9, 10, 14, 56, 61–63] by preserving the calf muscle pump [10, 14, 56, 60–62, 64, 65]. The risk of malignant hyperthermia is virtually eliminated [10, 63, 66]. Avoiding paralysis may also obviate the need for anticoagulation [9, 10, 14, 61], which carries a risk of more bleeding [64, 67]. Side-to-side movement of the patient in surgery [13] and avoidance of pelvic pressure [67] may also be helpful in reducing the risk of venous stasis and other problems associated with prone positioning, such as difficult airway management requiring intubation and ventilation, a delay in surgery for repositioning, and unsuitability for combined breast surgery (best done first to optimize sterility) [10].

Traditionally, lipoabdominoplasty has been performed under general endotracheal anesthesia or, more recently, conscious sedation [9, 56, 59, 61]. Only these types of anesthesia were included in a 2010 evidence-based review [68]. However, total intravenous unconscious anesthesia may represent an optimal intermediate "goldilocks" alternative (Fig. 5.8) by eliminating some unnecessary anesthetic risks and shortening the patient's time in the recovery room [10].

> Total intravenous unconscious anesthesia may represent an optimal intermediate "goldilocks" alternative by eliminating some unnecessary anesthetic risks and shortening the patient's time in the recovery room.

Preserving the Calf Muscle Pump

A propofol bolus causes a brief drop in blood pressure, typically about 5 min [65]. With propofol it is quite easy, by adjusting the rate of infusion, to maintain stable hemodynamics (Fig. 5.7). During the maintenance phase of anesthesia, the cardiovascular effects of both propofol and inhalational agents are minimal in healthy patients. However, a propofol infusion leads to more rapid recovery than inhalational agents, a significantly lower risk of nausea and vomiting, earlier discharge from the postanesthesia care unit, and earlier ambulation [10, 65]. A disadvantage for general endotracheal anesthesia is the need for muscle relaxants and positive pressure ventilation, which may reduce venous return [65].

Preservation of the calf muscle pump reduces the risk of venous stasis by maintaining pulsatile flow and avoiding hypoxia in the valves of the deep veins of the lower extremities, where thrombi originate [69]. Unfortunately, a lack of understanding of the basic physiology coupled with a strong mandate from the Centers for Medicare and Medicaid Services (CMS) to prevent venous thromboembolism has resulted in aggressive attempts at chemoprophylaxis with no reduction in risk [70–72]. This topic is discussed in detail in Chap. 12. Ominously, potent anticoagulation has been associated with an *increase* in all-cause patient mortality in hip and knee replacement [72].

> Preservation of the calf muscle pump reduces the risk of venous stasis by maintaining pulsatile flow and avoiding hypoxia in the valves of the deep veins of the lower extremities, where thrombi originate.

Fortunately, hemodynamic data are available to compare anesthesia methods in plastic surgery patients [65]. Kenkel et al. [57] examined the cardiovascular effects of general endotracheal anesthesia using a bolus of propofol (2 mg/kg) at induction, sevoflurane as the continuous inhalational agent, and rocuronium (50 mg) to facilitate intubation in five liposuction patients. These investigators [57] reported a significant ($p < 0.01$) reduction in mean arterial blood pressure after induction, from a mean pressure of 95 mmHg to 73 mmHg and then to 67 mmHg (−30%) over 1–2 hours without a return to baseline during surgery or immediately postoperatively (Fig. 5.7). Sustained hypotension with paralysis (>2 h) is linked to valvular hypoxia [69]. Using this method of anesthesia, a 2.8% risk of deep venous thrombosis (5% after abdominoplasty) was

	Local anesthesia	Conscious sedation	Total IV anesthesia (unconscious sedation)	General endotracheal anesthesia
Level of consciousness	Conscious	Sedated	Unconscious	Unconscious
Systemic anesthesia	None	None	Propofol	Sevoflurane or isoflurane*
Local anesthesia volume	Tumescent (3:1)	Superwet (1:1)	Superwet (1:1)	Superwet (1:1)
Infusion medications	Lidocaine/epinephrine +/- bicarbonate	Lidocaine/epinephrine	Lidocaine/epinephrine bipuvacaine/epinephrine for abdominoplasty	Lidocaine/epinephrine or epinephrine alone
Benzodiazepines (midazolam)	0/+	+++	+	+
Narcotics (fentanyl)	0/+	+++	+	+
Supplemental oxygen	No	Yes	Yes	Yes
Intravenous fluids	None	Maintenance	Maintenance	Maintenance
Airway	None	Nasal cannulae	Laryngeal mask airway	Endotracheal tube†
Ventilation	Spontaneous	Spontaneous	Spontaneous	Positive pressure, ventilated
Muscle relaxants	No	No	No	Yes
Malignant hyperthermia triggering agents	No	No	No	Yes
Recovery room time	0/+	++++	++	+++
Anesthesia monitoring	MD or nurse	MD or nurse	CRNA or anesthesiologist	CRNA or anesthesiologist
Negative inotropy	0	0	0	+
Risk of deep venous thrombosis	Baseline	Baseline	Baseline/+	+
Expense‡	+	++	++	+++
Need for licensed or accredited facility	Yes	Yes	Yes	Yes
Combined procedures	No	Yes	Yes	Yes
Discomfort in surgery	+++	+	0	0
Risk of vomiting in PACU	0/+	++	0	++
Patient recollection	+++	+	0	Remote risk of intraoperative recall

*Propofol may also be used instead of an inhalational agent.
†Risks of intubation and ventilation include dental trauma, laryngospasm, vocal cord injury, esophageal intubation, pneumothorax, and respiratory alkalosis.
‡Anesthesia cost-savings from conscious sedation may be offset by longer recovery stays and possible hospitalization.

Fig. 5.8 Comparison of anesthesia techniques for liposuction and abdominoplasty [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

reported among 347 patients undergoing excisional body contouring procedures, including belt lipectomies, despite the use of enoxaparin in 39% of patients [22].

These findings may be contrasted with liposuction and abdominoplasty outpatients treated with a 2 mg/kg bolus of propofol followed by a propofol infusion delivered at a rate of 160–200 μg/min and no inhalational agent or paralysis [10]. Mean heart rates and blood pressures did not fluctuate significantly from baseline during surgery or in the recovery room [10]. One case of deep venous thrombosis occurred among 551 consecutive liposuction and abdominoplasty procedures (0.2%) [73]. The risk was 0.6% (1/167) after abdominoplasty [73].

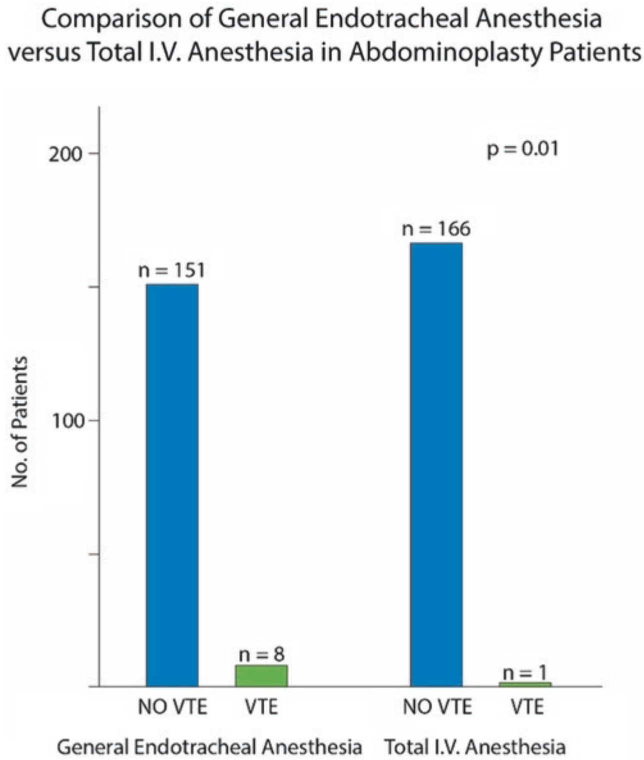

Fig. 5.9 The risk of VTE is compared between two groups of patients undergoing abdominoplasty with or without liposuction. The VTE rate is significantly reduced (0.6% compared with 5.0%, $p = 0.01$) in patients receiving total intravenous anesthesia without paralysis, despite the fact that no chemoprophylaxis was used in the patients undergoing total intravenous anesthesia. Perioperative enoxaparin was used in about 38.3% of body contouring patients treated with general endotracheal anesthesia [67]

Comparing the two studies, the risk of a VTE after abdominoplasty is significantly ($p = 0.01$) reduced in patients treated with total intravenous anesthesia (Fig. 5.9). Moreover, in 200 consecutive plastic surgery outpatients, no deep venous thromboses were detected on Doppler ultrasound scans performed the day after surgery [74]. Maintaining a normal blood pressure and preservation of the calf muscle pump seem to be effective in reducing the risk of deep venous thrombosis [65].

Pannucci et al. [64] recognize the importance of the calf muscle pump in their recent review, recommending “alteration in anesthetic management, especially using anesthesia that preserves the calf muscle pump, as a mechanism for deep venous thrombosis prevention.” Numerous studies [9, 73, 75–78] document a lower risk of deep venous thrombosis in plastic surgery patients treated with intravenous anesthesia. “SAFE” (spontaneous breathing, avoid gas, face up, extremities mobile) anesthesia is likely to improve patient safety [14].

SAFE Anesthesia

SAFE anesthesia is offered as an alternative method to reduce thromboembolism risk and improve safety [14]. As in traditional general anesthesia, it requires the assistance of an anesthesiologist or certified nurse anesthetist.

Spontaneous Breathing

Elective outpatient plastic surgery may be performed using an intravenous infusion of propofol in combination with a laryngeal mask airway [10]. Muscle paralysis is unnecessary, even when performing abdominoplasties with rectus plication. Infusion of the abdomen with an anesthetic solution provides adequate anesthesia of the abdominal wall [10, 73]. Spontaneous breathing allows the anesthetist to use the patient’s respiratory rate to guide intraoperative dosing of analgesics, expediting recovery. Respiratory alkalosis and secondary hypokalemia from mechanical ventilation are avoided [10].

> Muscle paralysis is unnecessary, even when performing abdominoplasties with rectus plication. Infusion of the abdomen with an anesthetic solution provides adequate anesthesia of the abdominal wall.

Avoid Gas

Inhalational agents have side effects [14]. These include cardiovascular and respiratory depression, bronchial irritation, malignant hyperthermia, increased nausea, and possible exposure to operating room personnel.

Face Up

The patient may be turned from side to side to access all areas for liposuction [10, 73]. Supine and lateral positioning avoids the need for a hip bolster and pelvic pressure that might impair venous return from the lower extremities [67]. Avoiding prone positioning makes intubation and mechanical ventilation unnecessary, avoids facial pressure and other pressure points, allows simultaneous breast surgery (best performed first to optimize sterility), and eliminates an unnecessary delay in surgery for patient repositioning. Sterility may be improved in lower body lift cases (Chap. 7).

Extremities Mobile

By turning the patient from the supine position to each side to infuse the areas with anesthetic solution and then repeating the process for liposuction, the lower extremities are kept moving, reducing the opportunity for venous stasis [10]. The calf muscle pump is preserved by avoiding paralytic agents [65].

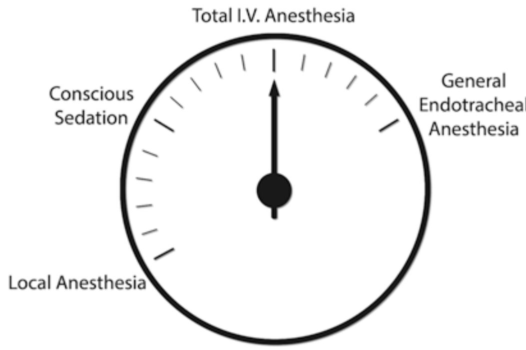

Fig. 5.10 Total intravenous anesthesia provides an ideal balanced anesthetic [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

Choosing an Anesthesia Method

Figure 5.10 demonstrates the four commonly used anesthetic methods. Local anesthesia is impractical for large cases or combination surgery. Conscious sedation provides a reduced risk of deep venous thrombosis [9]. However, these patients typically receive higher doses of benzodiazepines and fentanyl, prolonging recovery times [59]. General endotracheal anesthesia provides adequate anesthesia but carries additional risks, as discussed. Total intravenous anesthesia (“TIVA”) offers an ideal balance, combining patient comfort and safety [10, 14].

Surgical decisions typically rest on an assessment of the anticipated benefit versus risk. The same analysis applies to administration of a medication or anesthetic (Fig. 5.11).

Physiological Pain Pump

Pain pumps add to patient inconvenience, cost, and risk, with a questionable compensatory benefit in abdominoplasty [79]. Transversus abdominis plane (TAP) blocks have been used recently during abdominoplasties [80]. However, there may be no advantage in efficacy comparing TAP blocks with direct local anesthetic infiltration

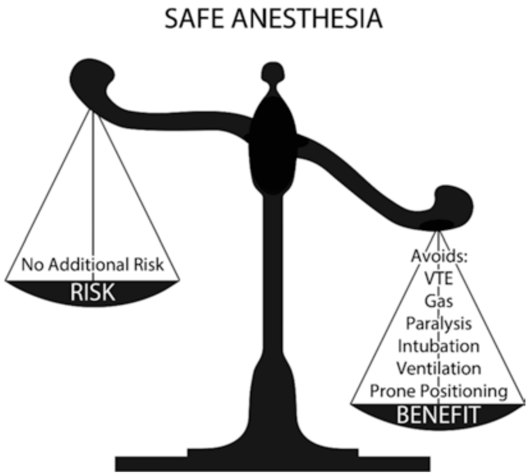

Fig. 5.11 SAFE anesthesia offers many safety advantages and no increased risk [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

[60]. TAP blocks do not provide sufficient analgesia for rectus plication [80]. The advantage of tumescent (or more precisely, superwet) analgesia over regional blocks is that a large area, with multiple sources of innervation (e.g., the abdomen), may be reliably treated [10]. Importantly, superwet infusions permit simultaneous infiltration of epinephrine to reduce blood loss [10].

> The advantage of superwet analgesia over regional blocks is that a large area, with multiple sources of innervation (e.g., the abdomen), may be reliably treated.

Bupivacaine is a more potent and longer-lasting local anesthetic than lidocaine [10]. Systemic toxicity is avoided by injecting this agent in a dilute 0.025% solution (250 mg/L normal saline) using a blunt cannula, in the presence of epinephrine (2 mg/L), which slows its absorption [10]. Plasma levels remain well below the toxic threshold (3 μg/mL) with a wide margin of safety (Fig. 5.3) [10].

Liposomal bupivacaine (Exparel, Pacira Pharmaceuticals, Parsippany, NJ) makes use of lipid chambers that encapsulate the medication and prolong analgesia, at a cost of about $300 per 20-mL vial versus $6 for a 50-mL bottle of 0.5% bupivacaine [60]. However, its "slow-release" advantage may also be its disadvantage. Unlike bupivacaine in saline solution, liposomal bupivacaine does not diffuse well into the tissues [81], likely accounting for its inconsistent effectiveness [82]. By contrast, administration of (non-liposomal) bupivacaine in a wetting solution allows the anesthetic to permeate tissue planes easily [81], including the rectus sheath, making subfascial injections unnecessary [10]. Bupivacaine's greater affinity for fat is an important advantage over lidocaine, both in terms of efficacy and safety (i.e., more in the tissues, less in the blood). Bupivacaine is not even detected in the plasma until 4 h after its infusion [10]. Its plasma level rises slowly over 20 h and then gradually drops (Fig. 5.3). Bupivacaine released incrementally from its fat cell reservoir may act as a "physiological pain pump" [60], shortening hospitalization times [34] and facilitating outpatient abdominoplasties [10]. Adipocytes serve as natural slow-release lipid chambers, making expensive synthetic capsules unnecessary [60].

> Administration of (non-liposomal) bupivacaine in a wetting solution allows the anesthetic to permeate tissues planes easily, including the rectus sheath, making subfascial injections unnecessary.

Importantly, the rectus diastasis may be repaired while the patient is breathing spontaneously without muscle paralysis [10]. The surgeon is better able to gauge the degree of fascial tightening because patient respirations may be monitored. It is important to avoid raising the intra-abdominal pressure, which some surgeons believe may cause venous obstruction and lead to a deep venous thrombosis [83], although this possibility remains unproven. The author routinely repairs the rectus diastasis, which is a valuable aesthetic benefit of an abdominoplasty.

Fig. 5.12 Comparison of bupivacaine infusion and regional blocks [Reprinted from Swanson E. A physiological pain pump for abdominoplasty: an alternative to regional blocks and liposomal bupivacaine. Plast Reconstr Surg. 2015;136:714e–716e. With permission from Wolters Kluwer Health, Inc.]

	Superwet infusion	Regional blocks
Need for assistance from anesthesiologist (percutaneous)		✓
Additional expertise and expense		✓
Need for ultrasound (percutaneous)		✓
Need for separate rectus fascial injection		✓
Additional operating room time		✓
Liposomal bupivacaine:		
Cannot co-administer lidocaine		✓
Limited diffusion into tissues		✓
Additional cost ($300)		✓
Risks:		
Visceral (percutaneous) or intraperitoneal penetration		✓
Inadequate analgesia		✓

Reassuringly, postoperative ultrasound scans of the deep veins performed the day after surgery do not reveal an increased risk of deep venous thrombosis occurring in surgery or immediately postoperatively [74].

Using a laryngeal mask airway (LMA), the anesthetist can gauge anesthetic administration by peripheral stimulation rather than tolerance of an endotracheal tube (81). Spontaneous breathing makes the respiratory rate available to closely titrate intraoperative anesthesia (propofol) and opioid (fentanyl) administration. Both pain and respiratory rate are clinical signs that are unavailable if general endotracheal anesthesia is used [60]. Nerve blocks add the risk of inadvertent intravascular, visceral (e.g., liver) [80], or intraperitoneal injection—problems that are best avoided.

Both pain and respiratory rate are clinical signs that are unavailable if general endotracheal anesthesia is used.

Multimodal anesthesia can be achieved with just two forms of anesthesia, local and systemic. Complementary anesthesia is preferred, not redundancy [81]. A reliable field anesthetic makes regional nerve blocks unnecessary [60]. There is no need for additional training, operating time, or expense. Thoughtful adoption of less intrusive forms of airway management (laryngeal mask airway), ventilation (spontaneous), and tissue-based anesthesia (infusions) all act together to minimize physiological alterations during surgery, expedite recovery, and improve safety (Fig. 5.12).

> Thoughtful adoption of less intrusive forms of airway management (laryngeal mask airway), ventilation (spontaneous), and tissue-based anesthesia (infusions) all act together to minimize physiological alterations during surgery, expedite recovery, and improve safety.

Epinephrine

In the 1980s, it was common to use epinephrine concentrations in the range of 1:200,000–1:500,000 [5, 35, 84]. When larger "tumescent" infusions became popular in the early 1990s, most operators opted for a more dilute epinephrine concentration of about 1:1000,000 [4, 12, 21, 33, 56, 85]. Even at this dilute concentration, patients received 10 mg or more of epinephrine when volumes of 10 liters or more were infused [31, 86–88]. Not surprisingly, some operators reported fluid overload [31, 33, 89]. As the risks of truly tumescent infusions (infusion/aspirate ratios of 3:1 or greater) became known [32, 90], the superwet technique (1:1 ratio) [20, 90] was adopted by most plastic surgeons as a safer fluid replacement formula [33, 52].

Although more dilute concentrations are no doubt beneficial, epinephrine concentrations of 1:400,000 are more effective in causing vasoconstriction and hemostasis than 1:800,000 solutions [58, 91] and similarly efficacious to more concentrated solutions [92]. A more concentrated epinephrine solution may also provide a greater anesthetic dampening effect, evidenced by the very gradual increase in bupivacaine levels (Fig. 5.3).

Unlike lidocaine, a toxic plasma level of epinephrine has not been identified [11, 91]. Normal values are less than about 100 pg/mL [93]. Norepinephrine levels revealed that the rise in epinephrine levels was caused by exogenous epinephrine rather than increased adrenal production [12]. The detection of peak levels between 2 and 4 h after infusion was similar to the findings of the only previous study that included early intraoperative blood samples [12]. Epinephrine is rapidly metabolized when administered as a subcutaneous injection [11]. The delay in peak levels in liposuction patients is likely caused by delayed absorption when epinephrine is infused in a dilute solution into the subcutaneous fat [11, 12].

Despite high plasma epinephrine levels, no clinical signs of toxicity were observed (including 11 patients on β-blockers) [10], an experience shared by others using a 1:500,000 epinephrine concentration completely infused before liposuction [51]. Lidocaine levels are not affected by the rapidity of the infusion [94], so that there is no need to stage the infusions during surgery, maximizing efficiency [10].

Epinephrine delays the absorption of lidocaine and therefore the time to peak lidocaine levels [17, 23]. Similarly, epinephrine delays and reduces peak bupivacaine levels [44], reducing the risk of toxicity. Can these local anesthetics "return the favor" by lessening the cardiac effects of epinephrine? Lidocaine may reach antiarrhythmic, therapeutic levels after liposuction [12] and may protect the myocardium from anesthetic toxicity [91]. Both lidocaine and bupivacaine have antiarrhythmic properties [95, 96].

Third-Space Blood Loss After Liposuction

Hematocrits of the infranatant fluid ("lipocrits") are typically negligible, in the range of 1–3% [4, 20, 33, 50] (1.76% in the author's study [10]). Klein claims that vasoconstriction is so complete that there is "virtually no blood loss with liposuction" [4, 97]. Blood loss has been estimated to represent approximately 1% of the liposuction aspirate volume for both tumescent and superwet techniques [7, 8, 20, 52, 98]. This very low estimate is difficult to reconcile with the requirements of some state medical boards that liposuction aspirate volumes be limited to 5000 cc in outpatients and as little as 1000 cc in combination with an abdominoplasty [7, 8]. In the absence of a known correlation with blood loss [8], these limits have been arbitrary.

Is this regulatory concern about aspirate volumes justified? Clinical experience with large-volume superwet liposuction suggests nontrivial blood loss [10, 31, 86, 87, 99]. The lowest hematocrits in the author's study measured 25.0% after liposuction and 22.1% after lipoabdominoplasty, sufficient to produce symptoms, although not quite low enough to require blood transfusions [10].

Although there is minimal visible blood loss during liposuction, there is substantial extravascular "third-space" blood loss into the interstitial tissues [15, 90, 100, 101], accounting for 98% of the blood loss (Fig. 5.13).

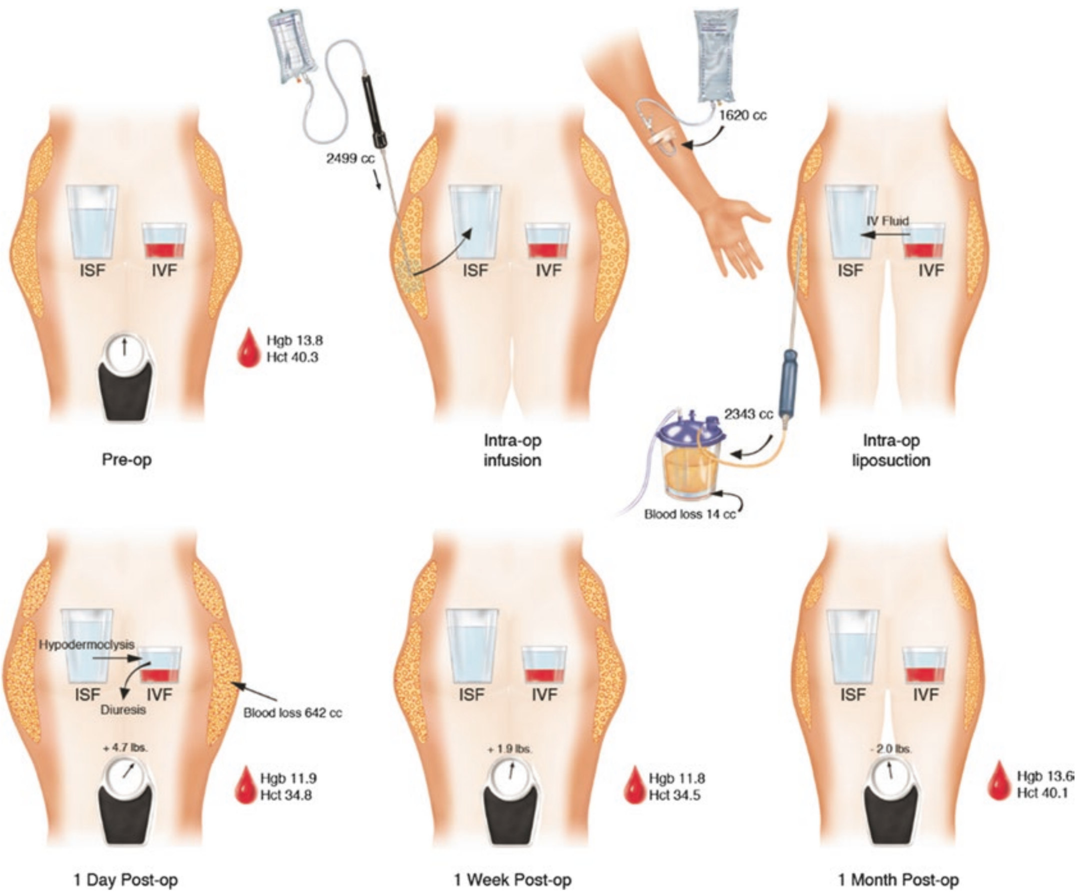

Fig. 5.13 Fluid shifts and changes in blood volume after liposuction. Mean values for liposuction patients are indicated. (*Upper, left*) The preoperative status. The interstitial fluid (ISF) is represented by the canister on the left, and the intravascular fluid (IVF) is represented by the canister on the right. These volumes are normally about 12 and 5 L, respectively [102]. (*Upper, center*) The patient receives maintenance intravenous fluids and an infusion of wetting solution into the interstitial tissues. (*Upper, right*) During liposuction, fat is removed, along with a small volume of interstitial fluid and about 9.8% of the wetting solution. Ultrasonic assistance is not illustrated. Blood is lost into the interstitial tissues. Most of the intravenous fluid distributes to the interstitial space within minutes, leaving the intravascular volume unchanged [102]. (*Lower, left*) Postoperatively, fluid gradually shifts from the interstitial space into the circulation ("hypodermoclysis") and is diuresed over a period of at least 2 days [102]. (*Lower, center*) The excess interstitial fluid has been diuresed, although there is still significant tissue swelling. The hemoglobin level remains about 2 g lower than before surgery. (*Lower, right*) The preoperative hemoglobin level is restored. Most of the tissue swelling has resolved, bruising has cleared, and the reduction in subcutaneous fat thickness is apparent [Reprinted from Swanson E. Prospective study of lidocaine, bupivacaine and epinephrine levels and blood loss in patients undergoing liposuction and abdominoplasty. Plast Reconstr Surg. 2012;130:702–722; discussion 723–725. With permission from Wolters Kluwer Health, Inc.]

> Although there is minimal visible blood loss during liposuction, there is substantial extravascular third-space blood loss into the interstitial tissues, accounting for 98% of the blood loss.

Patient weights—a reliable indicator of extracirculatory fluid storage [102]—reveal a significant interstitial fluid accumulation. Depressed hemoglobin and hematocrit levels 1 week after surgery confirm that the blood loss is as real as if it had occurred externally and is not simply an artifact of hemodilution.

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Knowledge of the expected blood loss from liposuction (Fig. 5.4) and combination procedures (Fig. 5.5), commonly performed today, is useful for the surgeon planning a combined procedure, so as to lessen postoperative anemia, a common cause of morbidity [87]. Fat volumes under 5000 cc (maximum 4700 cc in this study) may be safely aspirated in combination with abdominoplasty and other cosmetic procedures.

Glucose Ratio

Relying on variable plasma lidocaine levels in four patients, Klein estimated the fraction of wetting solution removed by tumescent liposuction to be 10–30% [4]. The high end of this range, 30%, has been repeated by other investigators [8, 12, 103]. Kenkel et al. [24] made a similar determination, also in four patients, despite substantial variability in plasma lidocaine levels [21]. High variability is not a desirable trait in a tracer. Another problem confronted by these investigators and others [104, 105] is that lidocaine partitions preferentially into fat, including the supranatant [17, 19, 21, 104–106], so that the amount of lidocaine in the infranatant fluid, reportedly 1–10% of the infused dose [19, 24], underestimates the amount of lidocaine in the aspirate.

A more reliable tracer is needed. Glucose levels in the interstitial tissues are known to follow plasma levels closely [107–109] and remain relatively stable in patients during surgery [110], making glucose useful as a tracer [111, 112]. Calculated using mean infranatant and aspirate volumes, only 9.8% of the wetting solution was removed by liposuction in patients using the superwet technique and allowing at least 10 min between infusion and aspiration.

> Only 9.8% of the wetting solution was removed by liposuction in patients using the superwet technique.

Electrolytes

Lipschitz et al. [113] reported hyponatremia and hypokalemia in five liposuction patients treated with Ringer's lactate infusions and general endotracheal anesthesia. Normal sodium levels in the author's study [10] suggest that hyponatremia may be avoided by using isotonic saline for the wetting solution rather than the slightly hypotonic Ringer's lactate. Normal potassium levels in the presence of high epinephrine levels [10] suggest that hypokalemia is probably caused by ventilator-induced respiratory alkalosis [113], not high epinephrine levels, and therefore may be prevented by allowing spontaneous breathing.

> Hyponatremia may be avoided by using isotonic saline for the wetting solution rather than Ringer's lactate, and hypokalemia may be prevented by allowing spontaneous breathing instead of mechanical ventilation.

Other Parameters

Another reported problem, hypothermia [57], was prevented by keeping the operating room warm (78 °F), using warmed fluids and blankets, and using a Bair Hugger (Arizant Inc., Eden Prairie, MN). High oxygen saturations and low creatinine levels [10] suggest that microscopic fat emboli to the lungs and kidneys [114, 115] are clinically unimportant.

Environmental Concerns Using Anesthetic Gas

Anesthetic gases such as isoflurane, sevoflurane, and especially desflurane are potent greenhouse gases that add to atmospheric pollution and depletion of the ozone layer, with the potential to add to global warming. Less than 5% of these volatile gases is metabolized by the patient [116, 117]. These agents are typically vented to the outside environment [116, 117].

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6 Abdominoplasty

Abstract

Over the last decade, several modifications have been made to the traditional abdominoplasty method. A limited "lipoabdominoplasty" dissection has been popularized. The upper abdominal dissection is restricted to a tunnel. However, quantitative perfusion studies using laser fluorescence fail to show any benefit. Scarpa fascia preservation has also been recommended to reduce the seroma rate, but recent anatomic studies are not supportive. Both methods compromise the aesthetic result by reducing flap mobility and the abdominal flattening effect of this operation.

Quilting sutures, also called progressive tension sutures, have been widely adopted to restrict the dead space and prevent seromas, at the cost of increased operating time. All of these modifications ignore the underlying cause of seromas. Seroma fluid is an inflammatory exudate, not a backed-up collection of lymphatic fluid. Fewer seromas occur after scalpel dissection compared with electrodissection. Seroma rates may be reduced by not creating an internal burn. Seromas that do occur may be easily managed.

Fortunately, a superwet infusion of the abdomen with 0.025% bupivacaine and 1:526,000 epinephrine (twice the traditional concentration) causes profound vasoconstriction, making electrodissection unnecessary.

A traditional dissection with removal of the Scarpa fascia from the lower abdomen, repair of the rectus diastasis, and low scar placement maximize the aesthetic result. Flexing the operating table to 90° allows the surgeon to keep the abdominoplasty scar low, within the bikini line. Deep fascial anchoring sutures prevent postoperative upward scar migration. Liposuction should be used routinely to treat the upper abdomen and flanks, correcting the muffin top deformity.

With attention to blood loss, operating efficiency, and SAFE anesthesia, abdominoplasty may be safely performed in combination with other cosmetic procedures. Abdominoplasty can provide a very high level of patient satisfaction. Surgeons who become proficient at it are likely to cultivate a huge patient base.

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Introduction

Abdominoplasty is one of the most gratifying procedures for the plastic surgeon to perform. Like breast augmentation, the results are apparent immediately after surgery. Patient satisfaction is remarkably high. Surveys reveal that abdominoplasty performed on its own or in combination with liposuction met patient expectations in 139 of 141 cases (98.6%) [1]. This level of patient satisfaction is, in the author's experience, rivaled only by breast augmentation (98.1%) [2].

Presently, only surgery can effectively treat excess skin laxity of the abdomen after pregnancy or weight loss. Nonsurgical options are inadequate. Therefore, abdominoplasty is a procedure with a very large patient base. Plastic surgeons and particularly those new in practice do well to pay particular attention to this patient group and learn to do the procedure safely and efficiently. Unfortunately, many treatment recommendations are largely based on first principles and clinical impressions rather than scientific study.

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A major source of controversy is the extent of the dissection. One of the risks of abdominoplasty is delayed wound healing caused by impaired circulation to the skin. In an effort to reduce risk, some investigators [3] advocate a limited-undermining technique, with greater preservation of the musculocutaneous perforating blood vessels, as originally proposed by Le Louarn [4]. A 2014 Continuing Medical Education review recommends limited flap undermining, with creation of a suprafascial tunnel from the umbilicus up to the xiphoid process [5].

Although a limited dissection seems to make sense intuitively, there is no objective evidence that this limited-undermining technique improves blood supply compared with a traditional abdominoplasty dissection. Why not do so anyway out of an abundance of caution? Abdominoplasty is a cosmetic operation, so that any intervention that compromises the cosmetic outcome, and a limited dissection that may do just that [6], must be justified by a substantial risk reduction.

Putting aside first principles, the logical question to ask is what is the effect on flap vascularity comparing limited and full dissections? Thanks to new perfusion imaging technology, we now know the answer [6], and it is not necessarily intuitive.

Limited Versus Full Dissection Abdominoplasty

To evaluate the effect of the dissection on flap perfusion, the author undertook a study of the blood supply of the abdominal skin during the abdominoplasty procedure [6].

By testing the circulation at two times during the dissection, after a limited dissection and then after a traditional dissection, laser fluorescence perfusion data were used to evaluate any difference in vascularity. "Limited dissection" refers to the extent of the subfascial undermining of the superiorly based abdominal flap, not to the skin resection, which was the same for each dissection [6]. This imaging method has been used previously in patients undergoing abdominoplasty [7, 8]. The author's study differed from previous studies in using patients as their own control to compare two different abdominoplasty dissections.

Twenty-two consecutive patients underwent a full abdominoplasty [6]. Inclusion criteria consisted of primary abdominoplasty in combination with liposuction of the abdomen and flanks, patient consent, and no history of an allergy to iodinated contrast dye. All patients met the inclusion criteria, making the inclusion rate 100%. Coincidentally, all patients were female. No mini-abdominoplasties (i.e., suprapubic skin resection without umbilical translocation) were included.

Imaging Technology

The SPY Elite Intraoperative Perfusion Assessment System (Lifecell Corp. and then Novadaq Technologies, Inc., now Stryker Corp., Kalamazoo, MI) uses a near-infrared laser to create fluorescence (Fig. 6.1). The contrast

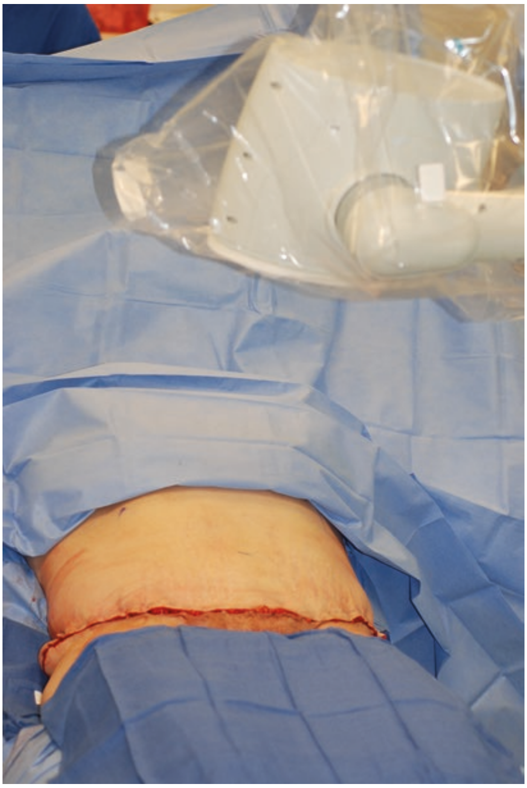

Fig. 6.1 The SPY equipment is in place, about to image a patient a second time, after transition to a full abdominoplasty dissection and deep fascial repair. The umbilical incision and skin closure are completed after imaging. The programmable operating table is positioned at the same angle of flexion, and the distance from the laser to the patient is held constant for both evaluations. The pubic area is partially exposed. It serves as a reference [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

agent, indocyanine green, is absorbed at 806 nm [9]. This contrast agent is injected intravenously and is bound to plasma proteins [9]. The dye is metabolized by the liver. Its half-life is 2.5–3 min [9]. This fast clearance allows repeated imaging of the same patient during surgery, which was not possible using the older fluorescein method. The cost of the dye kits, paid by the author, was $1300 per patient. There was no outside funding for the study.

The same operative sequence was used for all 22 patients. The abdomen and flanks were treated with liposuction in all cases. Ten patients were treated with simultaneous liposuction of the thighs and knees. Seven patients also underwent liposuction of the upper arms and/or axillae. In all cases, the resection was marked preoperatively, keeping the inferior margin within the bikini line and the superior resection margin coursing above the level of the umbilicus [6]. All patients underwent umbilical translocation and repair of the rectus fascia.

After infusion of the local anesthetic solution, ultrasonic liposuction was performed, treating the epigastrium, the pubic area, and the lower abdomen. Liposuction of the mons pubis avoids a contour mismatch with the reduced lower abdomen. Ultrasound assistance was limited to <1 min for each area. The author does not normally perform liposuction of the lower abdomen because this tissue is discarded in the traditional abdominoplasty technique. However, in an effort to simulate the limited dissection technique as performed by Saldanha et al. [3], the lower abdomen was also treated with liposuction. Next, the flanks were treated. Liposuction of other body areas—outer thighs, knees, arms, and axillae—in 12 patients was performed after the abdominoplasty. Patients are never turned prone.

Liposuction of the mons pubis avoids a contour mismatch with the reduced lower abdomen.

After liposuction, a limited-undermining abdominoplasty was performed [3]. The Scarpa fascia was preserved on the lower abdominal wall. The deep fascia was removed in the midline, extending above the umbilicus as a tunnel. Videos of this procedure, including both limited and full dissection techniques, and imaging are available to subscribers at the *Plastic and Reconstructive Surgery* website: http://journals.lww.com/plasreconsurg/pages/videogallery.aspx?videoId=660&autoPlay=true [10].

The medial musculocutaneous perforating vessels supplying the skin flap over the rectus abdominus muscles were preserved (Fig. 6.2). The rectus abdominus diastasis was repaired using two layers of running 0-Prolene (Ethicon, Inc., Somerville, NJ)

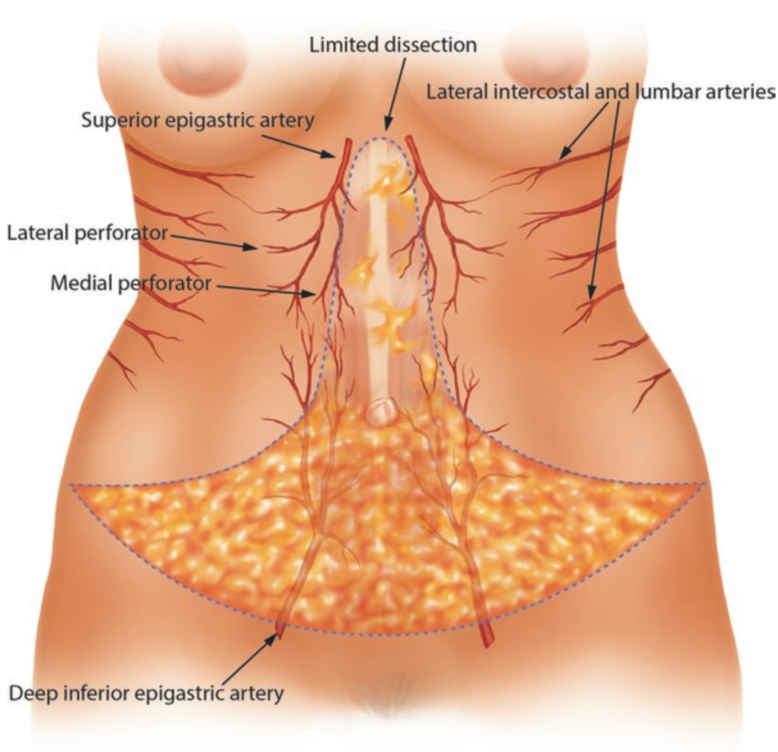

Fig. 6.2 Illustration showing the limited dissection technique. The hatched line (blue) represents the margins of the subcutaneous dissection. A vertical tunnel superior to the umbilicus preserves medial perforators that supply the skin, arising from the vascular arcade connecting the superior and deep inferior epigastric circulation. The Scarpa fascia and sub-Scarpa fat are left attached on the lower abdominal wall. Collateral blood supply is provided by the lateral branches of the posterior intercostal arteries and by lumbar segmental vessels. Anastomotic connections exist between superior and deep inferior epigastric vessels and between superior epigastric and lateral intercostal arteries [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

sutures. The dissection was performed using scalpel dissection, not electrodissection. The operating table was flexed to a jackknife position [11]. The position of the operating table (flexion and height) was programmed so that it could be reproduced later for the full dissection. The wound tension was measured using a tensiometer (Chatillon Scales and Force Measuring Instruments, Kew Gardens, NY) (Fig. 6.3). After this limited dissection and superficial fascial wound closure, 3 mL (7.5 mg) of indocyanine green were injected intravenously. Starting immediately after the 10 mL saline flush, the video was recorded for 136 s (Fig. 6.4).

Next, the abdominal wound was reopened. The Scarpa fascia and most of the fat attached to it (Fig. 6.5) were removed from the lower abdomen, preserving an areolar layer of fat on the abdominal fascia. The dissection continued to the costal margins. Lateral perforators were preserved (Fig. 6.6). In this way, a limited-undermining abdominoplasty was converted to a full abdominoplasty dissection. No quilting sutures were used. Scalpel dissection was performed exclusively (Fig. 6.7). Electrocautery was limited to treatment of individual vessels using a 9½ in. (24 cm) Potts-Smith monopolar, insulated, serrated, 2.0 mm handswitch cautery forceps (Kirwan Surgical Products, Marshfield, MA).

The operating table was again flexed, using the program function to ensure that its position was identical to the earlier position. Figures 6.8 and 6.9 compare the limited and full dissections. The tensiometer was used once more to measure the wound tension as the superior flap was approxi-

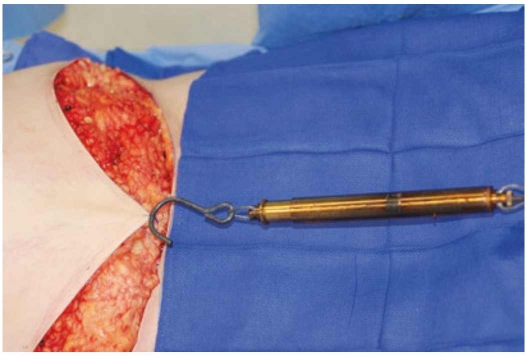

Fig. 6.3 A tensiometer is used to measure wound tension as the abdominal flap is pulled down to align with the inferior wound margin (right side of photograph). The patient has undergone a limited-undermining abdominoplasty with preservation of the Scarpa fascia of the lower abdomen. The wound tension (scale not visible on instrument in this photograph) measures 4 lbs. Additional photographs of this patient are shown in Figs. 6.5, 6.8, 6.9, and 6.13

mated to the inferior wound edge (Fig. 6.10). The wound was repaired using 2–0 Vicryl (Ethicon Inc., Somerville, NJ) sutures to anchor the Scarpa fascia of the abdominal flap to the lower abdominal fascia [11]. The wound was partially closed using interrupted 3–0 Vicryl deep dermal sutures, similar to the limited dissection. Next, the abdomen was re-imaged (Fig. 6.11). After the second video, the umbilicus was brought through a midline incision, a single drain was inserted through the right side of the incision, and the skin was closed using a running 4–0 Monocryl intradermal suture (Ethicon, Inc., Somerville, NJ). No additional skin excision was performed at the time of wound closure.

Perfusion Measurements

Both absolute values and percentages were tabulated [6]. Percentages were based on a 100% reference assigned to the pubic site [8]. The pubic measurement was chosen as the reference value because: (1) it was not subject to dissection, (2) it was in all cases treated to both the infusion and liposuction, and (3) it was within the field of view.

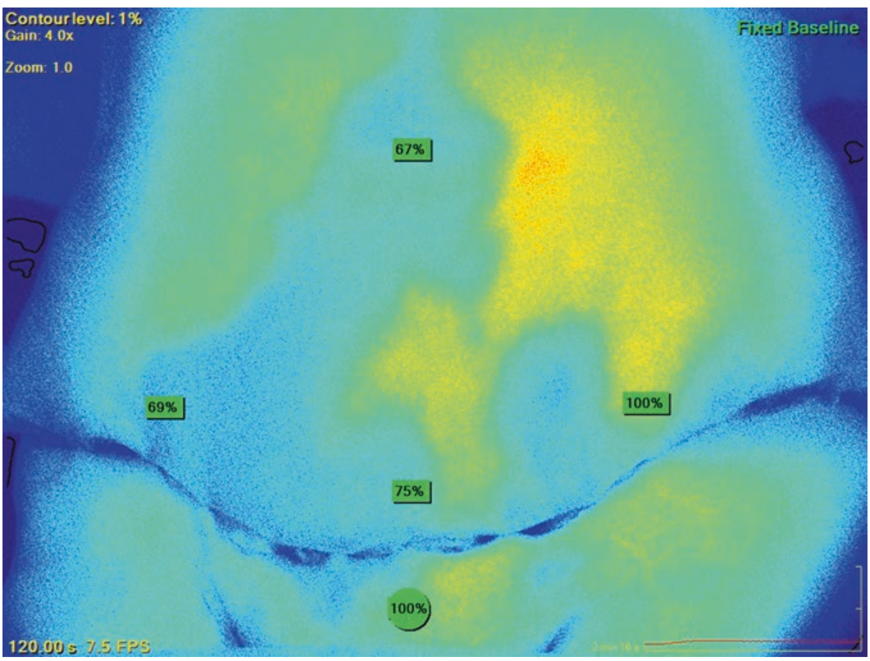

Fig. 6.4 This image is taken from the video 120 s after the flush of the contrast agent. A limited dissection and superficial fascial repair have been performed. The skin has not been closed. Five anatomic sites are measured: the left and right lower abdomen, lower abdominal midline, pubic area, and epigastrium. In this image, percentages are indicated, with 100% assigned to the pubic perfusion, which serves as a reference. Areas with greater perfusion appear red and areas with less perfusion appear blue [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

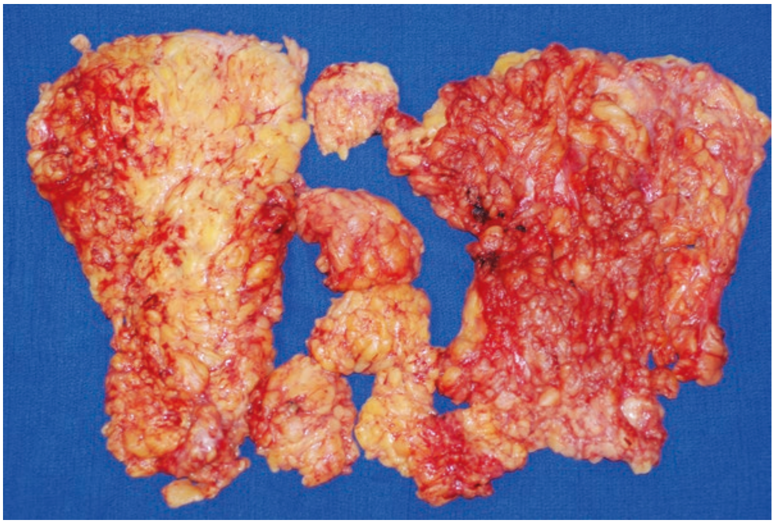

Fig. 6.5 After the limited dissection technique is completed and the patient is imaged the first time, the Scarpa fascia and most of the fat associated with it are removed from the lower abdomen. The resected tissue is seen here on the operating table before it is discarded [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

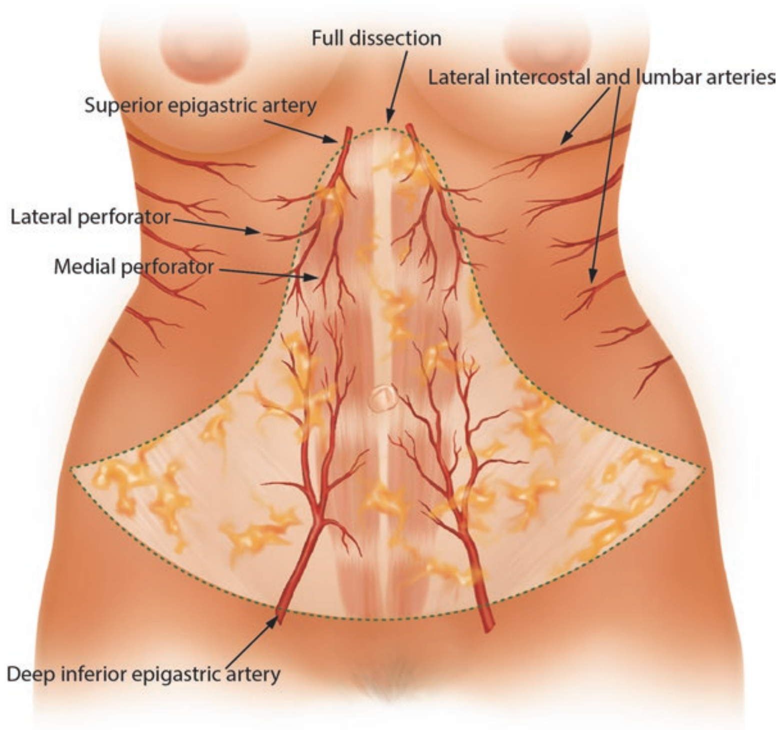

Fig. 6.6 Illustration showing the full abdominoplasty dissection. The hatched line (green) represents the superior extent of the subfascial dissection and the inferior resection margin. The upper abdominal dissection has been widened, so that branches from medial perforators no longer supply the abdominal flap. Blood supply from the lateral perforators is preserved. The Scarpa fascia and pre-Scarpa fat have been removed from the lower abdomen, preserving a small amount of fat on the lower abdominal wall [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

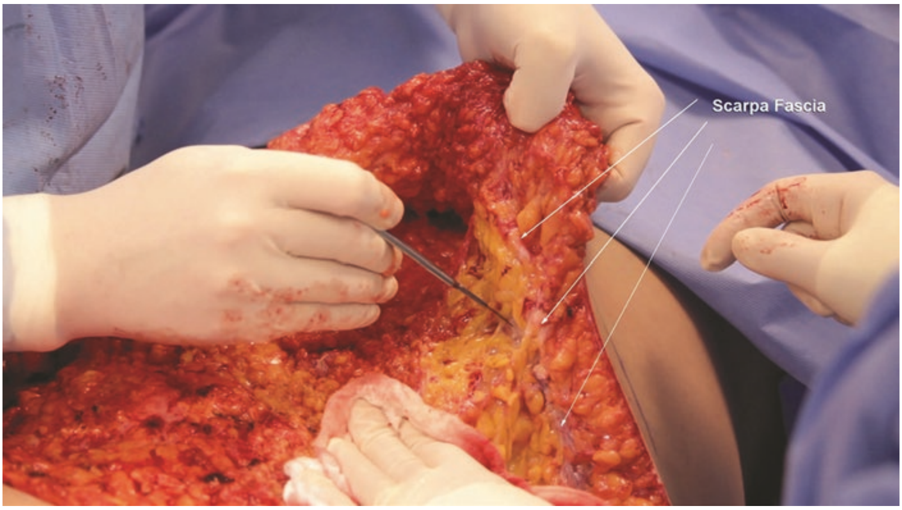

Fig. 6.7 Intraoperative photograph showing conversion of the limited dissection to a full dissection, with sub-Scarpa elevation of the upper abdominal flap after resection of the excess lower abdominal tissue. Scalpel dissection is used, reserving electrocautery for individual blood vessels, so as to reduce the risk of seroma. For orientation, the pubic area is barely visible at the lower left corner of the photograph [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

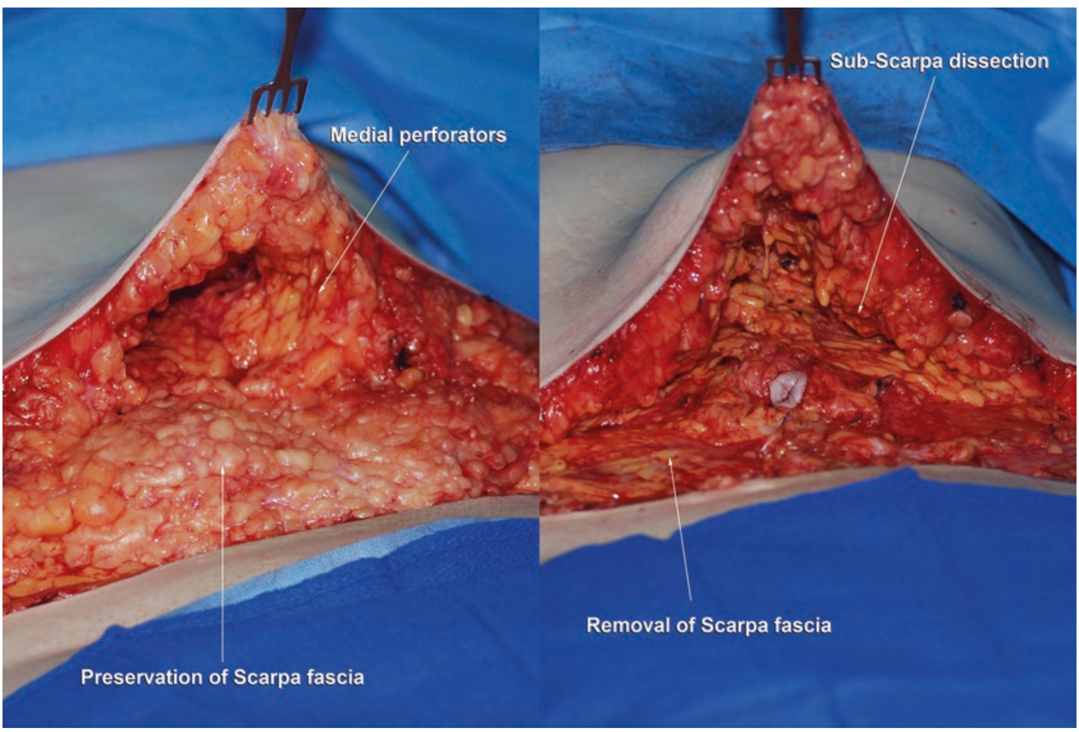

Fig. 6.8 Intraoperative photographs compare limited (*left*) and full (*right*) dissections in the same patient. The medial musculocutaneous perforating blood vessels are preserved in the limited technique (*left*), leaving a midline tunnel up to the xiphoid. After conversion to a full dissection, the Scarpa fascia and most of the fat are removed from the lower abdominal wall. The upper abdominal dissection is extended deep to the Scarpa fascia [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

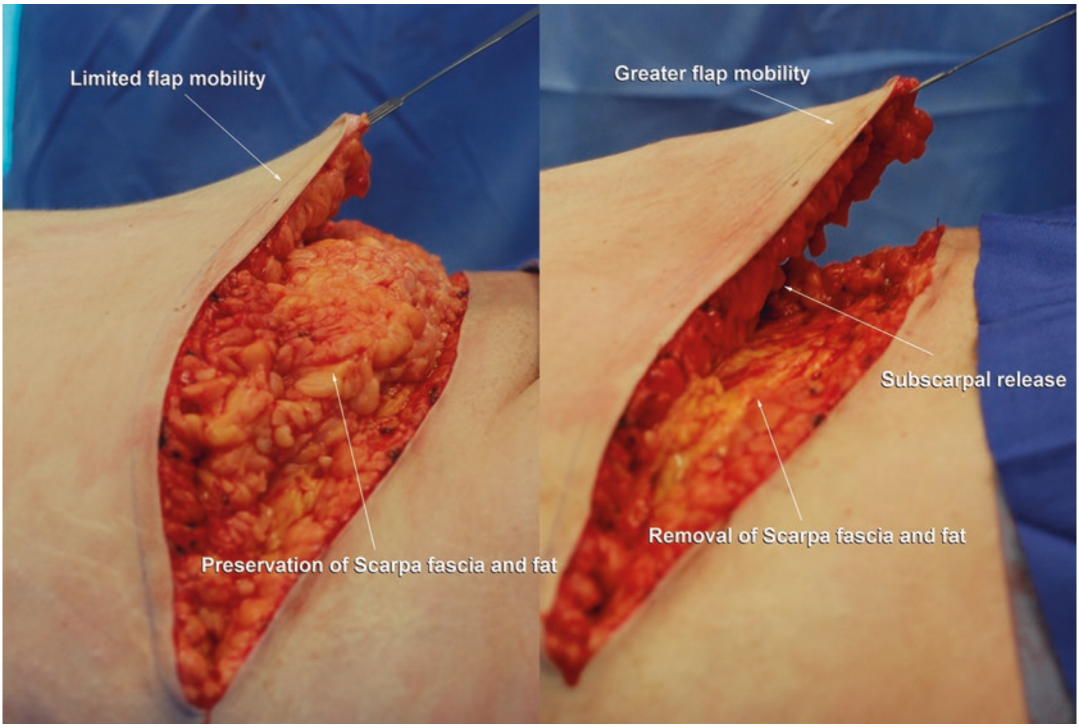

Fig. 6.9 Lateral intraoperative photographs compare the limited (*left*) and full (*right*) dissections in the same patient. The retained Scarpa fascia and fat (*left*) leave bulk on the abdominal wall, compromising the degree of flattening of the lower abdomen and creating a longer distance for the upper abdominal flap to travel. After conversion to a full dissection (*right*), the abdominal wall is flat and the flap has greater mobility [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

Fig. 6.10 The tensiometer is used again to measure wound tension after conversion to a full dissection and removal of the Scarpa fascia and most of the fat from the lower abdomen. The operating table is flexed equally using its programmable function. The additional release of the flap and removal of excess fat and fascia allow approximation of the wound edges with less tension, measuring 1 lb. This patient's before-and-after photographs are provided in Fig. 6.13

There was no significant difference in any of the perfusion measurements after limited and full abdominoplasty dissections, either in comparing absolute values or percentages, at either a 0.01 alpha level or at a 0.05 alpha level.

> There was no significant difference in any of the perfusion measurements after limited and full abdominoplasty dissections.

A fasciocutaneous flap is known to have a more robust circulation than a subcutaneous flap that relies entirely on the subdermal plexus [12]. Anatomic studies demonstrate that the subdermal plexus is important to abdominal skin perfusion [13–15]. However, the deep subcutaneous layer also contains interlinking blood vessels, extending almost to the Scarpa fascia [13–15]. Inclusion of the deep fascia is likely to benefit flap perfusion [6].

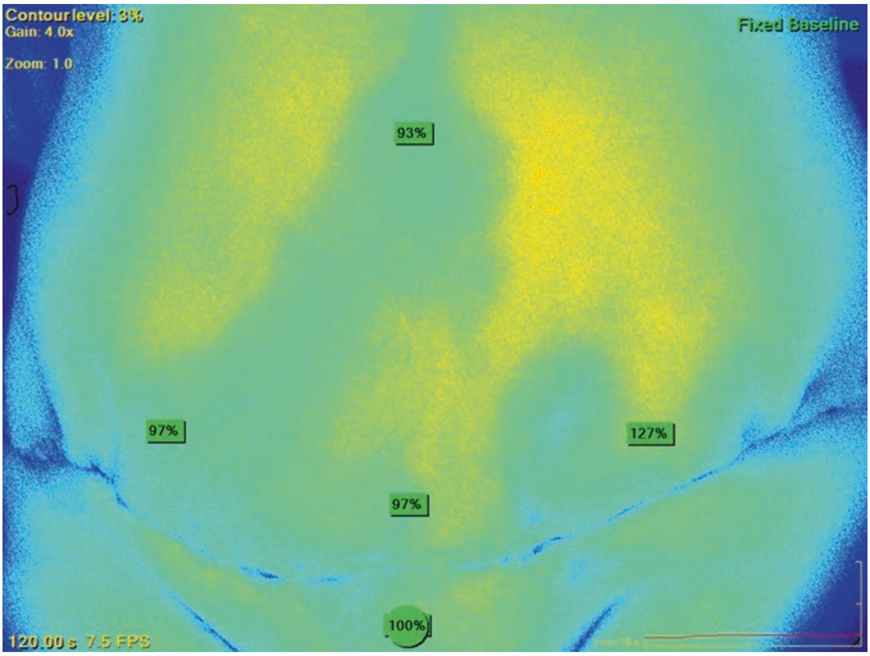

Fig. 6.11 This image is taken from the video 120 s after the flush of the contrast agent. The same patient is imaged after a limited dissection in Fig. 6.4. The dissection has now been converted to a full dissection plus removal of the Scarpa fascia from the lower abdominal wall. The deep fascia has been anchored, and interrupted deep dermal sutures have been used. The umbilical incision has not been made yet, and the skin has not been closed, consistent with the earlier image. The same five anatomic sites are measured. Percentages are applied by the SPY imaging software, with the pubic area assigned 100%. Areas with greater perfusion appear red and areas with less perfusion appear blue [Reprinted from Swanson E. Comparison of limited and full dissection abdominoplasty using laser fluorescence imaging to evaluate perfusion of the abdominal skin. Plast Reconstr Surg. 2015;136:31e–43e. With permission from Wolters Kluwer Health, Inc.]

Wound Tension

The wound tension for the limited dissection was significantly higher ($p < 0.001$) than the wound tension for the traditional dissection [6]. Using a limited dissection, there is less flap mobility (Fig. 6.9). Without deep fascial anchoring sutures, the scar migrates superiorly (Fig. 6.12). The finding that wound tension is reduced in a traditional dissection is not surprising. Less tension is expected after greater undermining. A full dissection releases the deep fascia, allowing the flap to mobilize (Fig. 6.9). There is less tendency for the scar to migrate superiorly. Figures 6.13 and 6.14 depict two of the study patients and show a low scar, located within the panty line with no tendency to migrate superiorly (Fig. 6.12).

> Less tension is expected after greater undermining. A full dissection releases the deep fascia, allowing the flap to mobilize.

Scar Level

One might reasonably ask, why not preserve the Scarpa fascia out of an abundance of caution? There are two reasons: One is the increased abdominal thickness, as discussed above. The other reason is that the deep fascial repair anchors the superior flap and prevents upward migration of the hair-bearing pubic skin (Fig. 6.12). Saldanha et al. [3] redrape the superior flap using a two-layer superficial fascial and skin closure with no deep fascial repair. These authors [3] rely on the lateral wound closure to

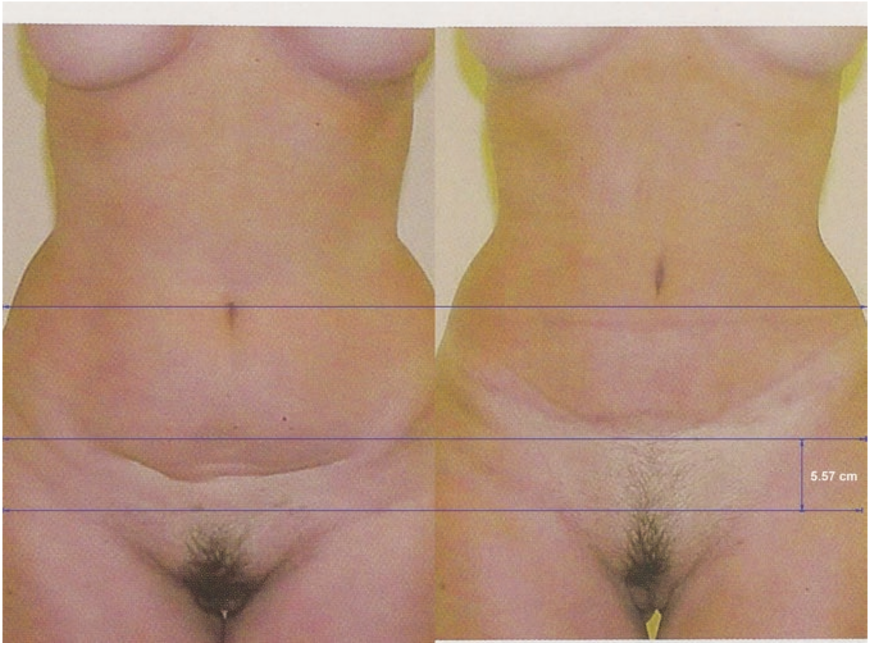

Fig. 6.12 Example of published result of lipoabdominoplasty with limited undermining and preservation of the Scarpa fascia as provided by Saldanha et al. [3]. The preoperative view (*left*) is matched for size and orientation to the postoperative view (*right*), allowing comparisons. The orientation of the mons pubis has been changed, which can be a benefit to such a woman with ptosis. However, the superior border of the mons pubis has been moved upward, extending the pubic hair onto the lower abdomen. The scar may be difficult to conceal in a bikini. Postoperatively, the umbilicus is positioned slightly higher, with an upward orientation. For calibration, a 34 cm width at the iliac crest level was used [Reprinted from Swanson E. Prospective clinical study of 551 cases of liposuction and abdominoplasty performed individually and in combination. Plast Reconstr Surg Glob Open 2013;1:e32. With permission from Wolters Kluwer Health, Inc.]

Fig. 6.13 This 27-year-old woman is seen before (*left*) and 3 months after (*right*) an abdominoplasty and liposuction of the abdomen and flanks. Her flap weighed 4 lbs and the liposuction volume was 500 cc. Intraoperative photographs are shown in Figs. 6.3, 6.5, 6.8, and 6.9

Fig. 6.14 This 32-year-old woman is seen before (*left*) and 22 months after (*right*) an abdominoplasty and liposuction of the abdomen and flanks. The resected flap weighed 7 lbs. The liposuction volume was 1450 cc. This patient's intraoperative photographs are depicted in Figs. 6.1 and 6.10

reduce central wound tension, rather than a deep fascial repair. They remove additional skin at the end of the procedure in an attempt to lower the incision line. This method does not appear to be effective in avoiding a scar that is too high and difficult to conceal in a bikini (Fig. 6.12). The scar level is a practical concern for women and their clothing.

> The deep fascial repair anchors the superior flap and prevents upward migration of the hair-bearing pubic skin.

Level 2 Controlled Study

Randomized trials are usually impractical when studying surgical operations because patients are generally unwilling to have their surgery randomized, as discussed in Chap. 1 [16]. Fortunately, rigorous nonrandomized controlled studies with a high inclusion rate and a minimum of exclusion criteria can provide valuable information [16].

Using the patient as her own control eliminates uncontrolled variables and is particularly advantageous when the study population is necessarily limited by the high cost of using this sophisticated imaging technology. This study design takes advantage of the fact that comparison of limited to full dissection is possible in the same patient because a limited dissection with Scarpa fascia preservation can be extended to a full dissection and Scarpa fascia removal without compromising the full dissection technique. Equipoise is observed because no patient is subjected to a procedure known or suspected to be inferior. Two different patient groups would permit the influence of numerous confounding variables [6].

Blood Supply to the Upper Abdomen

The theoretical basis for a limited dissection abdominoplasty is greater preservation of abdominal flap vascularity because the medial musculocutaneous perforating blood vessels are preserved [3, 10].

The abdominal wall circulation has been studied extensively, largely because of its importance as a tissue donor site in breast reconstruction [13–15, 17–20]. A vascular arcade provides circulation to the overlying abdominal skin [13]. The deep inferior epigastric and superior epigastric arteries contribute to this arcade [13]. The dominant blood supply derives from the larger deep inferior epigastric circulation [13]. Moon and Taylor [14] describe three different vascular patterns. The most common pattern includes two major vertically oriented arteries that give rise to medial and lateral perforators (Figs. 6.2 and 6.6). Most medial perforators derive from the deep inferior epigastric circulation and supply the medial skin of the lower abdomen [14]. Although a medial row of perforators may be apparent in the lower abdomen [19], the location of these perforators is variable in the upper abdomen [13, 14].

During an abdominoplasty, the lower abdominal skin inferior to the level of the umbilicus is resected [11]. The medial row perforators located in the lower abdomen are divided and cauterized. Importantly, the number and caliber of the medial perforators superior to the level of the umbilicus are smaller than the number and size of these perforators in the lower abdomen [13].

> The number and caliber of the medial perforators superior to the level of the umbilicus are smaller than the number and size of these perforators in the lower abdomen.

In their cadaveric dissections, Boyd et al. [13] documented a concentration of perforators around the umbilicus. A watershed area exists above the level of the umbilicus [13, 14, 19] with extensive arborization and a paucity of large vessels [13]. Superior to the umbilicus, there are relatively few large medial perforators [13, 20]. Boyd et al. [13] counted 22 large perforators in the medial zone versus 65 large perforators in the middle and lateral zones in 50 muscle dissections. These anatomic findings are consistent with the clinical experience of plastic surgeons, who typically encounter (and cauterize) several large periumbilical perforators during the abdominoplasty dissection but find few medial perforators as the dissection proceeds superiorly to the xiphoid [6].

In two recent publications, Taylor et al. [19, 20] describe the anastomotic connections between adjacent anatomical vascular zones (angiosomes) of the abdomen. These investigators [19, 20] document two forms of anastomotic connections, known as true and choke anastomoses. True anastomoses represent uninterrupted vessels that can be identified clinically [13] or radiographically [19, 20]. "Choke" anastomoses [13, 20] are finer communications that can dilate, allowing collateral blood flow [19, 20]. These vascular connections allow an adjacent vascular zone to supply sufficient blood supply to ensure flap survival [19, 20].

The importance of collateral blood supply between the superior epigastric perforators and the lateral branches of the posterior intercostal arteries is well-recognized [13, 14, 17, 20, 21]. A large true anastomosis connects the superior epigastric circulation to the lateral intercostal circulation [13, 14]. Boyd et al. [13] were sufficiently impressed with the size and consistency of this vessel to label it the "superficial superior epigastric artery." The lumbar arteries are also recognized as substantial segmental vessels supplying the lateral abdominal wall [17]. Anatomic studies suggest that a large superiorly based fasciocutaneous flap contains sufficient collateral blood supply from adjacent vascular zones (in the absence of surgical scarring) [14] to ensure adequate blood supply to the flap margin. Division of a small number of medial perforators would not be expected to jeopardize flap viability. The findings of the author's perfusion study confirm the anatomic studies documenting the adequacy of collateral blood supply in the abdomen and the angiosome concept [6]. Imaging and clinical data support the safety of a traditional abdominoplasty performed simultaneously with liposuction [6].

> A large superiorly–based fasciocutaneous flap contains sufficient collateral blood supply from adjacent vascular zones to ensure adequate blood supply to the flap margin.

Indications

Abdominoplasty is recommended for treatment of abdominal skin redundancy and musculofascial laxity, usually in combination with liposuction. Indications for surgery include abdominal skin excess, striae, and musculofascial laxity. Other indications include removal of lower abdominal scar deformities (or tattoos), repair of a ventral hernia, and, occasionally, correction of a hidden penis in men. Many women comment favorably regarding elevation of a ptotic mons pubis, an underappreciated benefit of abdominoplasty. An abdominoplasty can also provide modest tightening of the skin of the anterior and inner thigh (Fig. 6.15), which is a consideration when patients are deciding whether or not to undergo a medial thigh lift. An abdominoplasty provides ideal exposure for repairing a large umbilical or ventral hernia (Fig. 6.16) without making a conspicuous periumbilical incision. The rectus plication provides additional reinforcement of the repair. Implantable mesh is seldom necessary. There is typically sufficient fascia to recruit from either side.

> Many women comment favorably regarding elevation of a ptotic mons pubis, an underappreciated benefit of abdominoplasty.

Preoperative Marking

The incision is marked with the patient standing before surgery. In my practice, "photo panties" are used for reference along with the inguinal skin creases (Fig. 6.17). These are the same type of panties used for taking photographs at the preoperative and postoperative visits.

The level of the superior resection margin is determined in surgery and does not necessarily follow the marked line (Fig. 6.18). This incision may be made inferior to this line but still just above the umbilicus to avoid a midline vertical scar.

Patients who are concerned about the scar placement are encouraged to bring along their preferred bikini bottoms on the day of surgery to ensure that the scar is covered by the bikini (Figs. 6.19 and 6.20). Some bikinis are more high-cut than others.

Fig. 6.15 This 44-year-old patient was 5′0″ and weighed only 119 lbs, but her post-pregnancy deformity creates an unflattering body shape that makes her appear overweight. She is seen before (*left*) and 6 months after abdominoplasty and liposuction of the abdomen, flanks, inner thighs, arms, and axillae (*right*). The skin tone of the anteromedial thighs is improved. Her weights were 119 lbs before surgery and 113 lbs after surgery. This 6 lb. weight loss is expected for a patient whose flap weighed 4.25 lbs and who lost 1700 cc from liposuction (weighing about 2 lbs per 1000 cc), making the comparison calorically neutral

The abdominoplasty incision courses inferior to any existing scars from previous cesarean sections or other surgery. Typically, the new scar ends up at about the same level as an old cesarean section scar because it is pulled up a little by tension from above. One of the benefits of an abdominoplasty is removal of unattractive old scars, particularly vertical scars that may leave an unsightly cleavage, giving the abdomen the unwelcome appearance of buttocks (Fig. 6.21).

Overweight Patients

Many patients with body mass indices (BMIs) over 30 kg/m^2 may benefit from abdominoplasty (Fig. 6.21), although the author rarely performs an abdominoplasty on a patient with a BMI >35 kg/m^2. Instructing a patient to first lose weight, for example, 30 lbs and then return for surgery is unlikely to be effective. The more relevant criterion is the laxity of the abdominal

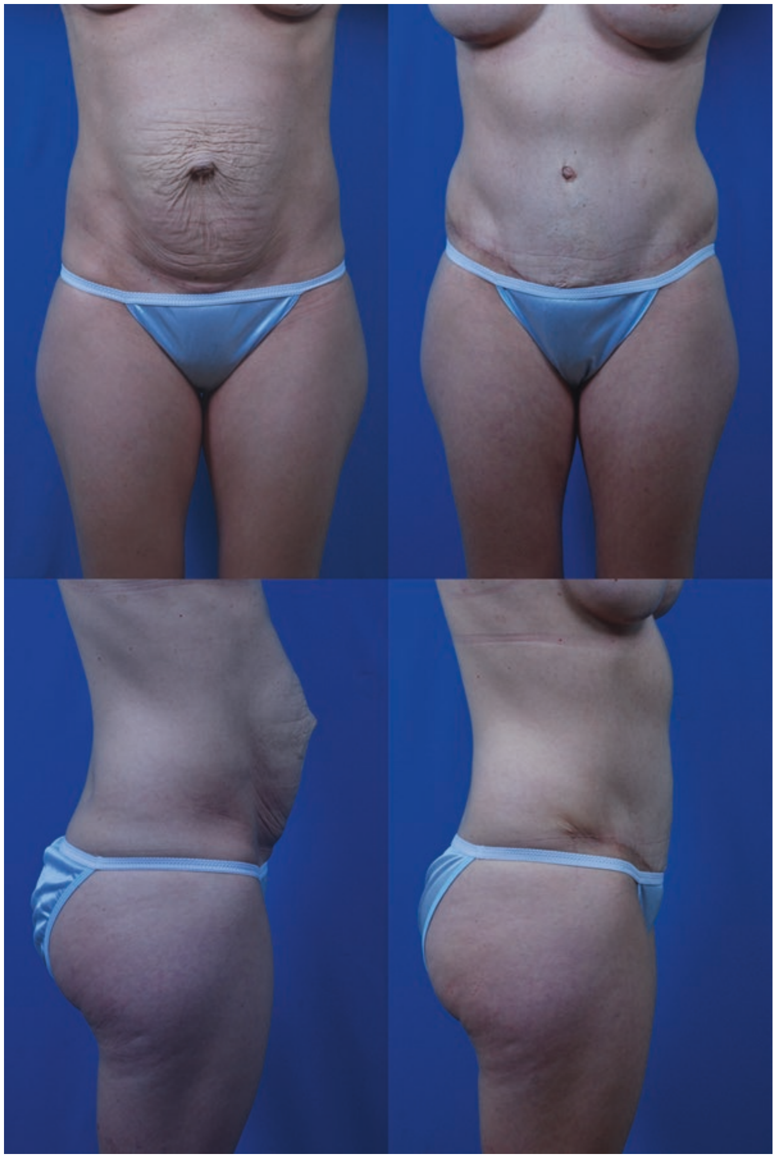

Fig. 6.16 This 31-year-old woman had four children including a set of twins. She had a wide rectus diastasis and an umbilical hernia. She is seen before (*left*) and 10 months after (*right*) an abdominoplasty and breast augmentation. She required no liposuction

skin. If a patient has a very lax tissue, an abdominoplasty can be helpful even if she is obese. Hopefully this surgery will improve her body image so that she is more motivated to make lifestyle changes and lose weight after surgery. On the other hand, a patient, male or female, with a "beer belly" (protuberant abdomen with minimal skin laxity) is a poor candidate for an abdominoplasty.

Anesthesia

Traditionally, abdominoplasties have been performed under general endotracheal anesthesia, including paralysis, intubation, and ventilation—the maximum degree of anesthesia. This is the same type of anesthesia used for major abdominal procedures such as laparotomies. However, abdominoplasty may be performed

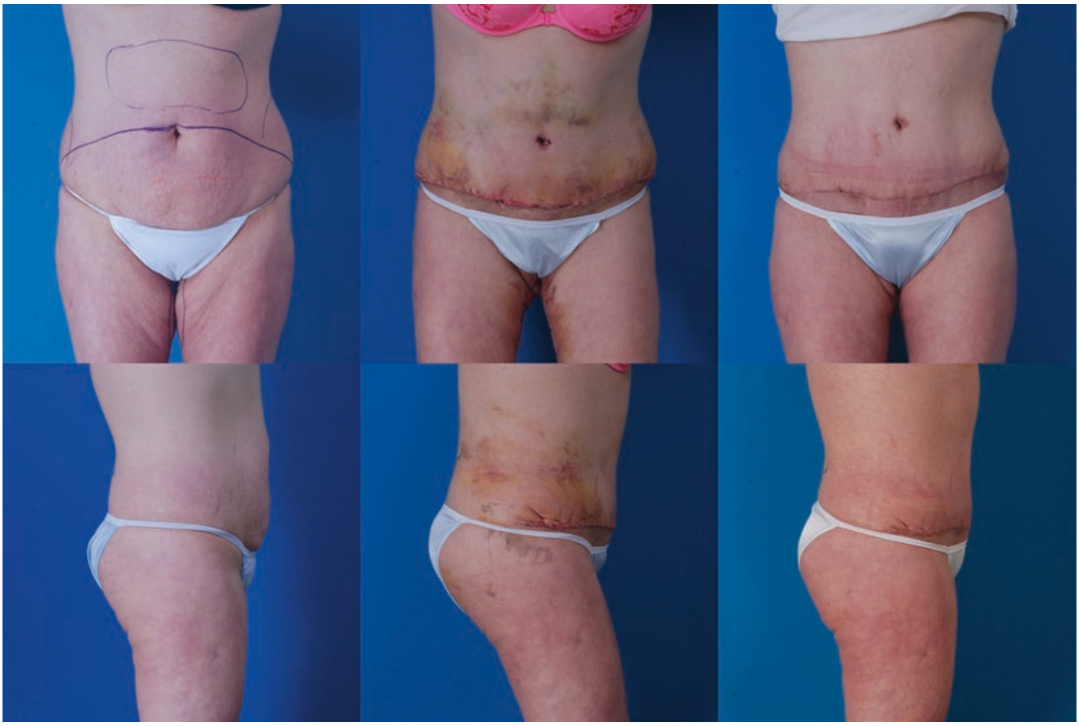

Fig. 6.17 This 39-year-old woman is seen before surgery (*left*), 5 days after surgery (*center*), and 7 weeks after surgery (*right*). She underwent an abdominoplasty; liposuction of the abdomen, flanks, and inner thighs; vertical medial thigh lifts; and buttock fat transfer (300 cc per buttock). Her flap weight was 2.2 lbs. She demonstrates the usual stooped position 5 days after surgery

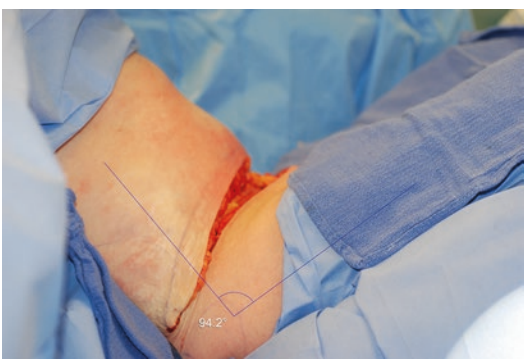

Fig. 6.18 The operating table is flexed to 94°. Note that the lower incision has been made at the site of the original marking, but the upper incision is made lower than the marking, although still coursing above the umbilicus, which is preserved on its pedicle (not seen). The rectus diastasis has been repaired. This patient's before-and-after photographs are provided in Fig. 6.17

under (unconscious) intravenous sedation, using a laryngeal mask airway (LMA) and a propofol infusion, no differently from other cosmetic procedures. Anesthesia administration is discussed in detail in Chap. 5.

In my practice, all surgery is performed in a state-licensed ambulatory surgery center. No patient receives chemoprophylaxis. Other methods to reduce venous thromboembolism risk—no paralysis and ultrasound surveillance—are used instead. This subject is discussed in detail in Chaps. 5, 12, and 13.

Preoperative Testing

A complete blood count is obtained before surgery. Liposuction and body contouring surgery are associated with a nontrivial blood loss [22]. If the patient is anemic, further investigation is needed. Patients after gastric bypass may have low hemoglobin levels, reducing the margin for safety when performing body contouring surgery [23].

Fig. 6.19 This 34-year-old woman with two children is seen before (*left*) and 3 months after (*right*) an abdominoplasty; liposuction of the abdomen, flanks, axillae, and inner thighs; and augmentation/mastopexies. Her flap weight was 2.5 lbs and the liposuction aspirate volume was 1000 cc. She wore her bikini bottom on the day of surgery to assist in marking the incision. Her scar is revealed in Fig. 6.20

> Patients after gastric bypass may have low hemoglobin levels, reducing the margin for safety when performing body contouring surgery.

Preoperative iron supplementation or a hematology consult may be helpful. Serum protein and albumin levels are recommended for the patient with a questionable nutritional status [23]. Bossert and Rubin [23] report a patient with an unknown

Fig. 6.20 Same patient shown in Fig. 6.19, wearing photo panties to reveal the scar position

thiamine deficiency who did not awaken in the recovery room, but quickly recovered after receiving thiamine.

Ultrasound Surveillance

The author uses ultrasound surveillance routinely, as discussed in Chap. 13 [24]. In patients undergoing liposuction and/or abdominoplasty, the abdomen is also scanned to check for an undiagnosed abdominal wall defect (Fig. 6.22). Abdominal hernias may be clinically evident (Fig. 6.23) but less obvious when the patient is supine on the operating table (Fig. 6.24).

An unexpected abdominal tumor discovered at the time of an abdominoplasty has been reported [25]. Ideally, such pathology is detected before surgery. Abdominal penetration with the cannula is a well-known and potentially serious complication [26].

> In patients undergoing liposuction and/or abdominoplasty, the abdomen is also scanned to check for an undiagnosed abdominal wall defect.

Wetting Solution

After induction of systemic anesthesia, the abdomen, including the epigastrium and pubic area, is infused with anesthetic solution. This solution consists of up to 1 L of normal saline, 250 mg (0.025%) bupivacaine, and 2 mg epinephrine (1:526,000) [22]. A blunt infusion cannula is used, and this procedure is not delegated because of the risk of abdominal perforation. There have been no reports of bupivacaine toxicity when it is administered in dilute form in a wetting solution [22].

By infusing the abdomen and then allowing time (at least 15 min) for the epinephrine to constrict the small blood vessels, there is a remarkable reduction in bleeding at surgery [22]. Blanching of the skin is usually evident. The estimated blood loss for an abdominoplasty performed at the time of liposuction is 290 cc, on average [22]. Larger blood vessels such as the superficial circumflex iliac or superficial inferior epigastric vessels sometimes do not even bleed when divided. Of course they are cauterized regardless.

It is reasonable to ask about hematomas developing later from rebound bleeding. Fortunately,

Fig. 6.21 This 59-year-old nonsmoker had an unattractive old vertical cesarean section scar and a well-healed old open cholecystectomy scar. She is seen before (*left*) and 6 months after (*right*) abdominoplasty; liposuction of the lower body, arms, and axillae; and a submental lipectomy. Her height was 5′6″ and preoperative weight 225 lbs, for a BMI of 34.7. The flap weighed 7 lbs and the liposuction aspirate volume was 4600 cc. Despite her old scars, she had no wound healing problems. This patient was more motivated to lose weight after her surgery because she was no longer discouraged by her abdominal deformity. Her postoperative weight was 198 lbs

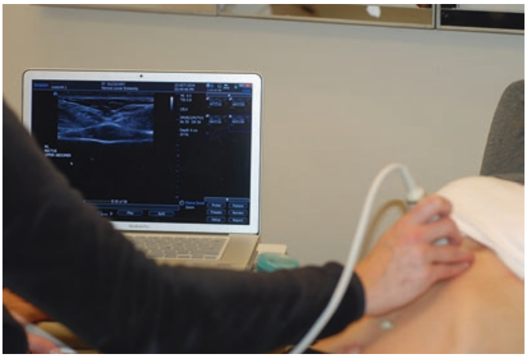

Fig. 6.22 Routine preoperative ultrasonic evaluation of the abdomen in a 57-year-old patient to rule out any fascial defects or other abnormalities before abdominoplasty

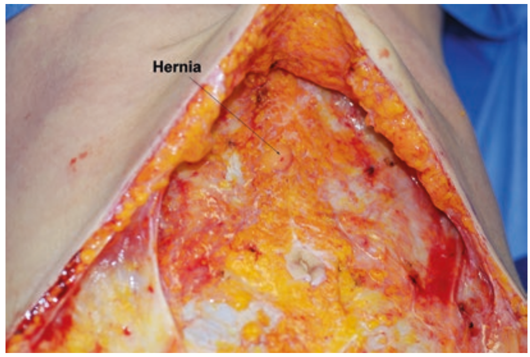

Fig. 6.24 Intraoperative photograph showing a small ventral hernia. This patient's preoperative photograph is shown in Fig. 6.23

Fig. 6.23 A 57-year-old woman who exercises daily presented with a midline swelling. She also had laparoscopic scars from a recent gynecologic procedure. She elected to have an abdominoplasty with repair of the hernia, which was evaluated preoperatively by ultrasound. An intraoperative photograph is shown in Fig. 6.24

such bleeding is rare. In the author's series of 167 consecutive abdominoplasties, there were no abdominal hematomas [11].

Adequate local anesthesia also reduces the need for central anesthesia during surgery, so that there is less medication to metabolize, expediting recovery. Failey et al. [27] report shorter hospitalizations for patients treated as inpatients with bupivacaine wetting solutions compared with saline.

Using 2 mg of epinephrine per liter doubles the conventional Klein concentration (1:1,000,000) [28]. Studies show that more concentrated epinephrine solutions are more effective in producing vasoconstriction [29, 30]. When infused before an abdominoplasty at a concentration of 1:526,000 (the slightly greater dilution is caused by the 50 cc volume of bupivacaine solution injected into the bag and 2 cc of 1:1000 epinephrine), the epinephrine greatly reduces blood loss [3], making electrodissection unnecessary [22].

Avoiding Hypothermia

Warmed fluids and blankets and a Bair Hugger (Arizant Inc., Eden Prairie, MN) are used to avoid hypothermia. The ambient room temperature is kept at about 75 °F, depending on the patient's temperature as monitored with a temperature strip on the forehead. Patient normothermia, not the comfort of the operating personnel, is the priority, especially when large body areas are exposed. Fluids used for the superwet infusion are placed in a warmer, taking care that they are not overheated.

Ambulatory Surgery

Although abdominoplasties have been traditionally done in a hospital setting with an overnight stay, today they are done more commonly in ambulatory surgery centers and accredited office surgical facilities. This change was made possible by advances in technique and anesthesia to reduce surgery times, limit blood loss, improve pain management, and shorten recovery times. Early ambulation is thought to reduce the risk of deep venous thromboses. Also, treatment in outpatient surgical settings helps contain costs and make the surgery more affordable and therefore more available.

The advantages of outpatient surgery are predicated on safe surgical practices. The surgeon must be well-trained and experienced to ensure that operating times and blood loss are not excessive. Combination procedures are often advantageous for patients. However, the surgeon must be proficient in the procedures done individually first. Any advantage from combining procedures is lost if the patient experiences excess morbidity.

> The advantages of outpatient surgery are predicated on safe surgical practices. The surgeon must be well-trained and experienced to ensure that operating times and blood loss are not excessive.

Recent studies have found lower complication rates among plastic surgery patients treated as outpatients rather than in a hospital [31, 32]. However, such comparisons are unfair because hospitalized patients may be selected because of an anticipated increased surgical risk [33].

One advantage of outpatient surgery may be (depending on the administration of the facility) greater freedom to implement quality improvements [33]. An example is total intravenous "SAFE" (spontaneous breathing, avoid gas, face up, extremities mobile) anesthesia [34]. Surgeons in academic practice may find this conversion impossible because their anesthesia providers use general endotracheal anesthesia [35]. Some of my academic colleagues inform me that ultrasound surveillance for deep venous thrombosis detection is simply not possible because their division or department would be unlikely to approve the expense. Many plastic surgeons find themselves forced to use hospital-mandated risk assessment models and order chemoprophylaxis [35]. Indeed, changing the status quo can be difficult in institutions—someone will always object. Academic medicine is not synonymous with evidence-based medicine [33].

Liposuction

In lipoabdominoplasty cases, liposuction of the abdomen and inner thighs (if treated) is performed first, followed by the abdominoplasty. Liposuction may be done while the epinephrine is starting to work and the bupivacaine is permeating the tissue, so that operating time is used efficiently.

The epigastrium and frequently the pubic area are treated with judicious liposuction, using radial strokes, ultrasound times <1 min, and typical suction volumes <150 cc. A single supra-umbilical incision is used to access the upper abdomen. The abdomen and inner thighs (if treated) undergo liposuction prior to the abdominoplasty (it is difficult to perform liposuction on the inner thighs with the patient flexed after abdominoplasty).

The author performs the abdominoplasty while the patient is supine, before turning from side to side to treat the flanks and extremities with liposuction. This is done to maximize sterility of the operating field during abdominoplasty.

After the abdominoplasty, the patient is turned from side to side to infuse the remaining areas to be treated (outer thighs, flanks, arms, axillae), taking care to keep the patient flexed at the hips so as not to stress the abdominal repair. The sequence is then followed by liposuction of the same areas. The areas treated with liposuction are infused with a solution of normal saline with 500 mg (0.05%)

lidocaine and 2 mg epinephrine (1:526,000), simply substituting lidocaine for bupivacaine [22].

The prone position is not used by the author. The Lysonix 3000 (Mentor Corp., Santa Barbara, CA) ultrasonic system and a superwet technique are often used. However, if buttock fat injection is being performed, ultrasonic assistance is not used so as to maximize the viability of the transferred adipocytes [36]. Most patients (61.5%) undergo simultaneous cosmetic procedures of the face or breasts [11].

The Incision

Historically, abdominoplasty incisions have been made in the shape of a W [37], in the shape of bicycle handlebars (Fig. 6.25), or as a gentle concave curve like a saucer. A gentle upward concave curve provides the least objectionable scar.

The abdominoplasty incision typically runs from hip to hip or, more precisely, from anterior superior iliac crest to anterior superior iliac crest. Patients are often concerned about the length of the scar before surgery but do not seem to mind after surgery if the scar is low and easily concealed. Among 141 surveyed abdominoplasty patients, surprisingly few (4.3%) were unhappy with their scars [1]. The author does not measure the horizontal length of the incision or any vertical midline distance. Except in the rare case of a revision of an existing midline scar, no vertical component is used.

> Patients are often concerned about the length of the scar before surgery but do not seem to mind after surgery if the scar is low and easily concealed.

A fleur-de-lis approach may be used to correct circumferential skin excess after massive weight loss [38]. The disadvantage of this approach of course is the midline scar and the added potential for wound healing problems. Fortunately, this method is unnecessary in patients who have not undergone extreme weight loss.

Patients readily understand that the incision needs to be long enough to allow removal of a wide apron of excess skin without postoperative puckering (dog ears) at the ends. A common surgical error is to place the incision too high, so that the scar is above the bikini line. Some patients who have had previous abdominoplasties complain about a high-riding scar that is difficult to conceal (Fig. 6.26).

A low incision is not difficult in a patient with a large apron of extra skin (Figs. 6.13 and 6.14). It is more difficult to keep the incision low in a thin patient with less loose skin or at the time of a secondary abdominoplasty (Fig. 6.26). Of course, these are the same patients that value a hidden scar. The difficulty in placing the incision low is that the upper resection margin is fixed at the level of the umbilicus if a vertical scar is to be avoided. The lower the incision is placed, the more skin is removed between this incision and the level of the umbilicus. Moving the upper flap down to meet the lower skin edge can be difficult unless the operating table can be adjusted to provide flexion at the hips by bending in the middle. The tighter the repair, the more the patient will be stooped over after surgery (Figs. 6.17 and 6.26).

The flap is elevated to the level of the costal margins, maintaining as much vascular supply to the flap as possible [11]. Scalpel dissection is used exclusively, preserving an areolar tissue layer and some fat on the abdominal wall (Fig. 6.27).

Some operators limit their table flexion to 30° [39]. Others will flex to 45° [40]. However, it is possible to flex much more, as much as 90° (Fig. 6.18), more “jackknife” than “beachchair.” This position does look peculiar in the operating room. Both the back and the lower extremities are angled up 45° from the horizontal. One might reasonably wonder how long it will take for the patient to resume a fully erect position after surgery. The mean time for fully erect standing is 3 weeks [1]. Patients know that they will be stooped over after surgery but find this temporary inconvenience a worthwhile trade for a low scar. Another advantage of maximum intraoperative flexion is that an unattractive vertical midline scar may be avoided in almost all cases.

Fig. 6.25 This 48-year-old woman was unhappy with her old abdominoplasty scar. The scar was revised to conceal it within her bikini. Her umbilical scar was revised simultaneously. She also underwent liposuction of the abdomen, flanks, and inner thighs. She is seen before (*left*) and 15 months after surgery (*right*)

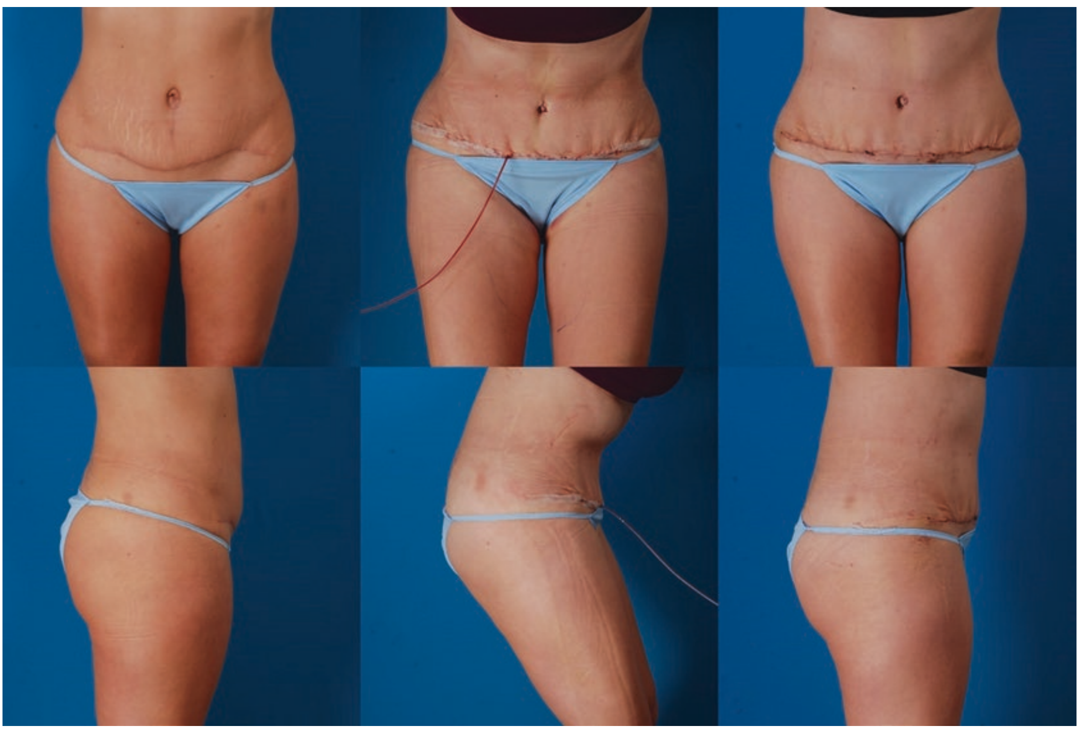

Fig. 6.26 Secondary abdominoplasty in a 35-year-old woman who was unhappy with the result of an abdominoplasty performed elsewhere 1 year previously. She is seen before (*left*), 1 day after (*center*), and 2 weeks after surgery (*right*). She also underwent ultrasonic liposuction of the abdomen, flanks, and inner thighs (volume: 800 cc). It was possible to remove the remaining skin and stretch marks and eliminate an existing vertical scar just below the umbilicus. Her new scar could be concealed within her panty line. The drain was removed 3 days after surgery. Although she was very stooped over the day after surgery (*below, center*), she was standing almost fully upright by 2 weeks (*below, right*)

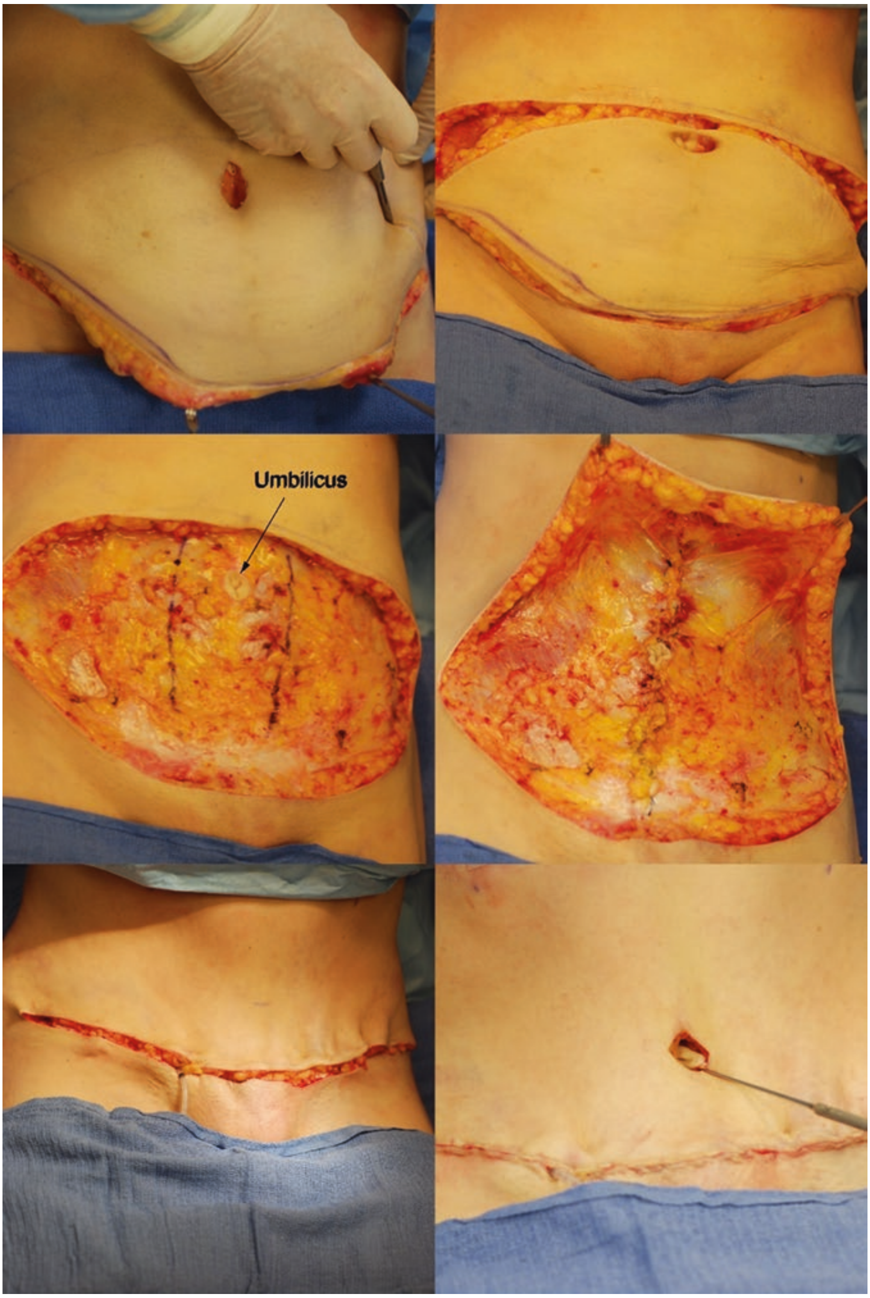

Fig. 6.27 Intraoperative photographs of a 40-year-old woman undergoing abdominoplasty. Liposuction of the abdomen and flanks has already been completed. (*Above, left*) A curved incision is made within the bikini line. (*Above, right*) The superior incision has been made. The resected tissue weighed 500 g. (*Center, left*) The medial borders of the rectus abdominis are marked. (*Center, right*) The superior flap is undermined only as far as necessary to allow wound closure. The diastasis has been repaired. (*Below, left*) Deep fascial closure has been completed, relieving skin tension. A single drain is used, exiting along the incision line. (*Below, right*). The umbilicus is brought out with a slight downward inclination. This patient also underwent bilateral augmentation/mastopexy and buttock fat injection [Reprinted from Swanson E. Prospective clinical study of 551 cases of liposuction and abdominoplasty performed individually and in combination. Plast Reconstr Surg Glob Open 2013;1:e32. With permission from Wolters Kluwer Health, Inc.]

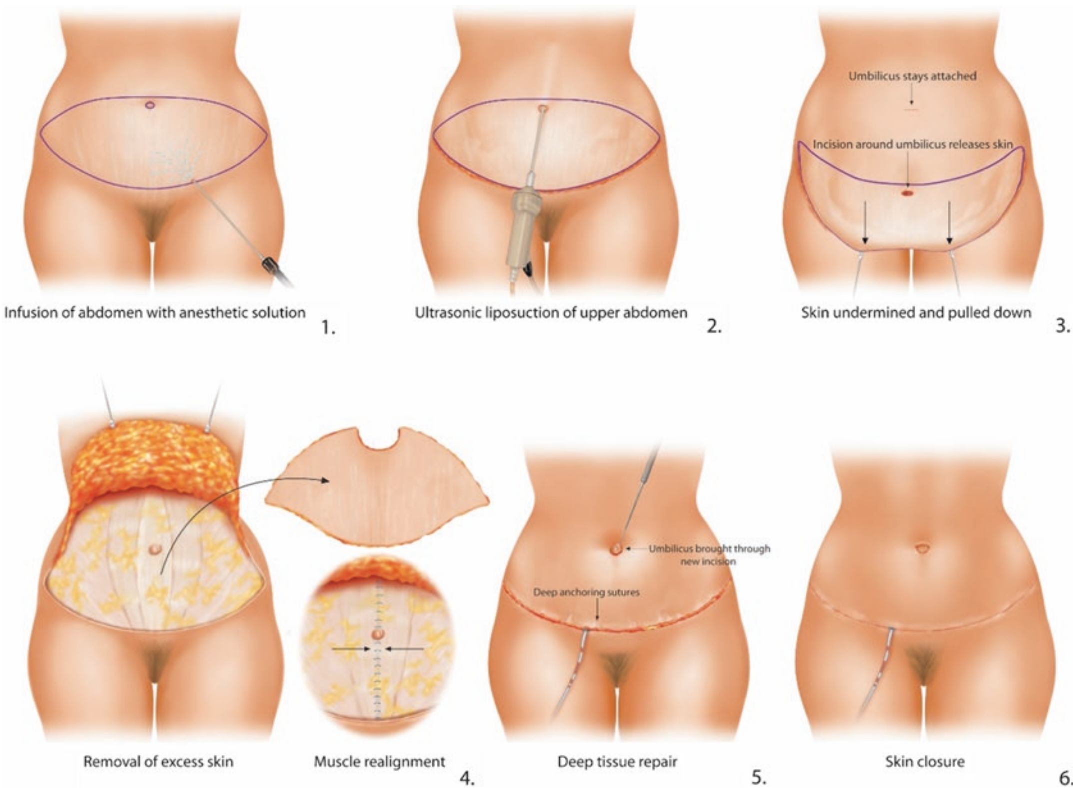

Fig. 6.28 Operative sequence for traditional abdominoplasty with liposuction. (1) Infusion of local anesthetic solution. (2) Ultrasonic liposuction of epigastrium (and frequently the mons pubis). (3) Skin undermining to costal margins. (4) Resection of lower abdominal skin and repair of rectus diastasis. (5) Deep anchoring sutures and umbilical repair. (6) Skin closure. Drain exits right pubic portion of the incision

> Patients know that they will be stooped over after surgery but find this temporary inconvenience a worthwhile trade for a low scar. Another advantage of maximum intraoperative flexion is that an unattractive vertical midline scar may be avoided in almost all cases.

Rectus Abdominus Plication

One of the most satisfying components of an abdominoplasty is the muscle repair. A survey found that almost all respondents repair a rectus diastasis [41]. Rectus abdominus fascial plication is performed using two layers of monofilament polypropylene sutures (0-Prolene, Ethicon Inc., Somerville, NJ) (Fig. 6.28).

Patients must recognize that the abdomen is not typically flat, even in lean, muscular individuals. However, the muscle repair can correct excess protuberance and leave a pleasing gentle convexity. I have a bronze statue in my office that I use to help make this point (Fig. 6.29).

Symptomatic Improvement

Theoretically, muscle realignment might be expected to improve the mechanical advantage of the abdominal muscles, alleviating back pain that is exacerbated by muscle and weight imbalance (Figs. 6.30, 6.31, 6.32, and 6.33). Bowel function might be improved. An outcome study confirmed these hypotheses. Patient surveys showed that 28% of patients reported a reduction in back pain after lipoab-

Fig. 6.29 This French bronze statue depicts ideal female proportions, including the slight convexity of the abdomen

dominoplasty or abdominoplasty and 19% reported an improvement in bowel function [1]. These changes may be underappreciated benefits of this surgery.

> Patient surveys showed that 28% of patients reported a reduction in back pain after lipoabdominoplasty or abdominoplasty and 19% reported an improvement in bowel function.

Deep Fascial Anchoring Sutures

The operating table is flexed to facilitate closure (Fig. 6.18). The wound is closed in three layers using absorbable, braided polyglactin sutures (2–0 Vicryl) to anchor the Scarpa fascia of the upper flap to the lower Scarpa fascia, with additional passes through the lower muscle fascia medially to anchor the flap and prevent upward migration, followed by deep dermal approximation (interrupted 3–0 Vicryl) and skin closure (running intradermal 4–0 Monocryl) under minimal tension. The umbilicus is transposed and brought through a midline transverse incision (Figs. 6.27 and 6.28). A single drain, exiting the right pubic portion of the abdominoplasty incision, is removed after 3 or 4 days.

Deep fascial fixation sutures are used to prevent the pubic tissue from being dragged up, bringing pubic hair up onto the abdomen. Anchoring sutures help to keep the incision low, avoid upward traction on the hair-bearing pubic skin, and avoid a vertical scar (Figs. 6.34 and 6.35).

> Anchoring sutures help to keep the incision low, avoid upward traction on the hair-bearing pubic skin, and avoid a vertical scar.

Deep fascial sutures also facilitate a slightly everted wound closure (Fig. 6.34), avoiding a contour depression, which might create a ledge just above the scar. These sutures also relieve skin tension. No effort is made to create a midline sulcus [40].

Videos of this procedure are available at the Plastic and Reconstructive Surgery Global Open website: http://journals.lww.com/prsgo/Pages/videogallery.aspx?videoId=1&autoPlay=true [42].

Mini-abdominoplasty

Patients often ask their surgeon whether a "mini-tummy tuck" might offer the best combination of results and minimal scarring [43]. Shestak et al. [44] describe a short scar variation in conjunction with liposuction, called "marriage abdominoplasty."

In a mini-abdominoplasty, the umbilicus stays attached to the surrounding abdominal skin, preventing any improvement in upper abdominal skin tone. The umbilicus may be transposed inferiorly, depending on the degree of skin tension

Fig. 6.30 This 32-year-old woman had a severe abdominal deformity after three pregnancies (*left*). Her back pain disappeared after an abdominoplasty. The flap weight was 2.75 lbs. Her posture is improved 3 months after surgery (*right*). Her lumbar lordosis is improved (*below, right*). The psychological benefit cannot be overstated (Fig. 6.31)

from below. A much smaller ellipse of skin is removed from the lower abdomen. The scar is typically shorter than a full abdominoplasty scar. It may be possible to repair a rectus diastasis of the lower abdomen, but it is more difficult to repair the muscle above the level of the umbilicus because the upper abdomen is not exposed.

A mini-abdominoplasty is best reserved for a woman who requests removal of a roll of skin just above the pubic area (Fig. 6.36) and often just above an old cesarean section scar (whether such a procedure really constitutes an "abdominoplasty" is open to question). The results tend not to be dramatic. If the patient is concerned about loose skin of the upper abdomen that appears when she bends forward, or a roll that borders the umbilicus, a full abdominoplasty is recommended instead. Patients often accept this recommendation once they are informed that the difference in scar length is inconsequential, and the scar will be kept low so that she can conceal it.

"Floating the Umbilicus"

The umbilicus may be detached and moved with the skip flap as it is redraped, so that there is no need for an incision around it and therefore no periumbilical scar. However, the transposed umbilicus may appear too low on the abdomen.

Fig. 6.31 This 32-year-old woman is seen 16 months after surgery. Her before-and-after photographs are provided in Fig. 6.30

Endoscopic Abdominoplasty

Endoscopy allows a muscle imbrication with a smaller incision [45]. This method never became popular, however, because there is usually excess skin and striae. Skin contraction is limited.

Long-Term Follow-Up

Figures 6.37, 6.38, and 6.39 demonstrate long-term follow-up 3.5 years, 5 years, and 9 years after abdominoplasty (Fig. 6.40).

Clinical Examples

Patient photographs are presented in Figs. 6.41, 6.42, 6.43, 6.44, 6.45, 6.46, 6.47, 6.48, 6.49, 6.50, 6.51, 6.52, and 6.53, youngest to oldest, women followed by men.

Male Abdominoplasty

Clinical examples are provided in Figs. 6.54 and 6.55.

Postoperative Care

In men, the garment is simply a Velcro binder. In women, who often are treated with liposuction of the thighs, a girdle is used that extends either above or below the knees. Gentle compression is recommended for 1 month, although it is not mandatory and alternatives may be worn such as spandex or pantyhose if the patient finds the garment uncomfortable. Care is taken to keep a layer of gauze between the skin and the drain while the garment is on to avoid an indentation and possible scar. The drain is removed in 3 or 4 days.

Patients are ambulatory immediately. All patients are seen in office the day after surgery. The dressing is removed. The patient has her 1-day postoperative Doppler ultrasound examination. She then starts bathing. Exercising is permitted 1 month after surgery, although abdominal "core" exercises are deferred until at least 2 months after surgery.

Swelling slowly resolves over a period of months. Patients are often surprised how long it takes and require reassurance that the firm lower abdominal area will soften eventually. Numbness of the lower abdomen is to be expected. It gradually improves but may never return completely to normal.

Patient-Reported Outcomes

Surveys were conducted among 360 body contouring patients, including 167 patients treated with abdominoplasty [1] to gather information regarding the recovery experience, patient satisfaction, and any effect on quality of life.

Not surprisingly, patients treated with abdominoplasty on its own or combined with liposuction reported higher pain scores than patients treated with liposuction alone. The mean pain rating on a scale of 1 (least) to 10 (most severe

Fig. 6.32 This 32-year-old woman is a full-blooded Seminole native American. She had two children. She is seen before (*left*) and 6 months after (*right*) abdominoplasty; liposuction of the lower body, arms, and axillae; and breast augmentation. Her abdominal deformity was so severe that she needed to lift up her tummy, so I could mark her before surgery. She reported that her lower back pain resolved after surgery. The flap weight was 8 lbs and the liposuction aspirate volume was 1400 cc. Close-up views of the umbilicus are shown in Fig. 6.33

pain) was 7.5 for abdominoplasty patients, with no significant difference in patients who also received liposuction. The mean pain score for liposuction-only patients was 6.1. The average time taking prescription painkillers was 9 days, corresponding to the time that patients resumed

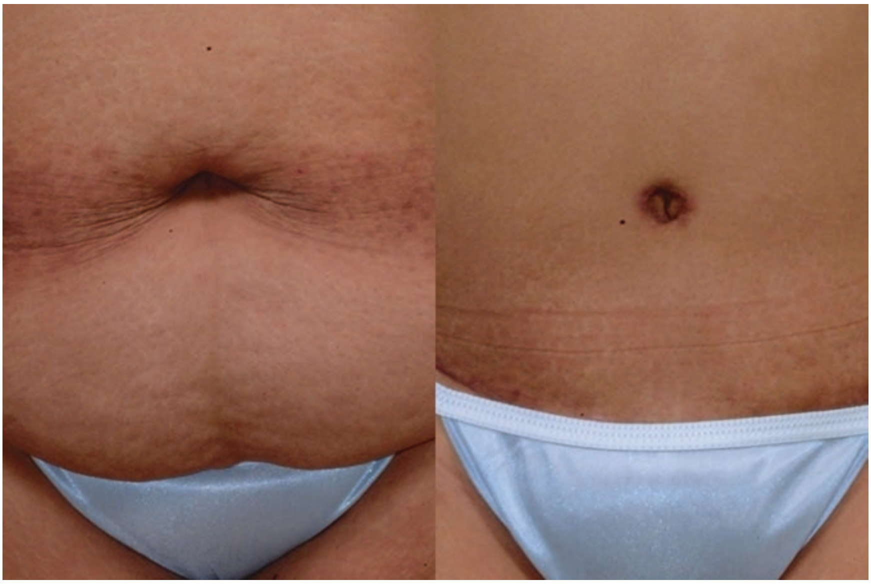

Fig. 6.33 Close-up views of the umbilicus before (*left*) and 6 months after surgery (*right*) of the patient in Fig. 6.32

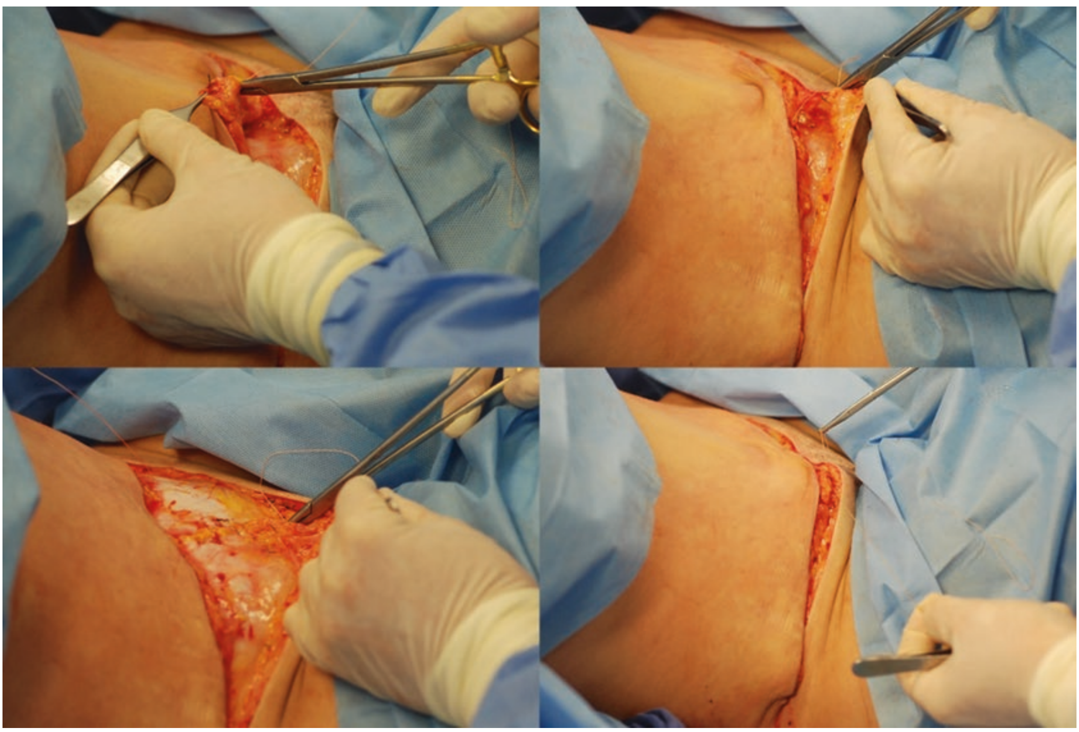

Fig. 6.34 Intraoperative photographs of a 34-year-old woman undergoing abdominoplasty. (*Above, left*) An inverted 2–0 Vicryl suture is anchored to the Scarpa fascia of the abdominoplasty flap. (*Above, right*) A second bite is taken in the Scarpa fascia of the lower flap. (*Below, left*) A third bite is taken in the muscle fascia. (*Below, right*) The deep fascial suture provides secure fixation and limits skin tension and upward migration. These steps are illustrated schematically in Fig. 6.35

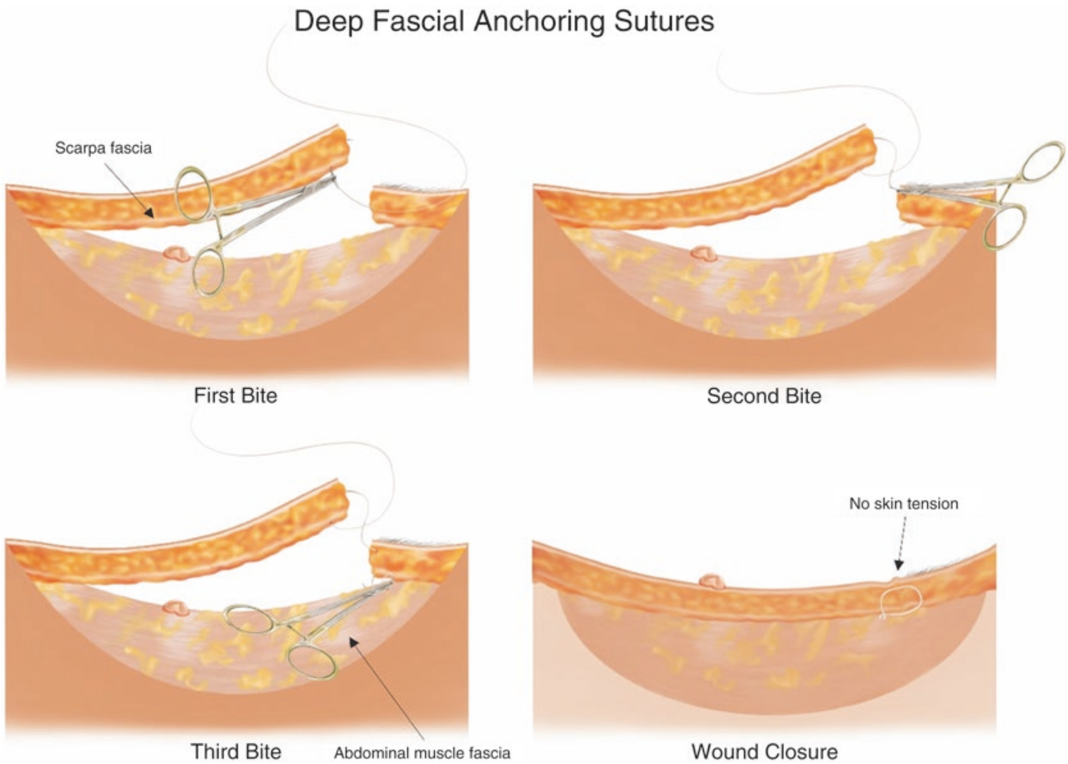

Fig. 6.35 A 2–0 Vicryl suture is used to provide deep fascial anchoring, starting with an inverted bite of the Scarpa fascia on the margin of the abdominoplasty flap (*above, left*), followed by a second bite in the corresponding Scarpa fascia of the pubic resection margin (*above, right*). A third bite of the abdominal muscle fascia (*below, left*) secures the flap to a dense connective tissue layer, alleviating skin tension and preventing upward skin migration (*below, right*)

Fig. 6.36 This 47-year-old woman wished to eliminate the skin excess of her lower abdomen. She was not concerned about skin laxity above her umbilicus. She is seen before (*left*) and 3.5 months after (*right*) a mini-abdominoplasty and ultrasonic liposuction of the abdomen, flanks, and inner thighs

Fig. 6.37 This 29-year-old woman is seen before (*left*), 3 months after (*center*), and 3.5 years after (*right*) an abdominoplasty; liposuction of the abdomen, flanks, and outer thighs; and buttock fat injection. There is no sign of upward scar migration 3.5 years after surgery on comparison of matched photographs. Flap weight: 2.4 lbs. Liposuction volume: 650 cc

driving, on average. The average time off work among surveyed patients was 16 days. The average time before patients resumed exercising was 45 days [1].

Patients often inquire as to how the pain from an abdominoplasty compares with either a hysterectomy or a cesarean section. Survey respondents were split between finding it more or less painful than a hysterectomy, but most found it worse than a cesarean section [1].

Result scores averaged 8.7 on a scale of 1 (worst) to 10 (best) for patients treated with abdominoplasty and 9.0 for patients treated with abdominoplasty with liposuction, significantly higher ($p < 0.001$) than for liposuction alone (7.8/10) [1].

Abdominoplasty met patient expectations in 98.6% of patients, significantly more often than liposuction alone (82.5%) [1]. Self-esteem was improved in 90.8% of patients, and 75.5% of patients reported an improvement in their quality of life. Almost all patients (97.1%) would repeat the surgery and recommend it to others (99.3%). Notably, 94.2% of abdominoplasty patients reported that they were more motivated to stay in shape after surgery [1].

Notably, 94.2% of abdominoplasty patients reported that they were more motivated to stay in shape after surgery.

Complications

Complication rates after abdominoplasty vary widely, from 0% to 43% [41, 46–59] depending largely on the investigator's definition of a complication. In the author's series of 551 consecutive patients, including 167 patients treated with

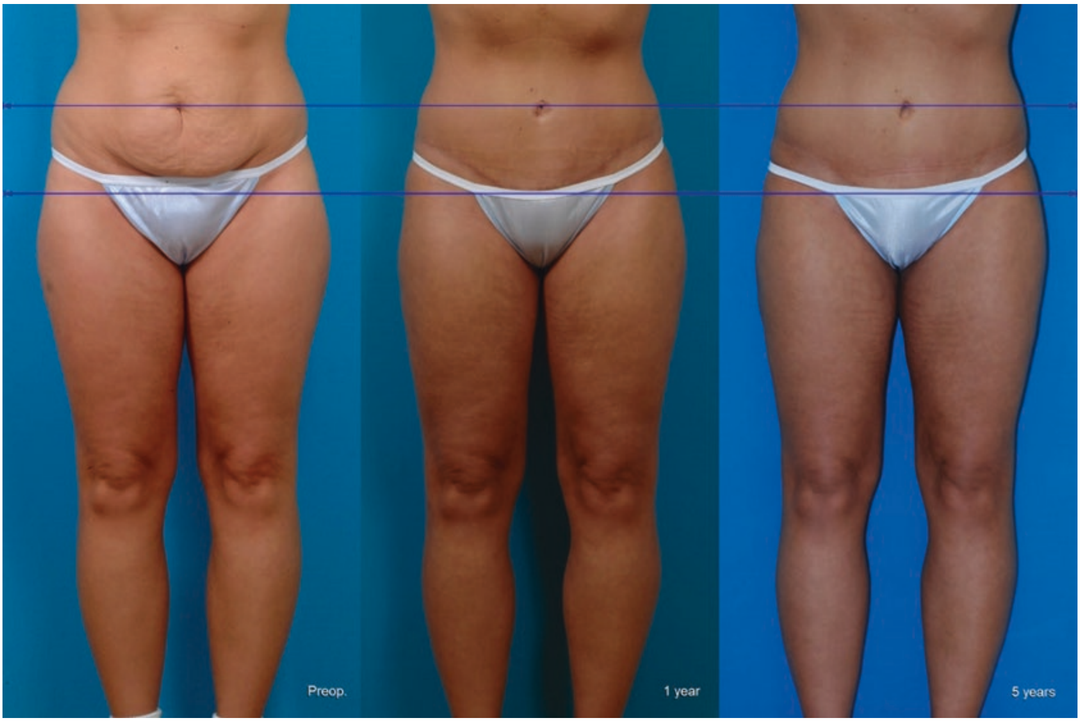

Fig. 6.38 This 28 year-old woman is seen before (*left*), 20 months after (*center*), and 5 years after (*right*) abdominoplasty; liposuction of the lower body including calves, arms, and axillae; and augmentation/mastopexy. Photographs are matched for size and orientation. This sequence of photographs shows the gradual improvement in appearance of the abdominoplasty scar. There is no tendency for the scar to migrate upward. Her weight before surgery was 132 lbs and after surgery 130 lbs. Flap weight: 2.25 lbs. Liposuction volume: 2550 cc [Reprinted from Swanson E. Prospective clinical study of 551 cases of liposuction and abdominoplasty performed individually and in combination. Plast Reconstr Surg Glob Open 2013;1:e32. With permission from Wolters Kluwer Health, Inc.]

abdominoplasty or abdominoplasty with liposuction, the overall complication rate was approximately 50% [11]. There were no deaths. Three patients were admitted to the hospital. One patient who developed a deep venous thrombosis after lipoabdominoplasty was hospitalized for anticoagulation. Another patient was hospitalized 3 weeks after surgery to treat a methicillin-resistant staphylococcal infection, likely contracted from her infected partner. This was also the only patient to receive a blood transfusion. A third patient was hospitalized overnight after surgery for suspected negative pressure pulmonary edema, possibly caused by laryngospasm.

Although a 50% complication rate is high, a wide net was used in assigning complications. Patients with minor spreading of the lateral aspect of their umbilical scar or a tiny dog ear at the end of the abdominoplasty scar were included. If such minor complications treated under local anesthesia in the office are excluded, the complication rate drops to approximately 25% [11].

The most common complication after abdominoplasty was an umbilical scar deformity (17.4%), treated with a scar revision under local anesthesia in the office. The author has a low threshold for performing touch-ups in the office, which are provided at no charge. Patients do not typically regard such minor issues as complications. The complication rate as reported by patients after abdominoplasty was 21% [1].

Fig. 6.39 This 42-year-old Hispanic woman is seen before (*left*), 5 months after surgery (*center*), and 9 years after abdominoplasty and liposuction of the lower body (*right*). The umbilicus has healed with a natural superior fold and oval shape (Fig. 6.40). Liposuction volume: 5375 cc

Fig. 6.40 Close-up views of the umbilicus of the patient in Fig. 6.39 before surgery (*left*), 5 months after surgery (*center*), and 9 years after surgery (*right*). The umbilicus has a desirable oval shape with a fold along the superior border

Deep Venous Thrombosis

There was one known clinical case of a deep venous thrombosis (Fig. 6.56) among 551 consecutive liposuction and/or abdominoplasty patients in the author's series [11], for an incidence of 0.6% among abdominoplasty patients.

Infection

The 10.8% infection rate in the author's series [11] includes any patients with redness, indicating possible cellulitis (Fig. 6.57), who were treated with antibiotics as a precaution.

Fever and chills are important early signs of infection and all patients are instructed to report them immediately. Any abscess must be opened, the fluid sent for culture (aerobic and anaerobic and sensitivities), and the wound irrigated with an antibiotic solution such as povidone-iodine. A broad-spectrum antibiotic effective against *Staphylococcus* (e.g., sulfa-trimethoprim or amoxicillin/clavulanate) and an antibiotic effective against anaerobes (e.g., clindamycin) may be prescribed until sensitivities are available.

Seromas

Most investigators report clinical seromas that require treatment. Having ultrasound available in the office increases detection. In the author's (pre-ultrasound) series of 551 consecutive patients, 9 clinical seromas developed after abdominoplasties (5.4%). The mean number of aspirations was 5, with a range of 1–12. The mean time of the last aspiration was 28 days after surgery (range, 15–43 days). The mean aspirate volume was 74 cc (range, 3–240 cc) [11].

A seroma rate of 5.4% compares favorably to most published series (range, 3.5–32%) [39, 46, 51–54, 57, 59–66]. In all cases, this problem was successfully treated with needle aspirations in the office, without a need for reoperation. In several patients this amounted to a nuisance (one patient

Fig. 6.41 This 32-year-old woman is seen before (*left*) and 4.5 months after (*right*) abdominoplasty and liposuction of the lower body. Flap weight: 2 lbs. Liposuction volume: 1725 cc

Fig. 6.42 This 36-year-old woman is seen before (*left*) and 3 months after abdominoplasty and liposuction of the abdomen and flanks (*right*). Flap weight: 3.8 lbs. Liposuction volume: 600 cc

Fig. 6.43 This 37-year-old woman is seen before (*left*) and 1 year after (*right*) abdominoplasty and liposuction of the abdomen, flanks, arms, and axillae. Flap weight: 5 lbs. Liposuction volume: 1500 cc

had a single aspiration of 3 cc), not necessarily rising to the level of a complication as perceived by patients [11].

Limitations of Meta-Analyses of Seroma Rates

Three recently published meta-analyses, each claiming to be first, compare seroma rates after abdominoplasty [67–69]. Two studies find in favor of quilting sutures [67, 69], and both studies evaluating Scarpa fascia preservation find it beneficial [67, 68]. An earlier meta-analysis of tissue adhesives (surprisingly) found no significant reduction in seroma rates [70].

The conclusions of three meta-analyses would seem to be compelling evidence in favor of quilting sutures and Scarpa fascia preservation. Meta-analyses are usually regarded as a very high level of evidence. However, this is only true when the analyses include high-quality data [16]. Systematic reviews are notoriously difficult in plastic surgery because of confounding variables—the surgeon, method, body mass index, tissue resection weight, liposuction, diagnostic method (e.g., clinical or ultrasound), compression garments, drains, and tissue adhesives. Publication bias is a problem [67].

Fig. 6.44 This 39-year-old woman had an abdominoplasty elsewhere 8 years previously. The absence of a scar around the umbilicus suggests this was a mini-abdominoplasty. She had a "double-bubble" deformity of the lower abdomen and pubic area. She is seen before (*left*) and 6 weeks after (*right*) an abdominoplasty; liposuction of the lower body, including the pubic area and axillae; buttock fat transfer; and augmentation/mastopexy. Flap weight: 2 lbs. Liposuction volume: 1845 cc

> Systematic reviews are notoriously difficult in plastic surgery because of confounding variables.

Seretis et al. [68] believe that a meta-analysis can overcome the methodological flaws of retrospective studies or case series. Unfortunately, no amount of statistical rigor can compensate for flaws in the constituent studies [71]. Nasr et al. [70] acknowledge the heterogeneity of data and risk of bias. Despite limiting their analysis to randomized trials, these investigators found inadequate study quality [70].

The Myth of Scarpa Fascia Preservation

Leaving a thin layer of areolar tissue on the abdominal wall is a traditional method used by most plastic surgeons [4, 49, 61, 72]; it is not the same as Scarpa fascia preservation, which typically leaves a thick layer of tissue (depending on patient weight of course) on the abdominal wall that includes the Scarpa fascia and subscarpal fat (Figs. 6.5 and 6.9) [6, 11]. Importantly, both meta-analyses evaluating Scarpa fascia preservation [67, 68] included a Level 1 study by Costa-Ferreira et al. [73]. Ordinarily one might consider the findings of such a high-level study almost irrefutable. However, a confounder undermined the conclusion [16]. In the group treated with Scarpa fascia preservation, an avulsion technique was used [73]. Flap elevation in the control group was performed using electrodissection.

Ardehali and Fiorentino [67] speculate that a dissection plane superficial to the Scarpa fascia may preserve vascular and lymphatic structures. Recent anatomic studies have shed some light on this question. Friedman et al. [74] found that most lymphatic vessels are located superficially; only 9.4% of the lymphatic vessels were contained within the Scarpa fascia. Tourani et al. [75], in their cadaveric study, concluded that Scarpa fascia preservation would not preserve the lower abdominal lymphatic collectors.

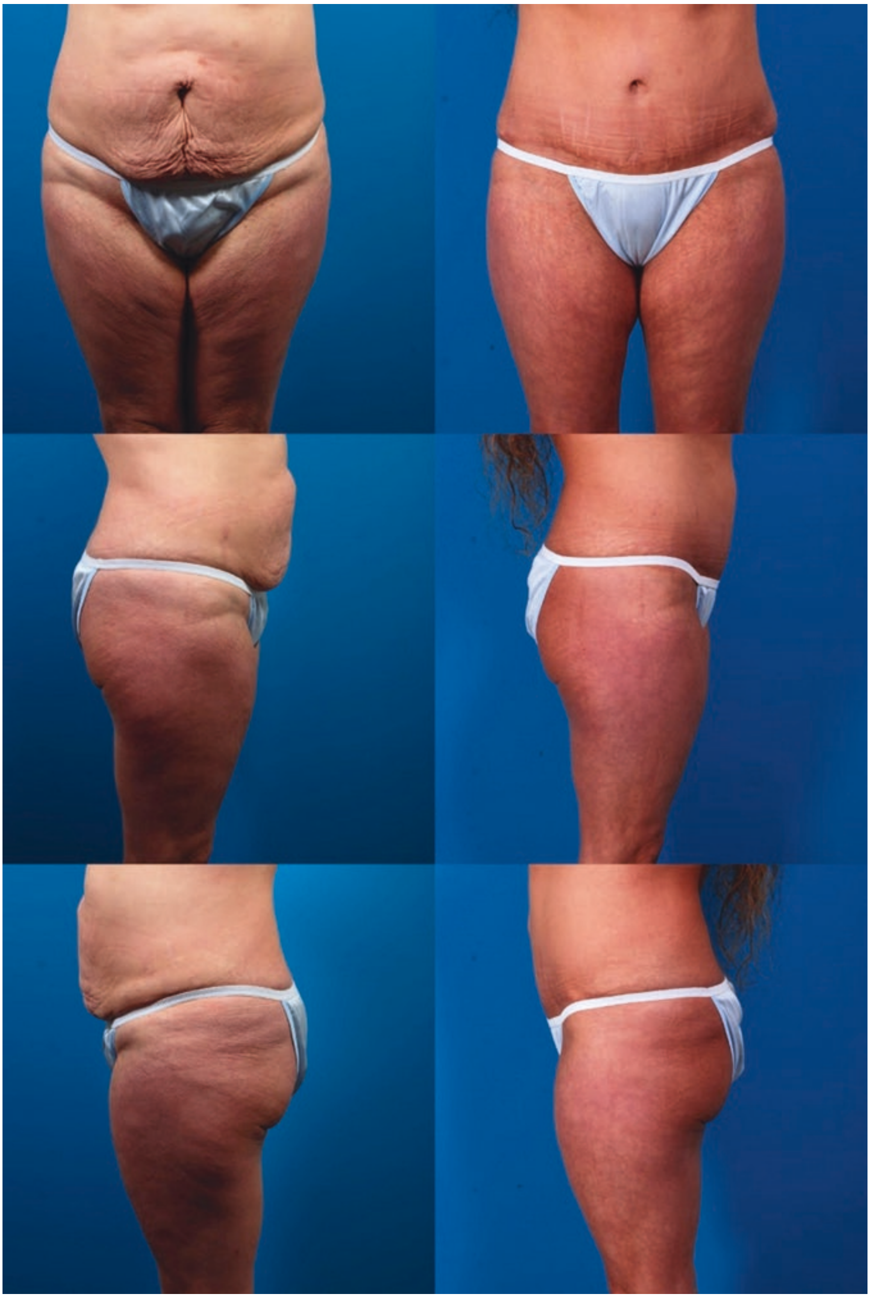

Fig. 6.45 This woman had a mommy makeover—abdominoplasty, liposuction of the abdomen, and augmentation/mastopexy. She is seen before (*left*) and 10 months after surgery (*right*). Flap weight: 2.5 lbs. Liposuction volume: 450 cc

Tourani et al., in their cadaveric study, concluded that Scarpa fascia preservation would not preserve the lower abdominal lymphatic collectors.

Scarpa fascia preservation does have a downside; the abdomen is not quite as flat because of the preserved fatty tissue (Figs. 6.5 and 6.9) [6, 11]. The abdominal wall thickness increases as the superior abdominoplasty flap is transposed over the lower abdomen, stacking the two fascial

Fig. 6.46 This 39-year-old woman is seen before (*left*) and 3 months after an abdominoplasty; liposuction of the abdomen, flanks, inner thighs, arms, and axillae; and augmentation/mastopexy (*right*). Flap weight: 3 lbs. Liposuction volume: 1125 cc

layers [11]. The scar may end up too high, with upward migration of the hair-bearing pubic skin (Fig. 6.12). Saldanha et al. [3] used open liposuction in an effort to reduce the bulk created by the preserved tissue layer. The quality of the wound closure may be compromised. Costa-Ferreira et al. [73] report a trend toward more wound healing problems among patients treated with Scarpa fascia preservation. Some proponents of lipoabdominoplasty recommend discarding the lower abdominal Scarpa fascia [76].

> Scarpa fascia preservation does have a downside: the abdomen is not quite as flat.

Fig. 6.47 This 45-year-old woman with three children, including a set of twins, is seen before (*left*) and 15 months after (*right*) abdominoplasty and liposuction of the lower body (no knees), arms, and axillae. Flap weight: 2.5 lbs. Liposuction volume: 1400 cc

Costa-Ferreira et al. [77] insist there is no aesthetic compromise in preserving the Scarpa fascia but did not provide before-and-after photographs [73, 77]. Abdominoplasty is an aesthetic procedure. Even if there were a benefit in preserving the Scarpa fascia to reduce the seroma risk, that advantage must be weighed against a long-term aesthetic compromise.

Fig. 6.48 This 46-year-old woman is seen before (*left*) and 1 year after an abdominoplasty; liposuction of the lower body, arms, and axillae; and augmentation/mastopexy (*right*). Flap weight: 7.25 lbs. Liposuction volume: 1970 cc

Disadvantages of Quilting Sutures

Quilting sutures have been recommended to reduce seromas [40, 78–81]. Quilting sutures are also called progressive tension sutures [78, 80], although there is no information available regarding tension measurements or their progression. "Quilting" would seem more descriptive, in that their placement is in a pattern much like a quilt, and the sutures can produce dimpling [69].

Fig. 6.49 This 48-year-old woman is seen before (*left*) and 8 months after (*right*) abdominoplasty and liposuction of the abdomen and flanks. Flap weight: 2.5 lbs. Liposuction volume: 1000 cc

Quilting sutures add about 23 min of operating time [69]. Seromas may still develop. Among patients treated with quilting sutures, the overall seroma rate reported in Ardehali and Fiorentino's meta-analysis was 5.8% (15/260) [67], similar to the rate associated with scalpel dissection and no quilting sutures (5.4%) [11].

Quilting sutures may be technically difficult to perform if the patient is placed in a jackknife position during surgery so as to maximize flap

Fig. 6.50 This 49-year-old woman is shown before (*left*) and 3 months after abdominoplasty and liposuction of the abdomen and flanks (*right*). After surgery, she wore a bikini for the first time. Flap weight: 3.5 lbs. Liposuction volume: 750 cc

mobility and keep the scar within the panty line [11]. Any cosmetic value is questionable. Care must be taken not to ligate the lateral femoral cutaneous nerve with a quilting suture [82].

Quilting sutures add about 23 min of operating time and may be difficult to perform with the patient in a jackknife position.

Fig. 6.51 This 54-year-old woman is seen before (*left*) and 13 months after an abdominoplasty and liposuction of the lower body, arms, and axillae (*right*). Flap weight 2.5 lbs. Liposuction volume: 2950 cc

There is no evidence that the nature of the healing surfaces (fat or fascia) [73] is relevant to seroma formation. Patient movement and shearing movement of tissue layers are thought to influence seroma development [40], but data are lacking. Patient immobilization or restrictive gar-

Fig. 6.52 This 63-year-old woman is shown before (*left*) and 3 months after abdominoplasty and liposuction of the lower body (*right*). Flap weight: 6 lbs. Liposuction volume: 2950 cc. Close-up photographs of her umbilicus are provided in Fig. 6.53 [Reprinted from Swanson E. Prospective clinical study of 551 cases of liposuction and abdominoplasty performed individually and in combination. Plast Reconstr Surg Glob Open 2013;1:e32. With permission from Wolters Kluwer Health, Inc.]

ments may cause more harm than good. It is important to remember that the morbidity from seromas is likely to be minimal. Only four of the nine patients who developed a seroma reported it as a complication on their surveys [1], suggesting the problem did not have a major impact on their recovery and result.

Scalpel Dissection Versus Electrodissection

Only one meta-analysis compares dissection methods—scalpel versus electrodissection [68]—but omitted a large comparative study of abdomino-

Fig. 6.53 Close-up of the umbilicus of patient in Fig. 6.52, before (*left*) and 3 months after surgery (*right*)

plasties by Rousseau et al. [83]. In their comparison of 327 patients treated with scalpel dissection versus 320 patients treated with electrodissection, Rousseau et al. [83] report significantly more seromas after electrodissection. Similarly, Valença-Filipe et al. [84] report no seromas in 39 scalpel dissections versus 15 seromas in 80 abdominoplasty patients (18.8%) treated with electrodissection. Both studies document a significant reduction in drain output and time to drain removal after scalpel dissection [83, 84]. The meta-data yield a significant seroma risk reduction using scalpel dissection ($p < 0.01$) [85].

The meta-data yield a significant seroma risk reduction using scalpel dissection.

Electrodissection was introduced decades ago to reduce bleeding, before wetting solutions were in use. Dissecting with electrical current has become commonplace in operating rooms. Operating personnel have become accustomed to the smell of smoke. Of course this smoke represents hydrocarbons from burnt tissues, signaling tissue injury. Perhaps surgeons would be more concerned if there were visible signs of the tissue injury that is occurring at a cellular level.

The use of Bovie dissection has long been implicated as a possible cause of increased tissue necrosis and seromas [49, 72]. Electrodissection causes more tissue destruction and seroma formation than scalpel dissection [86]. Isaac et al. [40], in describing a drainless abdominoplasty technique, recommend a wetting solution to act as a heat sink and reduce thermal injury. Of course, eliminating the cause (electrodissection) is likely to be even more effective [87].

Seroma fluid resembles an inflammatory exudate [88], as opposed to a transudate from lymphatic obstruction. Total protein, lactate dehydrogenase, cholesterol levels, and neutrophil percentage are higher in seromas than in lymphatic fluid [88]. Seromas are more frequent in mastectomy patients treated with electrocautery than with scalpel dissection; and the seroma fluid contains significantly higher levels of the proinflammatory cytokines tumor necrosis factor-α and interleukin-6 (all p values <0.01), signaling greater tissue damage and inflammatory response [89]. Lejour attributed her lack of seromas to scalpel dissection [90].

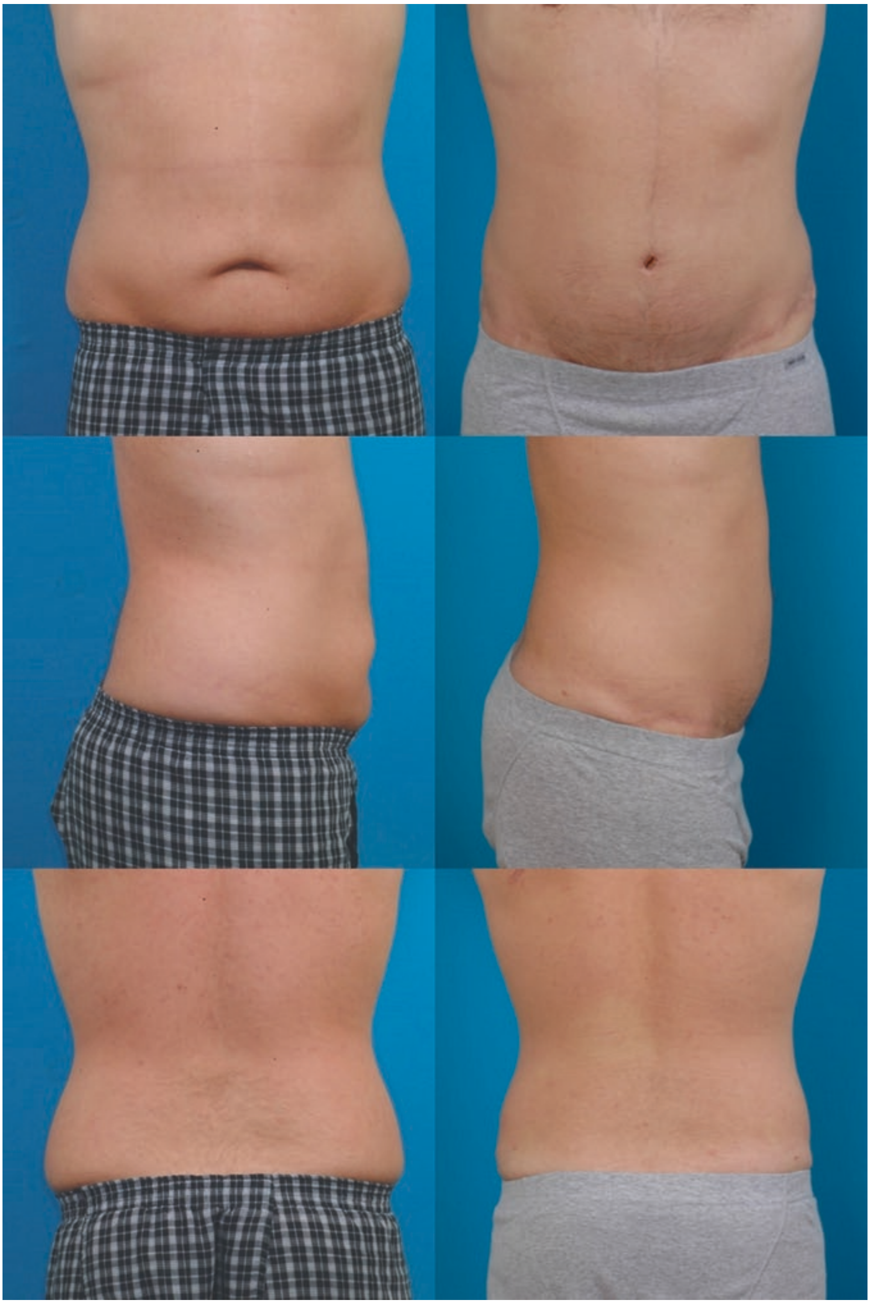

Fig. 6.54 This 20-year-old male had lost 70 lbs. He is seen before (*left*) and 2 years after (*right*) an abdominoplasty and liposuction of the abdomen, flanks, inner thighs, and axillae. Flap weight: 4 lbs. Liposuction volume: 1200 cc

Seroma fluid resembles an inflammatory exudate, as opposed to a transudate from lymphatic obstruction.

Saldanha et al. reported a seroma rate of 60% before adopting a limited dissection and Scarpa fascia preservation. Subsequently, their seroma rate dropped to <1% [3]. The authors believe that improved vascularity is responsi-

Fig. 6.55 This 49-year-old male had previous liposuction after losing about 30 lbs. His skin tone was poor. He is seen before (*left*) and 5 months after an abdominoplasty and touchup liposuction of the abdomen and flanks (*right*). Flap weight: 4 lbs. Liposuction volume: 550 cc

Fig. 6.56 This 39-year-old woman is seen before (*left*), 2 weeks after an abdominoplasty and liposuction of her lower body (*center*), and 3.5 months after surgery (*right*). She developed swelling of the left lower extremity 9 days after surgery. A Doppler ultrasound scan revealed a thrombosis extending from the left popliteal vein to the common femoral vein. She did not develop pulmonary emboli. She was hospitalized and treated with intravenous heparin, followed by oral warfarin. She made a full recovery. She had no risk factors for a deep venous thrombosis other than a 3-hour operation (Caprini score 3). Her ultrasound scans are provided in Chap. 13

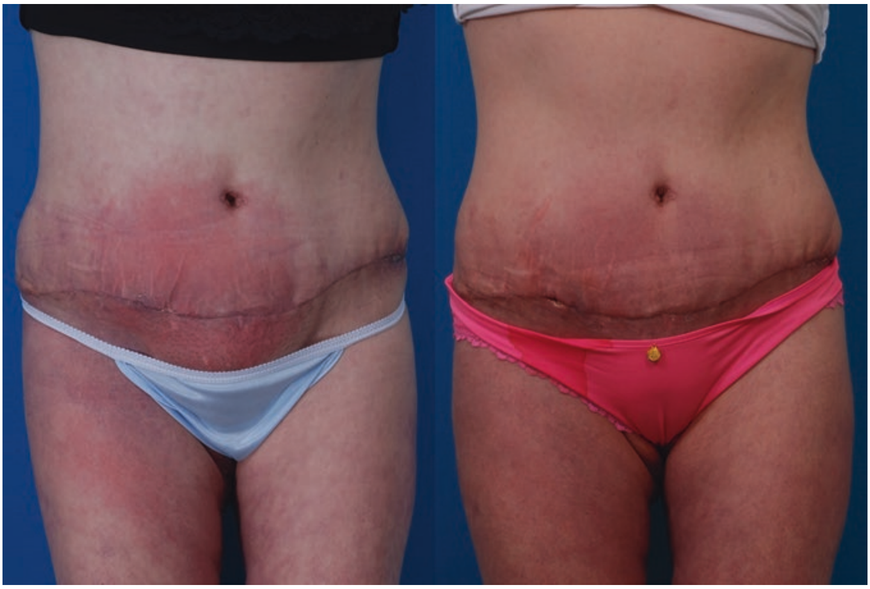

Fig. 6.57 This 39-year-old patient developed a large area of redness 1 month after surgery (*left*). She was afebrile. There was no drainage and an ultrasound examination detected no fluid collection. The cellulitis responded to oral antibiotics in the form of clindamycin 300 mg. p.o. qid and Septra DS bid. She is seen 5 days later in the office (*right*). Additional photographs of this patient are shown in Fig. 6.17

ble for the improvement [3]. This theory is not supported by perfusion studies [6, 8]. A reduced seroma rate may be related to less electrodissection and therefore less tissue injury, rather than preservation of perforators and the Scarpa fascia [6, 71].

A hemostatic alternative is available. A superwet infusion containing 1:500,000 epinephrine causes potent vasoconstriction, reducing blood loss from abdominoplasty to an average of 290 cc when the procedure is combined with liposuction [22]. Electrodissection is no longer necessary to control blood loss. There is no need for quilting sutures.

> Electrodissection is no longer necessary to control blood loss. There is no need for quilting sutures.

The author uses a scalpel exclusively for tissue dissection (Fig. 6.7) and a pinch-activated monopolar cautery forceps (Snowden-Pencer, now CareFusion Corp., San Diego, CA) for individual vessels. This technique is facilitated by a wetting solution that is given sufficient time to provide its hemostatic effect (20 min) [22]. Doubling the concentration of epinephrine (1:526,000) makes vasoconstriction more effective without increasing the risk of skin loss or toxicity [22].

> Doubling the concentration of epinephrine (1:526,000) makes vasoconstriction more effective without increasing the risk of skin loss or toxicity.

Simultaneous Liposuction

Some investigators report an increased risk of seromas in patients treated with simultaneous liposuction [55, 59]; others find no increased risk [54, 91]. Today, most surgeons recognize the importance of treating the flanks with liposuction to eliminate the unattractive “muffin top” deformity [11]. If the epigastrium is not treated with liposuction at the time of abdominoplasty, many patients will complain of persistent fullness of the upper abdomen, which may appear even fuller in contrast to the reduced lower abdomen [11]. Simultaneous liposuction of the flanks and epigastrium optimizes the surgical benefit and reduces the risk of patient disappointment and the need for subsequent surgery. Limiting epigastric ultrasound (<1 min) and liposuction times minimizes risk [11].

> Today, most surgeons recognize the importance of treating the flanks with liposuction to eliminate the unattractive "muffin top" deformity.

Postoperative Nausea

Only 3% of patients reported nausea in the recovery room, compared with 35% in plastic surgery in general [92]. No patient vomited in the recovery room. No patient required a postoperative hospital admission for treatment of nausea or dehydration.

Nausea is a major cause of patient dissatisfaction after surgery [51, 93] and is the most frequent cause of delayed discharge [49] and unplanned hospital admissions [51]. Avoiding an inhalational agent reduces the risk of nausea and vomiting [22], which is particularly important after abdominoplasty to avoid disrupting the muscle diastasis repair. Reducing the use of narcotics and benzodiazepines also reduces nausea and shortens recovery time. In the author's study [11], the mean length of stay in the recovery room was 50.7 min (range, 20–159 min), much shorter than reported stays for patients treated with conscious sedation using midazolam and fentanyl (mean 235 min; range, 95–520 min) [49]. An improved balance of greater anesthesia at the tissue level and less anesthesia systemically improves patient comfort, expedites recovery, and reduces troublesome side effects from systemic analgesics [22]. This topic is discussed in detail in Chap. 5.

> Avoiding an inhalational agent reduces the risk of nausea and vomiting, which is particularly important after abdominoplasty to avoid disrupting the muscle diastasis repair.

Smoking and Skin Loss

In the author's series [11], there were significantly ($p < 0.01$) more cases of delayed wound healing in smokers (6.2%) than in nonsmokers (1.5%). Smokers are informed regarding the increased risk of skin necrosis caused by nicotine. Patients are advised to cease smoking for 2 weeks before and 2 weeks after surgery. Of course longer periods of abstinence are preferred, but patients need a realistic goal. The author does not test patients for cotinine levels. My practice is to show patients the photographs in Fig. 6.58 to illustrate what is meant by skin necrosis and delayed healing. Patients may benefit later from scar revisions if necessary.

> There were significantly ($p < 0.01$) more cases of delayed wound healing in smokers (6.2%) than in nonsmokers (1.5%).

Patients with old abdominal scars (Figs. 6.59 and 6.60) also present additional risk. In patients with old oblique scars of the upper abdomen, care must be taken not to undermine beyond the scar, although this precaution may not be enough to prevent skin loss (Fig. 6.59).

Hematoma

Notably, there were no hematomas in the author's series of 167 consecutive abdominoplasties, suggesting that rebound bleeding after vasoconstriction is not a clinical problem, even when using a 1:500,000 epinephrine concentration [11]. The avoidance of chemoprophylaxis may also reduce the bleeding risk [34].

Fig. 6.58 Abdominoplasty and ultrasonic liposuction of lower body. This 50-year-old smoker did not follow advice to stop smoking. She is seen before (*left*), 2 weeks after (*center*), and 3 months after surgery (*right*). Once she stopped smoking, the wound healed quickly and was completely healed 2 months after surgery. She had increased scar tissue along the midportion of the scar

Scar Deformities

The patient in Fig. 6.61 demonstrates scar deformities after an abdominoplasty. Such problems are often amenable to correction. Although it is common for surgeons to place stab incisions in the mons pubis, new scars are created that may hypertrophy (Fig. 6.62). Exiting the drain through the existing abdominoplasty wound avoids a separate scar.

Sensory Neuropathies

Sensory neuropathies after abdominoplasty may be underreported. In their systematic review, Ducic et al. [94] found that the lateral femoral cutaneous (1.36%) and iliohypogastric nerves (0.10%) are most commonly affected. Although the incidence is low, neuropathies may be permanent. The authors documented other neuropathies involving the brachial plexus, musculocutaneous nerve, sciatic nerve, and common peroneal nerve related to patient positioning in surgery (overall incidence, 0.49%) [94]. Some cases are related to quilting sutures, and these paresthesias immediately respond to suture release [82]. Any deep fascial sutures in the inguinal areas—anterior and inferior to the anterior superior iliac spine—should be avoided. The traditional practice of leaving an areolar layer of loose connective tissue on the abdominal wall is recommended [94].

Correlations

In the author's clinical study, no significant correlations were detected between the overall incidence of complications and patient age, smoking history, or body mass index. Men had fewer complications than women overall, but this finding was related to the fact that fewer men underwent

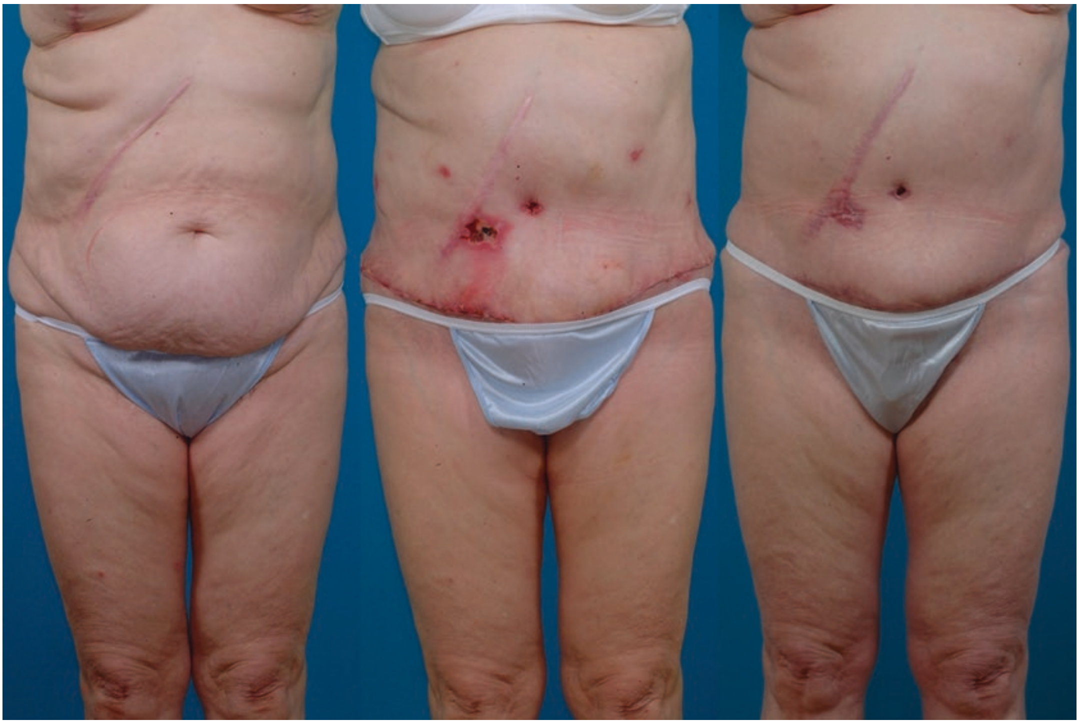

Fig. 6.59 This 63-year-old nonsmoker is seen before (*left*), 2 weeks after (*center*), and 3 months after (*right*) an abdominoplasty and liposuction of the abdomen, flanks, and inner thighs. She had an old cholecystectomy scar. Prior to surgery, we discussed the fact that this scar would compromise circulation to the abdominal skin and possibly cause some skin loss, which is exactly what happened, despite no undermining superior to the scar. The wound healed in gradually on its own. The patient was pleased nevertheless and declined a scar revision offered at no charge

Fig. 6.60 This 57-year-old smoker is seen before (*left*) and 2 weeks after an abdominoplasty and liposuction of the abdomen and flanks (*right*). She had an oblique scar in the left upper quadrant from an old nephrectomy. Despite having two risk factors, smoking and an old scar, she healed without complications

Fig. 6.61 This 34-year-old woman is seen before (*left*) and 5 weeks after (*right*) revision of a previous abdominoplasty scar from surgery performed elsewhere. She also underwent liposuction of the abdomen, flanks, and inner thighs. The original abdominoplasty scar was located slightly above her bikini line and had widened. There was a contour depression associated with it. Deep fascial anchoring sutures were used to secure the abdominoplasty flap and avoid superior displacement of the mons pubis. A deep tissue repair corrected the contour deformity. Liposuction corrected her muffin top deformity and tapered her inner thighs. The umbilicus was lowered slightly

Fig. 6.62 This 36-year-old woman developed keloids at two drain sites on her mons pubis after an abdominoplasty performed elsewhere (*left*). Fortunately, there was no sign of recurrence 4.5 months after revision (*right*). Surprisingly, the other areas of scar hypertrophy, affecting her abdominoplasty scar and umbilicus, were not a concern for her

an abdominoplasty. There were significantly ($p < 0.01$) more cases of delayed wound healing in smokers (6.2%) than nonsmokers (1.5%).

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Thigh Lift and Surgery After Massive Weight Loss

7

Abstract

Thigh lifts have become much more popular recently because of the large number of patients who lose weight by dieting or after bariatric surgery. In men, the abdomen and inner thighs are affected. Skin redundancy in women also affects the buttocks, outer thighs, arms, and scapular areas.

Surgery to treat these deformities has been fraught with wound healing complications, as high as 50%. Fortunately the results tend to be quite dramatic, and patient satisfaction is typically high in patients who understand and accept the scarring.

A major change in recent years is in the performance of medial thigh lifts. Traditionally an incision has been made in the groin crease. This scar tends to migrate and cause tension on the perineum. A vertical thighplasty is much more effective in correcting circumferential skin laxity and avoids perineal traction. Wound healing problems tend to occur at a T-point if a combined horizontal and vertical resection is used. The author prefers a J-shaped incision, which reduces the risk of wound dehiscence. Revisions may be needed proximally in patients who have severe skin laxity. Framing the mons pubis with scars is best avoided.

The outer thigh lift/buttock lift may be done on its own or combined with an abdominoplasty to provide a lower body lift. The incision is kept high so as to preserve the gluteal aesthetic unit. A near-circumferential incision avoids healing problems in the midline of the lower back.

Thigh lifts may be done on an outpatient basis provided that the surgeon understands how to limit blood loss, avoid hypothermia, and administer a safe anesthetic that allows a quick patient recovery. Prolonged operating times are avoided. It is much better to stage surgery than to risk excessive blood loss and patient morbidity. Blood transfusions should rarely be necessary.

Prolonged operating times are avoided. It is much better to stage surgery than to risk excessive blood loss and patient morbidity.

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Introduction

Overweight women tend to accumulate large deposits of fat in the lower abdomen, flanks, and thighs, producing a gynecoid or "pear-shaped" appearance. In men, fatty excess preferentially affects the abdomen, flanks, and inner thighs. Gravity, weight loss and gain, and loss of elasticity produce skin redundancy. In women, the abdomen, flanks, buttocks, and thighs are all affected by ptosis and cellulite. In men, the buttocks and outer and posterior thighs are affected to a lesser degree. The problem is not just aesthetic. Skin folds can impair hygiene and cause intertriginous dermatitis.

Thighplasty is becoming more popular as patients lose large amounts of weight from dieting and after bariatric surgery. However, this surgery may also be indicated for patients with skin laxity from aging.

Terminology

The inner and outer thighs are usually considered separately. The outer thighs may be lifted with the buttocks in an operation called an outer thigh lift. This may be done at the same time as an abdominoplasty. The combined procedure—outer thigh/buttock lift and abdominoplasty—is often called a lower body lift, or just body lift [1]. When the incision crosses the midline of the back, the term circumferential body lift or belt lipectomy is used.

In 1964, Pitanguy [2] described excision of trochanteric fat deposits in combination with an oblique skin resection that coursed across the buttock from the gluteal fold to the iliac crest. The scar was not ideal, interrupting the gluteal cosmetic unit. Lockwood's operation, using a transverse elliptical excision at the bikini level, represented a major advance [3, 4]. Lockwood extended the resection pattern from a point close to the midline of the back, or at the midline, to the inguinal area anteriorly.

Hamra and Small [5] use the term "cosmetic body lift" to describe a 270° extended lipoabdominoplasty in patients who have not experienced a massive weight loss. This operation modified the extended abdominoplasty described by Hunstad and Repta [6], who carried the lateral incision more posteriorly, but without turning the patient either on the side or prone. This procedure represents an intermediate incision length between a 180° traditional abdominoplasty and a 360° circumferential body lift.

Almutairi et al. [7] distinguish a belt lipectomy, which addresses skin and fatty excess of the waistline, from a circumferential body lift, which elevates saggy buttocks and thighs.

Medial (Inner) Thigh Lift

The inner thighs have been a source of frustration for patients and plastic surgeons. The traditional technique for a medial thigh lift makes use of an incision that parallels the groin crease, on the skin of the upper medial thigh (Fig. 7.1). If this approach is used, it is imperative to secure the superficial fascial system of the inner thigh to the Colles fascia overlying the pubic bone so as to avoid any skin tension [8]. Problems include limited effectiveness because this procedure only tightens the skin of the upper third of the inner thigh; wound tension, causing the labia to spread apart; and scar migration [7, 9, 10]. The surgeon's motivation to remove a large amount of skin is understandable, and patients want their plastic surgeon to tighten the skin as much as possible, but any skin tension is poorly tolerated. A patient with distortion of the introitus may complain of symptoms and even sexual difficulties. This procedure has been linked to a heightened medicolegal risk. The scar typically migrates inferiorly, where it may be visible below panties or bikini bottoms.

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Fig. 7.1 This 54-year-old woman is seen before (*left*) and 2 months after (*right*) outer and inner thigh lifts and liposuction of the lower body. The markings for the outer thigh lift incisions are visible. The groin crease incision was used, tightening the skin of the upper inner thighs. A mild degree of pleating is evident. This procedure has largely been replaced in the author's practice by the vertical thighplasty

Shermak [11] describes a medial thighplasty modification using an extension into the gluteal fold to provide a greater degree of traction, although disruption of the gluteal fold can occur [9]. The 18.6% infection rate and 8.2% lymphedema rate [11] are concerns.

Vertical Thighplasty

In the last decade, a different approach has been popularized—a longitudinal excision of excess skin from the inner thighs [9, 10, 12–14]. A horizontal vector is substituted for a vertical vector [13]. This operation leaves a scar running down the inseam of the thigh, similar in concept to the brachioplasty scar (Fig. 7.2). A vertical thighplasty may be done alone [9, 12–15] or in combination with a horizontal excision [9, 10]. Vertical skin excision is much more effective in correcting medial thigh skin laxity [7]. Most massive weight loss patients accept scar visibility as an acceptable trade for more effective skin tightening that treats the full length of the thigh.

Most massive weight loss patients accept scar visibility as an acceptable trade for more effective skin tightening that treats the full length of the thigh.

Capella and Matarasso [10] prefer to perform a lower body lift first, before a medial thigh lift. The medial thigh lift may no longer be needed because of the tightening effect on the inner thigh [10]. Staging the surgery ensures that the vectors of skin tension do not conflict [10]. Nevertheless, Capella and Matarasso [10] do combine a vertical medial thigh lift and body lift in a substantial number of their patients.

Similar to brachioplasty, the visible scar represents the downside of this method (Fig. 7.2). Patients with minor degrees of skin laxity may elect to have liposuction instead, which may provide a slight degree of skin tightening and improve the contour (examples are provided in Chap. 3). For greater skin laxity (i.e., the patient no longer wears shorts in the summer), then con-

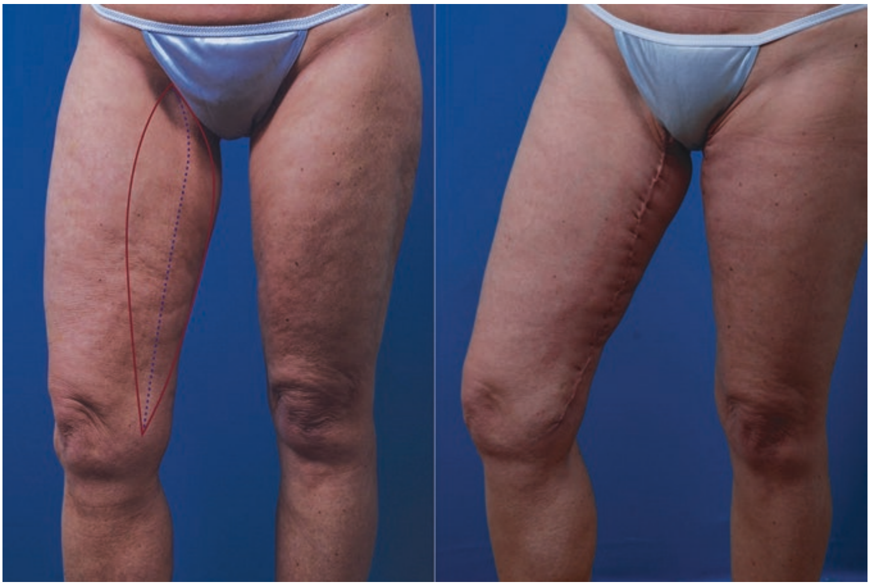

Fig. 7.2 This 50-year-old woman who did not have a history of massive weight loss presented with laxity of the skin of the thighs (*left*). She is shown 16 days after a medial thigh lift (*right*). The scar is positioned to lie along the inseam of her inner thigh

sideration may be given to the vertical thighplasty, provided the patient accepts the scar. Today the vertical thighplasty is my preferred method for treating loose skin of the inner thighs.

Today the vertical thighplasty is my preferred method for treating loose skin of the inner thighs.

Gusenoff et al. [9] recommend a horizontal excision when skin laxity is limited to the upper third of the thigh (13% of their massive weight loss patients), a short-scar vertical thighplasty when the laxity extends to the middle third of the thigh (23%), and a full-length vertical thighplasty when the laxity extends down to the knee (64%).

Fig. 7.3 This 53-year-old woman has a history of massive weight loss and a previous lower body lift and medial thighplasties. A secondary thighplasty is used to remove additional skin from the upper inner thighs. The inner thighs have already been infused with the wetting solution and treated with liposuction. Additional intraoperative photographs of this patient are provided in Figs. 7.4 and 7.5

Horizontal Versus Vertical Scar or a Combination?

Many surgeons, including the author, rarely perform horizontal thigh lifts anymore and avoid a T-junction in the groin [16], reasoning that a revision of persistent skin laxity of the medial upper thigh (7.3) is preferred over delayed wound healing and possible tension on the vulva. To avoid a T-junction, the author prefers a J- (or L-) extension when necessary to chase the dog ear into the perineal crease (Figs. 7.2, 7.3, and 7.4) [15]. No published series compares the L-shaped and T-point methods with regard to complications and outcomes [9]. However, avoiding a horizon-

Fig. 7.4 The proximal end of the skin resection is directed into the groin crease as a "J"

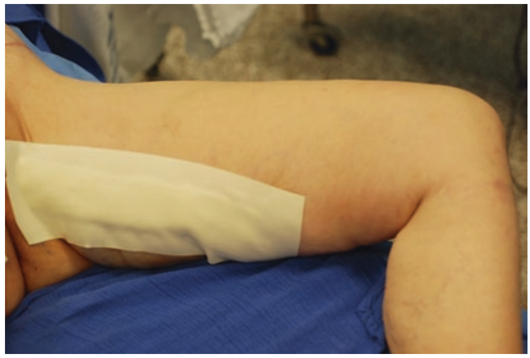

Fig. 7.5 The wound is dressed with Steri-Strips, gauze, and a longitudinal Microfoam tape (3M Comp., Maplewood, MN). An above-knee circumferential compression garment is then applied

tal skin resection in the groin crease can only improve the complication profile.

> The author avoids a T-junction in the groin, reasoning that a revision of persistent skin laxity of the medial upper thigh is preferred over delayed wound healing and possible tension on the vulva.

Framing the Pubic Area

Many surgeons continue the groin crease incision to connect, or almost connect, with the abdominoplasty incision (if performed simultaneously) or scar (if performed after the abdominoplasty), or incorporate such a scar as part of a monsplasty. This method "frames" the pubic area [9–11, 17]. The vertical scars create an unnatural appearance of the mons. It is preferable to end the incision from a medial thigh lift, whether a horizontal or vertical approach is used, within the upper portion of the perineal crease, where it remains hidden.

> It is preferable to end the incision from a medial thigh lift, whether a horizontal or vertical approach is used, within the upper portion of the perineal crease, where it remains hidden.

Preoperative Considerations

Massive weight loss patients have an increased risk of impaired wound healing and an increased prevalence of medical comorbidities including diabetes and hypertension [1, 9]. Despite the frequency of complications, massive weight loss patients often benefit immensely from contouring procedures [9].

Preoperative optimization of the patient's nutritional status, including iron, calcium, and vitamin B_{12} levels, is recommended [9]. Protein malnutrition is common in bariatric patients, who often have food intolerances [7]. Low albumin levels, iron deficiency, and vitamin A, D, E, and K deficiency are common and can compromise wound healing and increase blood loss if these conditions are uncorrected [7]. Patients are screened for anemia and hypoproteinemia [17]. Blood glucose evaluations are performed before, during, and after surgery in patients with glucose intolerance.

Avoiding Anemia

Blood loss from liposuction has been historically underestimated [18]. Large excisional procedures create substantial blood loss. Postoperative anemia is a major cause of patient morbidity [18]. In the series of body lifts reported by Nemerofsky et al. [1], 15.5% of patients received a blood transfusion (1–15 units). By obtaining a preoperative hemoglobin and hematocrit, and planning surgery so as to avoid excessive blood loss, blood transfusions should rarely be needed in cosmetic surgery patients. Expected blood loss is discussed in detail in Chap. 5.

> By obtaining a preoperative hemoglobin and hematocrit, and planning surgery so as to avoid excessive blood loss, blood transfusions should rarely be needed in cosmetic surgery patients.

Postbariatric patients, particularly menstruating women and those with who have had malabsorptive procedures (e.g., gastric bypass and duodenal switch), are often anemic [1]. Preoperative iron supplementation is frequently recommended [1]. A hematology consultation may be helpful [1].

Antibiotics

Most surgeons administer systemic antibiotic prophylaxis. The author administers intravenous antibiotics before surgery in the form of cefazolin (Ancef, GlaxoSmithKline, Brentford, London) 1 g or clindamycin 600 mg (Cleocin, Pfizer, New York City) in patients who are allergic to cephalosporins.

Smoking

Tobacco use is a well-known risk factor [7]. The number of patients who smoke may be as high as 28% in some series of body lift patients [10]. Most surgeons instruct their patients to abstain from smoking during the perioperative period, at least 1 month before and 1 month after surgery [7, 17], although patient compliance is obviously suspect [1].

Avoiding Hypothermia

The operating room temperature is critical in preventing hypothermia in patients who have large body areas exposed during surgery [4]. The author typically keeps the operating room temperature at about 75 °F, which may be a little uncomfortable for operating personnel. Patient temperature is monitored with a temperature strip placed on the forehead. Body warmers (Bair Hugger, 3M Comp., Maplewood, MN), warm blankets, and warm fluid irrigation are all helpful in avoiding hypothermia [7].

Preoperative Marking

Preoperative marking for a vertical thighplasty is performed immediately before surgery with the patient standing [1] and the lower extremities slightly abducted. The resection is marked so as to result in a linear scar running from the perineal crease at the level of the adductor magnus origin to a point just distal to the area of skin laxity, usually at the level of the knee (Fig. 7.2) [9, 10]. The surgeon will want to use the shortest scar possible. However, efforts to shorten the scar may result in distal dog ears that require subsequent correction [9]. Similar to brachioplasty, the incision is not really elliptical. The resection pattern widens superiorly. Fortunately, the scar tends to be hidden on both anterior and posterior standing views.

> The surgeon will want to use the shortest scar possible. However, efforts to shorten the scar may result in distal dog ears that require subsequent correction.

Surgery: Vertical Thighplasty

Patients are prepped circumferentially in a standing position by the circulating nurse using dilute chlorhexidine mixed with warm saline. The prep includes the perineal and anal regions. The patient then sits down on the operating table, which has been covered with a sterile sheet, and rotates and reclines to a supine position. In patients undergoing lower body surgery in combination with cosmetic breast surgery, the chest is reprepped and draped. The breast surgery is always performed first to optimize sterility.

A disadvantage of prone positioning for combined procedures is that the breast surgery must be done after prone positioning. Reprepping and draping may compromise sterility.

> A disadvantage of prone positioning for combined procedures is that breast surgery must be done after prone positioning. Reprepping and draping may compromise sterility.

A total intravenous anesthetic is administered with a laryngeal mask airway. Anesthesia details are provided in Chap. 5. Both thighs are infused with a superwet solution of 0.05% lidocaine and 1:500,000 epinephrine. Liposuction is performed using ultrasound assistance but limiting the ultrasound time to <1 min. Liposuction helps to develop the tissue planes and is used even when very little fat is aspirated. Small volumes (<50 cc) of additional local anesthetic solution (0.5% lidocaine, 1:200,000 epinephrine) may be injected directly into the marked resection area.

The lower extremities are abducted slightly and externally rotated to provide exposure (Fig. 7.3). The excess skin is removed superficial to the superficial fascial system, preserving the great saphenous vein. Scalpel dissection is used exclusively to minimize seromas. No undermining of skin edges is performed. Electrocautery is reserved for individual bleeders only. These tend to be few. A three-layer closure consists of 2–0 Vicryl sutures (Ethicon, Inc., Somerville NJ) to repair the subcutaneous fat layer, 3–0 Vicryl for dermis, and a 4–0 Monocryl intradermal suture for skin closure (Fig. 7.4). A noncircumferential gauze dressing is applied (Fig. 7.5).

Simultaneous Liposuction

Hunstad et al. [14] and Cram and Aly [12] use aggressive liposuction in the resection area to essentially defat this region. The author makes no effort to remove all fatty tissues in this area. Moderate tension is applied as the skin flap is elevated along the tissue plane that exhibits the honeycomb appearance after liposuction [10].

Gusenoff et al. [9] found no difference in complication rates comparing patients treated with liposuction inside the resection area versus liposuction of all areas of the thigh, although they (surprisingly) noted more infections in patients with larger liposuction treatment areas. Treating the inner thigh with liposuction before undertaking the skin resection helps to develop a safe tissue plane of dissection and reduces the volume of the extremity so as to allow greater skin removal [10].

> Treating the inner thigh with liposuction before undertaking the skin resection helps to develop a safe tissue plane of dissection and reduces the volume of the extremity so as to allow greater skin removal.

Tailor-Tacking

Many surgeons use towel clips to tailor tack the wound closed [9, 10]. Over-resection is a serious error. However, I do not use tailor-tacking when performing surgery of any type. Instead I gauge the skin laxity by pinching it and err on the side of under-resection. Like most surgeons, I commonly adjust my actual excision a little less or a little more than my markings indicate. Tailor-tacking does cause trauma to the skin edges and takes a little longer to perform but is certainly vastly preferable to over-resection, and I do not object to any surgeon who incorporates this method. Some surgeons leave the edges a little loose and resect the skin margin that contains the holes from the towel clips.

Outer Thigh and Buttock Lift

Usually an outer thigh/buttock lift is done in combination with an abdominoplasty—a lower body lift. Outer thighplasty may also be done separately in a patient undergoing staged treatment of skin deformities after massive weight loss. Occasionally I perform outer thighplasty as a stand-alone procedure in women who have skin laxity of the outer thighs but acceptable skin tone of the abdomen or after a previous abdominoplasty. Liposuction is frequently done simultaneously. Commonly the resection areas are used as donor sites for simultaneous buttock fat transfer.

Several operators [3–5, 10, 18], including the author, prefer supine and lateral positioning instead of prone/supine positioning. Advantages include optimal patient ventilation and reduced operating time by avoiding the need for a position change and reprepping and draping [5, 18]. Sterility may be optimized [5, 18].

Similar to medial thighplasty, a superwet infusion is used to reduce blood loss and provide local anesthesia, augmented with direct injection of 0.5% lidocaine and 1:200,000 epinephrine. The operating time for a lower body lift (outer thigh lifts + abdominoplasty) is typically about 3 h. Medial thigh lifts require <1 h. The author does not plan operations that are expected to take >6 h. Consequently, a urinary catheter is not used routinely during surgery. Usually the patient voids on her own or is catheterized in the recovery room. Patients are not discharged from the recovery room without urinating or being catheterized.

Near-Circumferential Lower Body Lift

Many surgeons believe that a complete circumferential incision is needed or the results will be suboptimal [1, 10]. It is true that in massive weight loss patients, a circumferential incision may be indicated. However, in the patient without circumferential skin laxity, it is unnecessary to connect the incisions across the midline, particularly if there is no skin excess directly in the midline. Preserving an intact skin bridge at the posterior midline does not appear to limit the degree of lift of the buttock and outer thigh. Aesthetically, the question is analogous to an incision that crosses the midline between the inframammary creases, which surgeons understandably avoid. Stopping short of the posterior midline helps to avoid the unattractive "plumber's crack" with a vertical cleft extending too high in the midline.

Stopping short of the posterior midline helps to avoid the unattractive "plumber's crack" with a vertical cleft extending too high in the midline.

Preoperative Marking for Outer Thigh/Buttock Lift

The patient is marked in a standing position immediately before surgery. The surgery is planned so as to leave the scar concealed by panties and bikini margins [3, 4, 6]. Some women bring their bikini bottoms with them on the morning of surgery. The line of the surgical closure is marked within the upper margin of the bikini, running from the inguinal crease to a point just lateral to the midline, terminating just below the dimple created by the posterior superior iliac spine. The resection width is determined by pinching the tissue. It is common for the widest point to measure up to 16 cm [3]. In patients with existing abdominoplasty scars, the resection pattern overlies the lateral ends of the abdominoplasty scar and terminates medially along the existing abdominoplasty scar.

The aesthetic importance of the buttock is increasingly recognized (discussed in Chap. 9). It is best to preserve this aesthetic unit, keeping the scar just above the buttock and avoiding any encroachment on the buttock itself (Figs. 7.6, 7.7, and 7.8). A slight curve is aesthetically preferable to a straight line [4–6].

The line of the surgical closure is marked within the upper margin of the bikini, running from the inguinal crease to a point just lateral to the midline, terminating just below the dimple created by the posterior superior iliac spine.

Fig. 7.6 This 66-year-old former model without a history of massive weight loss presented for a lower body lift. The planned incisions and level of scar (hatched blue line) are illustrated. The resection is near-circumferential, sparing the midline of the back. Her early postoperative and 5.5-month postoperative photographs are provided in Figs. 7.7 and 7.8

Fig. 7.7 A 66-year-old woman before (*left*) and 8 days after (*right*) a lower body lift with liposuction of the abdomen, flanks, arms, and axillae and fat injection of buttocks. This patient's preoperative and 5.5-month postoperative photographs are provided in Figs. 7.6 and 7.8, respectively

Fig. 7.8 This 66-year-old woman is seen before (*left*) and 5.5 months after (*right*) a lower body lift (abdominoplasty and outer thigh/buttock lift); liposuction of the abdomen, flanks, arms, and axillae; and buttock fat injection. This patient had a previous "mini-tummy tuck" and liposuction. Her preoperative and 8-day postoperative photographs are provided in Figs. 7.6 and 7.7

Operative Sequence: Lower Body Lift

The patient is prepped circumferentially with dilute chlorhexidine and assumes a supine position on the operating table, which has been covered with a sterile sheet. As in all of the author's surgery, total intravenous anesthesia and a laryngeal mask airway are used, with no muscle relaxation [18]. When a mommy makeover procedure is performed, the breast surgery is done first so as to optimize sterility.

When an abdominoplasty is performed as part of a lower body lift, the abdomen is infused with a (warmed) solution of 1 L of saline with 0.025% bupivacaine and 1:500,000 epinephrine. If the medial thighs are to be treated, they are infused next with a solution of 0.05% lidocaine and 1:500,000 epinephrine. The epigastrium and pubic area, and medial thighs, are treated with liposuction. The lower abdomen is also treated in patients who elect to have simultaneous buttock fat transfer.

Next the abdominoplasty is performed. The patient is flexed on the operating table to ensure low scar placement. The lateral ends of the wound remain open. The patient is then turned from side to side to allow superwet infusion of the flanks and any other areas requiring liposuction. Liposuction is performed, starting on the first side that was infused. Immediately after liposuction, with the patient still in the decubitus position, additional local anesthetic is injected and the outer thigh lift is performed. Care is taken not to injure the lateral femoral cutaneous and iliohypogastric nerves, which both course medial and inferior to the anterior superior iliac spine [19]. Preserving a layer of loose areolar tissue in this area is recommended [19]. Deep fascial sutures in the inguinal area are avoided. Scalpel dissection is used and electrocautery is reserved for individual bleeders.

> Care is taken not to injure the lateral femoral cutaneous and iliohypogastric nerves, which both course medial and inferior to the anterior superior iliac spine.

A three-layer repair is performed using 2–0 Vicryl for the deep (Scarpa) fascia, 3–0 Vicryl for the superficial fascia and dermis, and followed by a 4–0 Monocryl (Ethicon, Somerville, NJ) suture for the skin. The lower extremity is abducted vertically by a second assistant and/or flexion of the operating table. The patient is turned 180° and the contralateral side is treated in the same manner. No undermining is performed, and no drains are used for the outer thigh lifts (a drain is used for an abdominoplasty). The last step is buttock fat injection in patients who elect to have it (Figs. 7.6–7.8). Gauze and Microfoam (3M Comp., Maplewood, MN) tape dressing are applied followed by an elastic garment.

Buttock "Autoaugmentation"

Flap transposition has been used in an effort to avoid a flat buttock. A variety of methods have been described [20–25]. A medially based deepithelialized flap may be developed from the flank area and tunneled over the gluteus maximus (Fig. 7.9) [20, 24]. Bertheuil et al. [25] recently

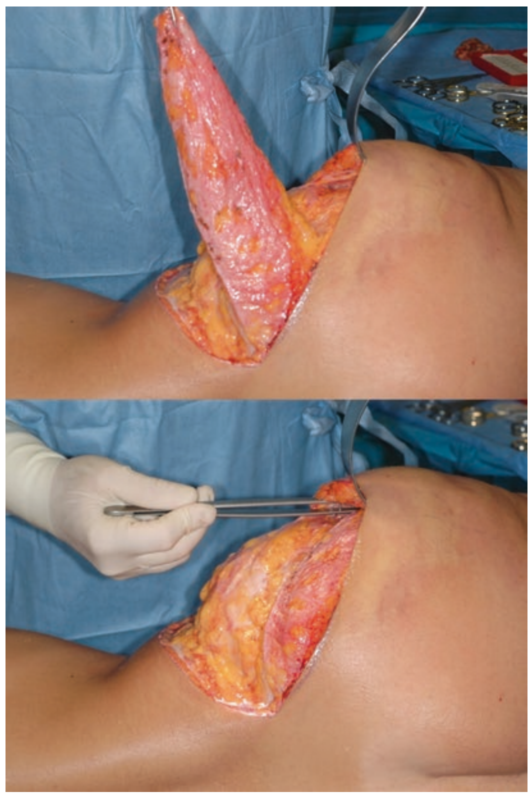

Fig. 7.9 This 53-year-old woman had a previous abdominoplasty. She returned for an outer thigh/buttock lift with buttock augmentation using deepithelialized dermal/fat flaps. The patient is positioned on her left side and her head is on the left. The flap is based medially and inset into a pocket that has been developed over the gluteus maximus. This patient's before-and-after photographs are provided in Fig. 7.16. Today the author uses fat transfer instead of flap transposition

described their lipo-body lift procedure, which lifts the tissues superomedially without undermining. However, comparison of photographs matched for size and orientation show no benefit (see Chap. 9). Hunstad and Repta [26] recommend a purse-string autoaugmentation. Intraoperative photographs show a pleasing increase in projection. Whether there is a lasting benefit is unclear. A problem for any autoaugmentation method, whether in the breast or buttock, is the lack of a net increase in tissue. Photographs of long-term results are lacking. Standardized lateral photographs may be unimpressive [25]. There may be no indication of the length of time between the surgery and the postoperative photographs, leaving open the possibility of a temporary effect from swelling [24].

> A problem for any autoaugmentation method, whether in the breast or buttock, is the lack of a net increase in tissue. Photographs of long-term results are lacking. Standardized lateral photographs may be unimpressive.

Autoaugmentation necessitates additional dissection, blood loss, and tissue undermining. These factors may increase the risk of wound dehiscence, delayed wound healing, and seromas [27]. Strivastava et al. [24] report a significantly higher complication rate (42.5%), mostly wound dehiscences, in patients treated with dermal/fat transposition compared with no flap transposition. The authors believe that over-resection and excessive tissue tension, and possibly gluteal skin undermining and postoperative pressure, account for the increased risk [24]. Patient satisfaction with their buttock projection was similarly high in patients with and without flap transposition (75% and 71.4%, respectively) [24]. Unnatural buttock shapes can occur [27]. Lateral gluteal deficiency is unimproved. Operating time is increased by about 45 min [27]. For these reasons, the author has abandoned flap transposition in favor of fat transfer.

> The author has abandoned flap transposition in favor of fat transfer.

Buttock Fat Transfer

Simultaneous liposuction provides fat that can be used for buttock fat transfer. Ultrasound is avoided so as not to compromise adipocyte viability [28]. This topic is discussed in detail in Chap. 9. Fat injection is simple and quick and provides a net increase in volume [29] without raising the complication rate, provided that care is taken to avoid injecting deeply so as not to cause a fat embolism. The flanks (and abdomen if an abdominoplasty is performed) are treated aggressively with liposuction because this skin will be resected, maximizing the fat volume available for transfer.

> The flanks (and abdomen if an abdominoplasty is performed) are treated aggressively with liposuction because this skin will be resected, maximizing the fat volume available for transfer.

Postoperative Care

Hunstad and Repta [6] found that an extended abdominoplasty incision provides a better aesthetic result without increasing patient morbidity. My experience is that patients who have a lower body lift (abdominoplasty + outer thigh/buttock lift) have a recovery experience that is not substantially different from an abdominoplasty alone.

Patients return to the office the day after surgery. Dressings are removed and the wounds are inspected. Vital signs are checked, and a Doppler ultrasound examination is done as part of surveillance for deep venous thrombosis.

Patients wear a standard elastic garment, either above or below the knee, for a period of 1 month. Gusenoff et al. [9] recommend that patients treated with a short- or full-scar medial thighplasty wear ankle-length compression garments for 6 weeks. Patients may use another garment of their choosing if they prefer. Patients start bathing the day after surgery. Walking short distances is encouraged. Exercising is typically resumed 1 month after surgery although any exercise that stresses the abdomen is deferred until 2 months after surgery. There is no need to avoid thigh abduction if a vertical medial thighplasty is used. Patients gradually resume an upright posture over 1–2 weeks after abdominoplasty.

Whenever possible, patients are photographed about 3 months after surgery, when swelling has largely resolved. Patients are weighed on the same office scales used to check their preoperative weight. Patients are reminded that their postoperative weight should be the same as their weight on the day of surgery minus the weight of the specimens removed [10] and weight of fat removed by liposuction (2 lb/L).

Drains

Some operators use up to four drains when performing body lifts that are removed at intervals up to 5 weeks after surgery [1, 30]. By contrast, Pascal and Le Louarn remove all drains by 3 days after surgery [20]. Drains can be an onerous part of the recovery experience. Surgeons may use a Bovie set on a high level for dissection [1], creating an internal burn that produces an inflammatory exudate. The issue of seromas and their prevention is discussed in detail in Chap. 6.

When the author performs an outer thigh and buttock lift on its own, without an abdominoplasty, no drains are used. When the combined procedure is performed, a single drain is used, exiting through the right pubic portion of the incision, not through a separate stab incision so as to avoid an unnecessary scar. The drain is removed in 3 or 4 days. By avoiding tissue undermining and using scalpel dissection exclusively [31], the risk of seromas is reduced. When seromas do occur, they may be managed in the office by needle aspiration, assisted by ultrasound guidance if available. In my experience, all seromas have been successfully treated by needle aspirations. No patient has required doxycycline injections through the drain [7] or a return to the operating room for removal of a pseudobursa [9].

> The drain is removed in 3 or 4 days. By avoiding tissue undermining and using scalpel dissection exclusively, the risk of seromas is reduced.

Clinical Examples of Lower Body Lifts

Examples of surgery in patients who had developed skin laxity as a result of aging and without substantial weight loss are shown in Figs. 7.8 and 7.10. Photographs of patients who underwent surgery after massive weight loss are provided in Figs. 7.11, 7.12, 7.13, and 7.14.

Complications

Venous Thromboembolism (VTE)

Hatef et al. [32] report that circumferential abdominoplasty is associated with a significantly higher rate of deep venous thrombosis (7.7%) than other excisional body contouring procedures. Aly et al. [33] report 3 pulmonary embolisms among 32 patients (9.4%) treated with belt lipectomies and a 37.5% seroma rate.

The author rarely performs a belt lipectomy, preferring a near-circumferential resection instead, as described above (Figs. 7.8, 7.10–7.14). However, it is unlikely that retaining a bridge of skin in the posterior midline is relevant to VTE. More likely, a drop in mean arterial pressure during surgery and the use of paralytic agents that relax the calf muscle pump are implicated [34]. This topic is discussed in detail in Chaps. 5, 12, and 13.

Many surgeons performing body lifts, including the author, prefer not to administer chemoprophylaxis so as to avoid unnecessary bleeding

Fig. 7.10 This 56-year-old woman with no history of major weight loss is shown before (*left*) and 4 months after (*right*) a lower body lift, liposuction of the abdomen and flanks, and secondary medial thigh lifts. She has a vertical scar of the lower back from recent surgery on her lumbar spine. She had undergone previous lower body liposuction

Fig. 7.11 This 52-year-old woman had a previous bariatric operation, accounting for the scars from laparoscopies on her abdomen (*left*). She is seen 4 months after (*right*) a lower body lift; medial thigh lift; liposuction of the abdomen, flanks, outer thighs, and knees; and buttock fat transfer

[1, 30, 35]. Nemerofsky et al. [1] obtain lower extremity venous Doppler evaluations before discharge on the second postoperative day. These authors [1] report a 2% rate of deep venous thromboses and 1% incidence of pulmonary embolism. Gusenoff et al. [9] report no venous thromboembolisms in their series of 106 medial thighplasties.

Fig. 7.12 This 42-year-old woman lost 150 lbs. after a gastric bypass. She underwent two procedures in close succession. First she had a lower body lift with liposuction of the inner thighs, knees, and medial calves. She returned 3 weeks later for an augmentation/mastopexy, liposuction of the arms, brachioplasties, and a medial thigh lift using an incision in the groin crease. She is seen before (*left*) and 2 months after her second procedure (*right*). The limitations of the transverse incision are obvious. Today a vertical approach for medial thighplasty would be recommended instead

Fig. 7.13 This 61-year-old man had a gastric bypass 30 years previously and subsequently lost about 200 lbs. He had an unusual (for men) gynecoid fat distribution (*left*). He underwent an abdominoplasty, medial thigh lifts using the groin crease incision, and liposuction of the abdomen, inner thighs, flanks, knees, axillae, and breasts. He reported that his back pain was alleviated and putting on clothing was much easier. He is seen 5 months after surgery (*right*). His memorable comment after surgery was "Everything is better now"

Fig. 7.14 This 26-year-old male had lost 130 pounds by dieting. He is shown before (*left*) and 1 month after (*right*) a lower body lift with liposuction of the abdomen and flanks and buttock fat transfer

Complications

Seromas, wound dehiscence, and delayed wound healing are common complications that are usually treated with local wound care and aspirations in the office [7, 9, 24]. Capella and Matarasso [10] find that complications after medial thigh lifts are similar to those following brachioplasty, with 45% of their massive weight loss patients experiencing a complication. Skin dehiscence occurs in 31% of their medial thigh lift patients. Nearly all (95%) dehiscences occur at the T-intersection in the perineal crease. These investigators instruct their patients to limit thigh abduction but recognize that this restriction is unlikely to entirely prevent this problem [10]. Wounds are treated with dressing changes.

Dehiscences may be caused by motion, moisture in the groin area, proximity to the perineum with a higher bacterial burden, and a diminished blood supply caused by an angulated flap closure [9, 10]. Capella and Matarasso [10] concede that motion and reduced skin elasticity "invariably" lead to a change in the anticipated location of the scar and some transference of tension to the labia. Despite the frequency of dehiscences, these surgeons believe that foregoing a T-point closure may compromise the aesthetic result [10]. Skin necrosis, infection, bleeding, and hematomas are unusual [10].

Gusenoff et al. [9] also attribute high complication rates after medial thighplasty to movement, moisture, and a potential T-point in the groin crease. These investigators report that 68% of their massive weight loss patients experienced at least one complication [9]. Complications include wound dehiscence (51%) (including minor skin breakdown), seroma (25%), infection (16%), and hematoma (6%). T-point issues may be avoided by staging the horizontal and vertical resections [9]. However, the additional cost and inconvenience of two operations are disadvantages. By contrast, Armijo et al. [15] report ten patients (22%) with minor wound breakdown after an L-shaped medial thighplasty and liposuction.

Complications after lower body lifts are also relatively frequent. Nemerofsky et al. [1] experienced a 50% complication rate after body lifts with a dehiscence rate of 32.5% and a skin necrosis rate of 9.5%. Skin dehiscences usually occurred at the buttock cleft and hips. Ischemia from postoperative pressure on the sacrum and coccyx may contribute to impaired wound healing in the midline (1, 30). Nemerofsky et al. [1] were able to reduce their dehiscence rate by measuring the tissue to be removed intraoperatively with the patient in a sitting position so as not to create excessive wound tension.

By contrast, in their study of 72 patients undergoing a cosmetic body lift (i.e., not after massive weight loss), Hamra and Small [5] report a seroma rate of 2.8%, infection in 4.2%, delayed wound healing in 5.6%, skin necrosis in 4.2%, and no hematomas. These surgeons encountered one deep vein thrombosis (1.4%). Revisions were performed in 18% of patients. Half of the revisions were liposuction touchups.

Baca et al. [35], in a study of 59 non-bariatric outpatients undergoing circumferential abdominoplasty, report that approximately half of their patients, 50.8%, experienced a complication and 13.6% required a revision. The most common complications were wound dehiscences (24.5%), suture granulomas (22.2%), scar deformities (17.8%), and cellulitis (17.8%). Despite the frequency of complications, 90% of their patients stated that they would undergo the procedure again [35]. Makipour et al. [30] report a 36% complication rate among 42 consecutive patients undergoing outpatient circumferential lower body lifts. No patient required hospitalization. The most common complications were wound separation (24%), mostly over the sacrum, and seromas requiring aspiration in the office (4.7%) [30].

Cosmetic procedures of the face, arms, or breasts may be done simultaneously [1, 5, 30]. The author commonly performs cosmetic breast surgery (1–2 h) or brachioplasties (1 h) simultaneously if the anticipated operating time does not exceed 6 h (an arbitrary figure). For example, the author does not combine a facelift with a lower body lift.

Complication rates in postbariatric body contouring surgery tend to exceed those of cosmetic surgery patients who have not experienced massive weight loss [10]. Nevertheless, these patients are often tolerant of complications because the benefits both aesthetically and functionally can be profound [1, 9, 10].

Buchanan et al. [17] report that 14 lower body lift outpatients (74%) had minor wound dehiscences. Wound breakdown typically occurred at the T-junctions between the vertical peripubic incision for monsplasty and the transverse abdominal incision. This connection, framing the mons pubis, is best avoided as discussed above.

Bertheuil et al. [25] report a 40% complication lift after a lipo-body lift, consisting of ten patients with wound dehiscences, two wound infections (8%), and two cases of fat necrosis (8%). An example of a minor area of delayed healing is provided in Fig. 7.15. An unusual cause of skin loss is shown in Fig. 7.16.

Lymphedema

Lymphedema is a dreaded problem of excisional body lifting. Liposuction is not believed to increase the risk of lymphedema of the lower extremity. On the contrary, Capella and Matarasso [10] believe that liposuction may reduce this risk by better preserving the vessels. These investigators report only two cases of lower extremity edema that persisted >3 months but <6 months among 350 vertical medial thigh lifts [10]. In the series of 106 medial thigh lifts evaluated by

Fig. 7.15 This 64-year-old woman has an area of delayed wound healing 4 weeks after lower body lift with liposuction of the abdomen, flanks, and axillae

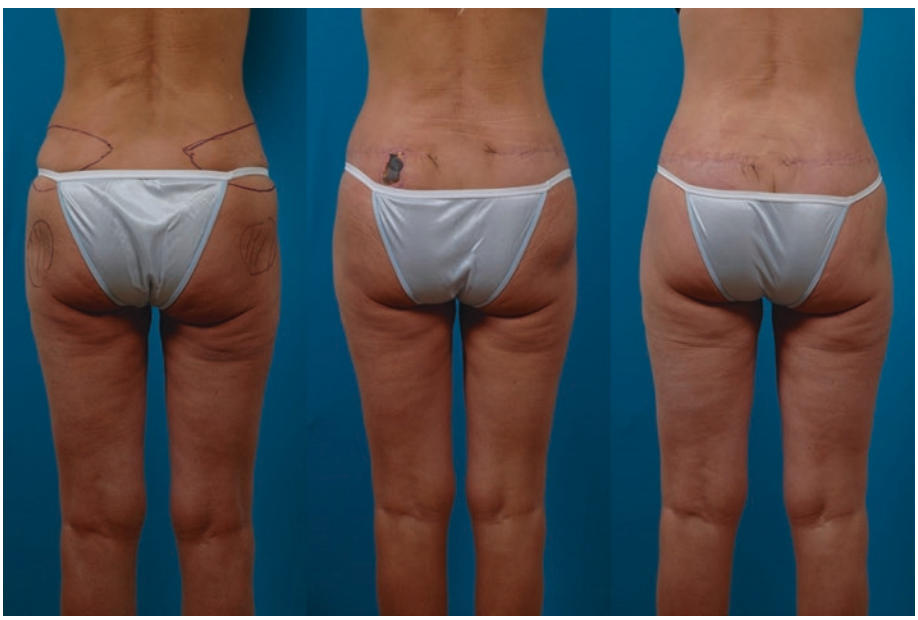

Fig. 7.16 This 53-year-old woman underwent a lower body lift with gluteal transposition flaps. The resection margins are marked (*left*). When the dressing was removed the day after surgery, the adhesive from the tape took off a layer of skin. The wound was allowed to heal. She is seen 5 weeks after surgery (*center*). She underwent revision 10 months after her original surgery, resecting the wound and providing additional lift. Needless to say, no adhesive tape was used at the second operation. She is seen 1 month after her revision (*right*) or 11 months after her original surgery. She still has temporary pleating at this early postoperative visit

Gusenoff et al. [9], lower extremity edema developed in 22% of patients. Two patients experienced prolonged edema that persisted >1 year despite lymphedema therapy.

Moreno et al. [36] found that thighplasty can impair the lymphatic network of the lower extremity. Moreover, massive weight loss patients may have preexisting lymphovascular disease [37]. A superficial dissection and preservation of the great saphenous vein are recommended [9, 15].

Seromas

Capella and Matarasso [10] report an 18% seroma rate after medial thighplasty, 90% of which occur along the distal medial third of the thigh. The authors note a high recurrence rate after needle aspiration. An example of a seroma after a medial thigh lift is provided in Fig. 7.17, although this patient required only two aspirations. Buchanan et al. [17] report a seroma rate of 21% (four patients) after an outpatient body lift. Similarly, Nemerofsky et al. [1] report a 16.5% seroma rate after a body lift.

Infection

Buchanan et al. [17] treated 12 of their 19 lower body lift outpatients (63%) with antibiotics for cellulitis. Patients were initially treated prone and then repositioned supine. Baca et al. [35] prescribed oral antibiotics to treat cellulitis in 17.8% of their non-bariatric circumferential abdominoplasty patients. By contrast, Nemerofsky et al. [1] report infections in only 3.5% of their body lift patients, who are not repositioned prone to supine. Prepping the patients once at the beginning of the case and avoiding patient repositioning from prone to supine eliminate a potential break in sterility.

Neuropathies

Postoperative neuropathies can be minimized by careful attention to body positioning and padding during surgery [7]. Avoiding deep dissection or

Fig. 7.17 This 47-year-old man with a history of massive weight loss developed swelling 2 weeks after a medial thigh lift. The ultrasound scan identifies the seroma and helps to locate if for aspiration. A volume of 70 cc of serosanguinous fluid was obtained. The patient's swelling was immediately relieved. Four days later, a volume of 20 cc of fluid was aspirated. The patient required no additional aspirations

sutures in the inguinal area reduces the risk of a lateral femoral cutaneous or iliohypogastric neuropathy [19].

> Avoiding deep dissection or sutures in the inguinal area reduces the risk of a lateral femoral cutaneous or iliohypogastric neuropathy.

Hematoma

Nemerofsky et al. [1] report a 3% hematoma rate after body lifts. Avoidance of routine anticoagulation reduces the risk.

Suture Granulomas

Many surgeons use permanent sutures such as polypropylene either to secure the superficial fascial system to the Colles fascia or to reinforce the T-point closure. However suture extrusion can be a problem [9]. Ultimately the integrity of the wound depends on the scar tissue, not the suture [38]. The author does not use permanent sutures when performing thigh lifts.

Correlations

Capella and Matarasso [10] report that a higher body mass index (BMI) correlates with a lower aesthetic outcome after medial thigh lifts. These investigators also find that a gynecoid body habitus (persistent saddlebags) and older age (skin excess along the distal thighs) negatively affect the cosmetic result [10]. Gusenoff et al. [9] conclude that anemia and age are significantly associated with an increased complication rate. Makipour et al. [30] report no significant link between the complication rate and concurrent cosmetic procedures, liposuction, or a BMI >25 kg/m^2, although the sample size was limited.

> Suture extrusion can be a problem. Ultimately the integrity of the wound depends on the scar tissue, not the suture.

Nemerofsky et al. [1] encounter significantly more complications after a body lift in patients with higher maximum body mass indices. Body mass index and the time of the body lift were not found to be significantly linked to the complication rate [1]. Age did not correlate significantly with complications. Not surprisingly, smokers had a significantly higher rate of skin dehiscence and skin necrosis than nonsmokers [1].

Nemerofsky et al. [1] find that advancing age, a higher BMI, and gynecoid body habitus in women are associated with a lesser aesthetic outcome, particularly with regard to persistent skin laxity and cellulite along the distal thighs.

Reoperation

Persistent or recurrent skin laxity is a frustrating problem in massive weight loss patients and makes revisions inevitable [7]. Asymmetry is another common problem [7]. Gusenoff et al. [9] report that 6% of their 106 medial thighplasty patients required reoperation for a complication and 14% underwent revision to improve the aesthetic result. Bertheuil et al. [25] performed three cosmetic revisions (12%) after a lipo-body lift. A revision rate of 26% was recently reported after outpatient circumferential lower body lifts [30]. Most revisions in this series treated a scar deformity. Revision rates are largely influenced by the surgeon's revision policy [30].

Outpatient Surgery

Buchanan et al. [17] believe that avoiding hospitalization minimizes nosocomial infections and improves access to the surgery because of reduced cost. Inpatient surgery may represent a financial barrier for prospective patients [30, 39].

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8 Brachioplasty and Hand Rejuvenation

Abstract

Brachioplasty is becoming more popular as patients lose large amounts of weight from dieting or bariatric surgery. Some patients seek treatment of excessive skin laxity in the absence of a history of weight loss. Most are women.

Unlike abdominoplasty, a brachioplasty scar cannot be easily concealed in a natural skin crease. Therefore, the scar must be considered when weighing the risk/benefit ratio. Lesser degrees of arm fullness and skin laxity may be treated with liposuction alone.

A scar located in the bicipital groove may be visible from the front. A scar located along the inferior border of the upper arm may be visible from behind when the patient relaxes her arms to her side. A posteromedial scar location is preferred.

Liposuction is done simultaneously both to reduce the fat layer and also to facilitate the skin dissection by opening up a subcutaneous tissue plane. The medial antebrachial cutaneous nerve must be preserved. Care must be taken not to over-resect the skin. Complications include wound dehiscences, spread scar deformities, and dog ears that may require revision. Seromas and infection are unusual.

An L-extension of a brachioplasty onto the torso requires a transaxillary scar. A vertical scar on the torso is not ideal. A scapular lift may be used to treat skin laxity of the lateral "bra fat" area while keeping the scar horizontal and hidden by the bra. This is an alternative option for women who do not have a severe degree of skin excess.

The hands can be a visible sign of aging. Fat injection provides a soft tissue cushion that can make veins and tendons less conspicuous. Laser resurfacing is used to treat brown spots. The two modalities may be combined for maximum hand rejuvenation.

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Introduction

Brachioplasty is increasing in popularity, coinciding with the increasing number of bariatric procedures being performed. Statistics provided by the American Society of Plastic Surgeons show a 50-fold increase in the number of brachioplasties performed between 2000 and 2016, a jump matched only by lower body lifts [1]. In a review of brachioplasty cases performed by nine plastic surgeons in Grand Rapids, postbariatric surgery patients accounted for half (48/96) of the total [2]. Most patients are women [2–9]. In a series of brachioplasties performed in 101 massive weight loss patients, 96% were women [4]. A French study reported a similar predominance of women (95%) [5]. Male candidates usually have a history of massive weight loss [3, 4].

Although some practices treat a large number of patients after massive weight loss [4–9], other practices may treat more women who have developed skin laxity from aging. In a series reported by Nguyen and Rohrich [10], only 38% of patients had previous bariatric surgery.

If the degree of skin laxity is mild, liposuction may suffice (Chap. 3). Patients with borderline skin laxity may choose to have liposuction, knowing they can always return later for an excisional procedure. Patients often ask if their skin will sag more after liposuction. If their degree of laxity is mild or moderate, liposuction does not tend to make it worse, provided the liposuction procedure is not overly aggressive so as to compromise any possible skin contraction.

> If their degree of laxity is mild or moderate, liposuction does not tend to make it worse, provided the liposuction procedure is not overly aggressive so as to compromise any possible skin contraction.

When the skin laxity is moderate or severe, the cost/benefit ratio favors an excisional procedure in that the skin tightening will be an acceptable trade for a scar. However, the scar is long and not as well-hidden as an abdominoplasty scar. Showing patients before-and-after photographs that include the scars is helpful.

Surgery for upper arm ptosis is analogous to surgery for inner thigh ptosis (discussed in Chap. 7). This fact should not be surprising. In both cases the surgery is undertaken on the proximal portion of an extremity.

Despite its effectiveness, brachioplasty has a high complication rate, in the range of 9.5–56.1% [2, 4–12], and revision rates (4–22.9%), usually related to scar deformities, persistent skin laxity, and contour irregularities [2, 4–9, 11–13].

Mini-Brachioplasty

A mini- or short-scar brachioplasty has obvious appeal [14–16]. A transverse resection is made in the axilla, creating a tightening effect on the loose skin of the upper arm while keeping the scar concealed in the axilla. However, the results are modest (Fig. 8.1) and limited to the most proximal portion of the upper arm. For most women, this result is insufficient. Figure 8.2 shows a woman who returned for a full brachioplasty after a short-scar brachioplasty. I have abandoned the short-scar method.

> I have abandoned the short-scar method.

Brachioplasty Incision

Traditionally, the brachioplasty incision has been made so that the resulting scar falls along the bicipital groove [4, 5, 9, 10]. The advantage of this scar placement is that the scar is not visible from behind. However, it may be seen from the front.

Alternatively, the scar may be located along the inferior margin of the upper arm when the arm is held in the anatomical position [11]. This scar is not visible from the front (Fig. 8.3) but can be seen from behind when the patient relaxes her arm (Fig. 8.4) [17]. It makes sense, therefore,

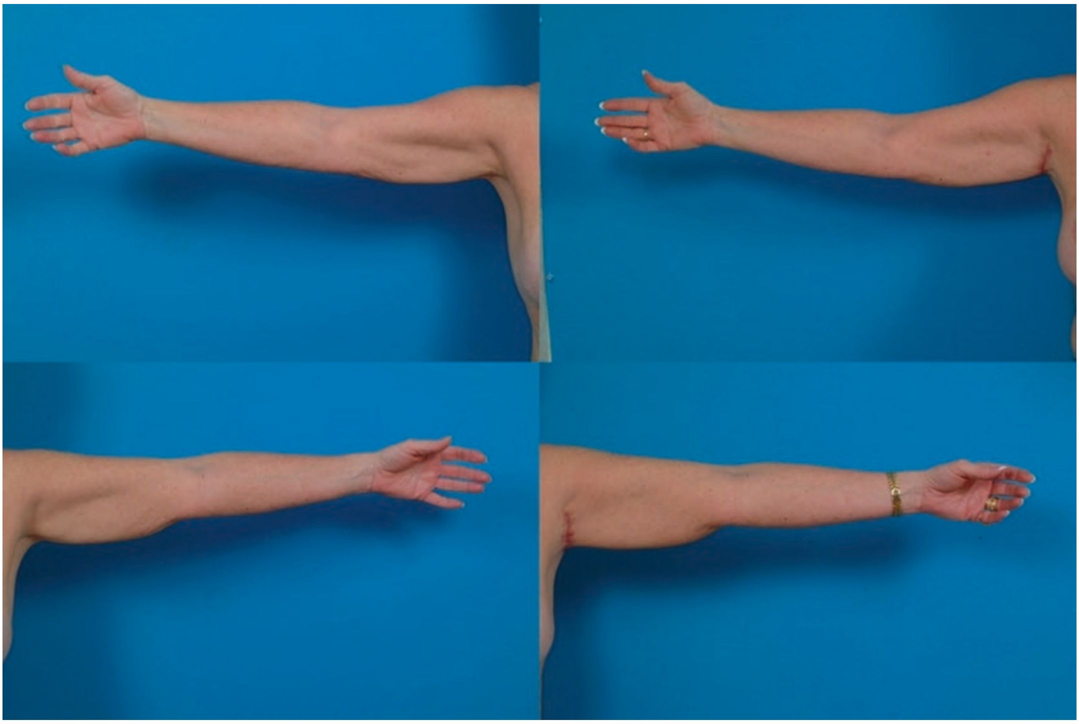

Fig. 8.1 This 56-year-old woman wanted to have the loose skin of her upper arms treated but wished to avoid a long scar. She is seen before (*left*) and 5 weeks after mini-brachioplasties (*right*). The result was underwhelming. The patient returned 8 years later for full brachioplasties (Fig. 8.2)

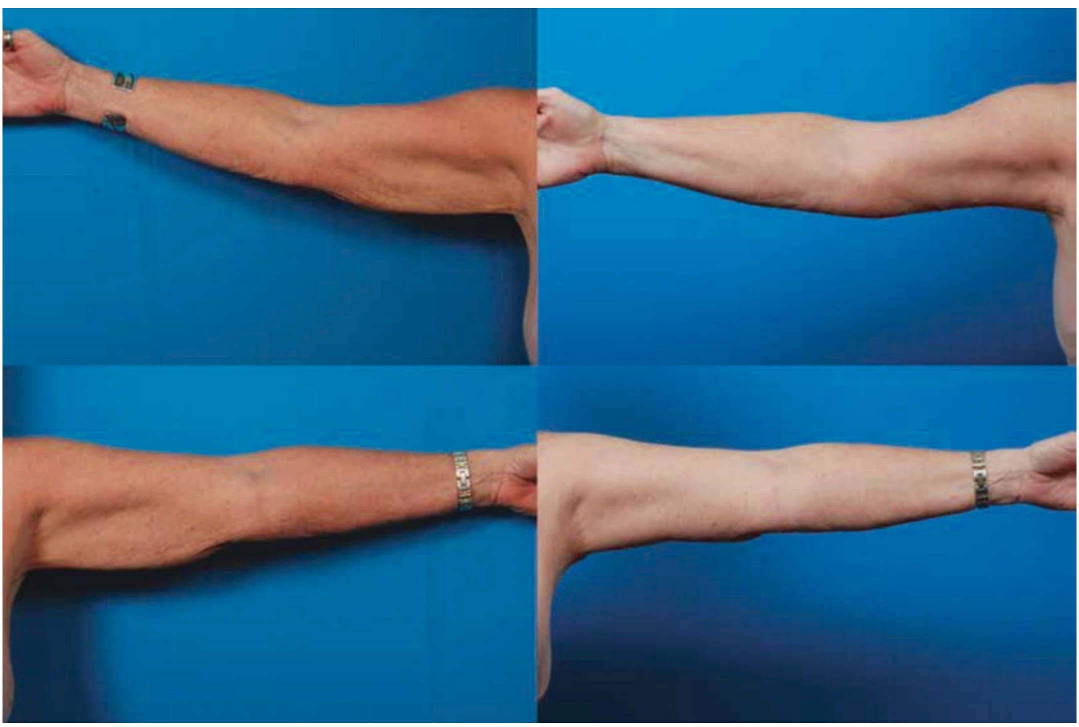

Fig. 8.2 This 64-year-old woman is shown before (*left*) and 2 months after brachioplasties (*right*). She had undergone mini-brachioplasties 8 years previously (Fig. 8.1)

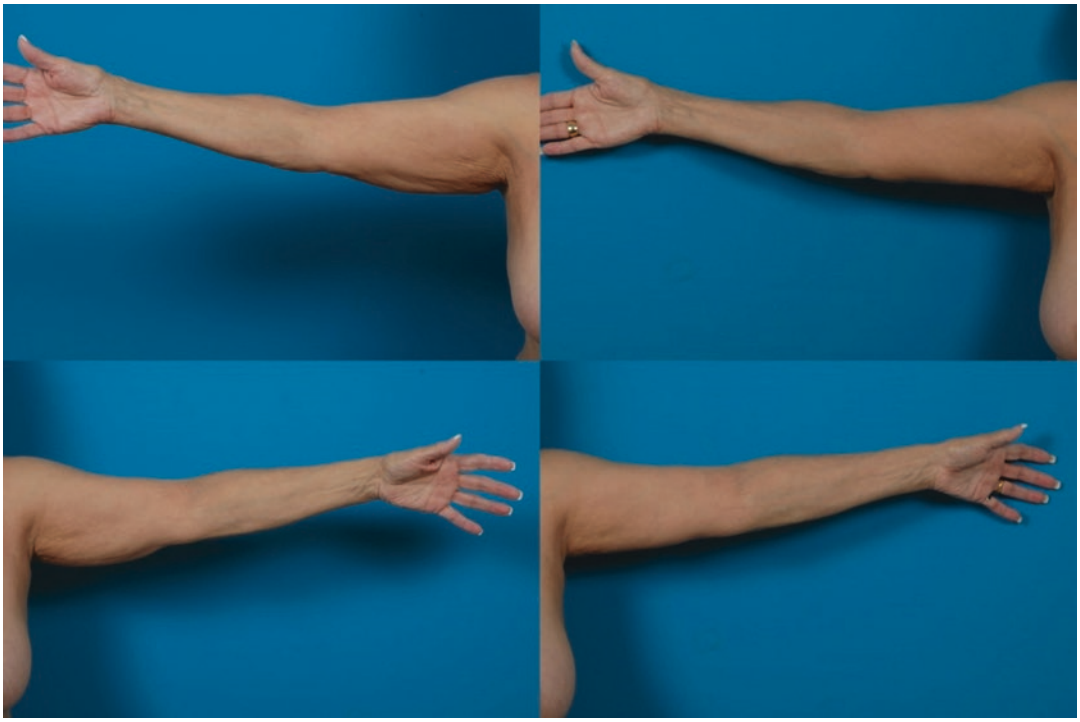

Fig. 8.3 This 70-year-old woman is seen before (*left*) and 3 months after brachioplasties and liposuction of the arms and axillae (*right*). The scars are not visible on the frontal view but may be seen from behind, as demonstrated in Fig. 8.4

Fig. 8.4 This patient's photographs are also shown in Fig. 8.3. Although the scars are maturing well 6 months after surgery, they are visible from behind

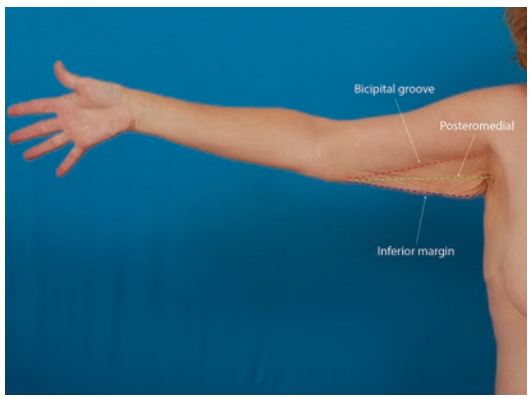

Fig. 8.5 Preoperative photograph of the right arm of a 53-year-old woman. Three possible sites are illustrated for the scar. The intermediate, posteromedial location is preferred

to place the scar in an intermediate or "posteromedial" location [8, 12, 13] (Figs. 8.5 and 8.6), and this is my preferred scar placement. It is not clear that the scar position affects the quality of the scar [12]. The planned position of the resulting scar is drawn preoperatively along the midaxillary line to the medial epicondyle [12].

It makes sense, therefore, to place the scar in an intermediate or "posteromedial" location, and this is my preferred scar placement.

Fig. 8.6 The skin resection is wider proximally, tapering distally to the elbow

An S-shaped scar has been described to reduce longitudinal and horizontal skin redundancy [18], although few surgeons have adopted it. Knotts et al. [12] advocate proximal-to-distal avulsion as a quick method that avoids having to dissect through the fat of the arm. The authors believe this method reduces bleeding [12]. Several investigators believe that pretreatment of the arm with liposuction helps to preserve the lymphatics, blood vessels, and nerves [8, 11–13].

> Several investigators believe that pretreatment of the arm with liposuction helps to preserve the lymphatics, blood vessels, and nerves.

In patients with coexistent skin laxity of the axilla, the incision may be extended onto the lateral chest [4, 6–10, 12, 19]. The inflection point in the axilla is the most common site for wound breakdown [8, 12]. A Z-plasty or other method to reduce tension is needed to reduce the risk of a contracture [4, 8, 12, 19]. Nevertheless, a contracture may develop, limiting upper extremity abduction and occasionally requiring a Z-plasty for correction [7].

Anesthesia

A total intravenous anesthetic is administered (Chap. 5). An LMA is secured with tape. The patient is turned from side to side, and the areas are prepped and draped. The anesthetist or nurse holds the forearm outside the sterile area.

Superwet Infusion

The wetting solution is infused through a single incision in the axilla and consists of normal saline with 500 mg lidocaine (0.05%) and 2 mg epinephrine (1:526,000). A superwet method is used, infusing 100–150 mL of wetting solution and aspirating a similar volume of fat, on average (Fig. 8.7). A tumescent technique (3:1 infusion:aspirate volume) may create too much swelling and limit the tissue resection. Although some operators prefer not to infuse the tissue to be resected [9], most operators do infuse this tissue [11, 12]. By infusing both arms and axillae first, and then performing liposuction, the epinephrine is given time to maximize vasoconstriction. The axilla is typically treated simultaneously.

> A tumescent technique (3:1 infusion: aspirate volume) may create too much swelling and limit the tissue resection.

Liposuction

Some operators believe that simultaneous liposuction at the time of brachioplasty increases the risk of complications [20]. Aly [20] is concerned that liposuction of the unresected area may cause edema and make wound closure difficult or alternatively predispose to under-resection after the swelling has subsided. He recommends against performing liposuction and brachioplasty simultaneously [20]. However, Bossert et al. [9] found this combination to be safe, with no increase in the risk of seromas. In a review conducted by Zomerlei et al. [2], over half of the patients (53.7%) were treated with simultaneous arm liposuction. Knotts et al. [12] use liposuction routinely before performing an avulsion brachioplasty.

The arm is first treated with liposuction to remove extra fat that may not be contained within the resection area. Liposuction helps to develop a tissue plane, making skin removal easier

Fig. 8.7 The upper arm is infused using an infusion cannula introduced through a single axillary incision. Only one incision is used for both the infusion and liposuction. The cannula is turned to treat the axilla through the same incision

Fig. 8.8 The degree of skin laxity is assessed before the resection is performed

(hydrodissection). Matarasso [3] notes that using liposuction to assist surgical dissections represents a new application of this method and might be considered "liposuction-assisted surgical excision." Nguyen and Rohrich [11] use superficial ultrasonic liposuction to remove superficial fat under the area of skin resection. The author also uses ultrasound assistance, limiting the ultrasound time to <1 min. If the suctioned fat is being transferred to the buttocks, ultrasound assistance is not used so as to optimize adipocyte viability [21].

The author prefers a 4-mm liposuction cannula with 3-hole Las Vegas tip. Occasionally a 5 mm cannula is used in patients with very bulky arms. By directing the cannula distally, there is no risk of injury to the axillary contents. By using just one axillary incision, no scars are left on the upper extremity from liposuction. Aggressive defatting of the skin as described by de Runz et al. [5] is unnecessary; this fat will be removed with the specimen. The resection area is treated with liposuction along with the rest of the posterior arm. Liposuction is not circumferential; the anterior part of the arm, over the biceps muscle, rarely requires liposuction.

> The resection area is treated with liposuction along with the rest of the posterior arm.

Bossert et al. [9] report that liposuction added 30 min of operating time. It is possible to perform a lesser degree of liposuction, taking only about 5 min per side. Liposuction makes the dissection easier, so that any net increase in operating time from liposuction may be negligible. Typically, liposuction of the axillary and scapular areas is done simultaneously through the same incision (Chap. 5).

Fig. 8.9 The skin is removed in one piece using a scalpel. Liposuction facilitates this dissection

Tissue Resection

A pinch test is used to check skin laxity and to ensure that the wound tension will not be excessive (Fig. 8.8). The specimen is removed en bloc, rather than in sections, dissecting along a plane superficial to the sensory nerves (Fig. 8.9). This plane is facilitated by the wetting solution and by liposuction, which opens up a superficial dissection plane of areolar tissue and reduces bleeding. Nguyen and Rohrich [11] call it a traction resection. Knotts et al. [12] avulse the tissue along the same plane after suctioning the subcutaneous fat. Knotts et al. [12] avulse the flap proximally to distally, reasoning that blood vessels, cutaneous nerves, and lymphatics branch proximally to distally. With the tissue plane already developed by liposuction, the direction of flap dissection is unlikely to be clinically important.

Scalpel dissection (Fig. 8.9) is used rather than electrodissection to reduce tissue injury and avoid seromas. Electrocautery is used only to treat individual vessels, using a 9 ½ in. (24 cm) Potts-Smith monopolar, insulated, serrated, 2.0 mm handswitch cautery forceps (Kirwan Surgical Products, Marshfield, MA). Minimal hemostasis is needed (Fig. 8.10).

Medial Antebrachial Cutaneous Nerve

The medial antebrachial cutaneous nerve is at risk, lying close to the lateral margin of a posteromedial resection, and care must be taken to avoid it so as not to cause paresthesias or a neuroma [4]. This nerve penetrates the deep fascia approximately 14 cm proximal to the medial epicondyle, about midway along the upper arm, dividing into anterior and posterior branches that continue superficial to the deep fascia [10]. Although the nerve may be located ≥5 cm anterior to the basilic vein in the midarm, it is typically located posterior to the basilic vein above the elbow [10], so that it is at risk in a posteromedial resection [10]. The superwet infusion expands the subcutaneous tissue plane, reducing the risk of nerve injury [11, 12].

Wound Closure

A 3-layer wound closure is performed using 2–0 Vicryl (Ethicon Inc., Somerville, NJ) for the fascia (Fig. 8.11), 3–0 Vicryl for dermis, and a 4–0 Monocryl suture for the skin (Fig. 8.12). No drains are used. A longitudinal gauze dressing is applied (Fig. 8.13).

Fig. 8.11 The fascia is approximated using 2–0 Vicryl sutures. Next, the dermis is approximated using 3–0 Vicryl sutures. Finally, the skin is closed using a running 4–0 Monocryl intradermal suture

Fig. 8.10 Individual bleeders are cauterized using an insulated pinch-activated cautery forceps

Fig. 8.12 The skin is approximated using a 4–0 intradermal Monocryl suture

Clinical Examples

Clinical examples are provided in Figs. 8.14–8.22. The patient in Figs. 8.14–8.16 had undergone bariatric surgery and massive weight loss; her preoperative and intraoperative photographs are shown in Figs. 8.5–8.13. Another patient with a history of massive weight loss after bariatric surgery is shown in Figs. 8.17–8.19. The other four patients, shown in Figs. 8.20–8.23, developed skin laxity with aging, not as a consequence of massive weight loss.

Fig. 8.13 The wound is dressed with Steri-Strips and a longitudinal gauze dressing with Microfoam tape (3 M Company, Maplewood, MN). Circumferential dressings are avoided

Postoperative Care

The gauze dressing is removed the day after surgery. Any saturated Steri-Strips (3M Comp., Maplewood, MN) are replaced, and a simple gauze dressing with tape is applied. Noncircumferential dressings are used. The patient is given a supply of gauze and tape. She can start bathing the day after surgery. The procedure is usually not painful. Patients are often pleased because they can already see the improvement the day after surgery. At first, there is normally some irregularity and gathering along the incision. This unevenness smooths

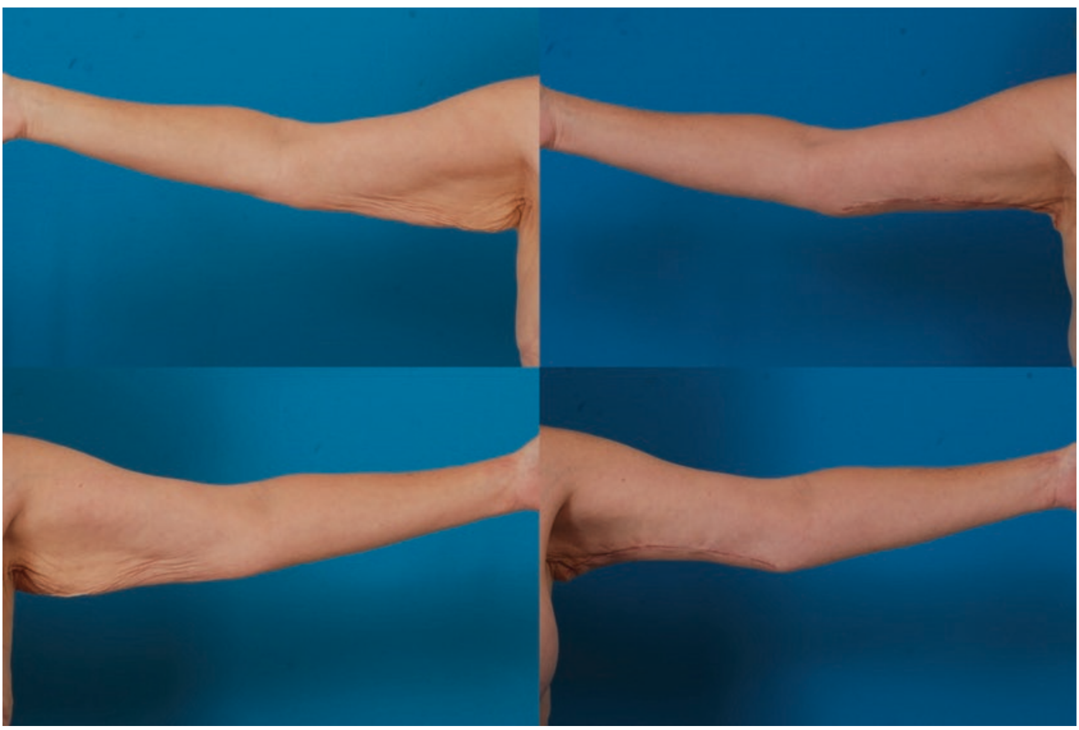

Fig. 8.14 Before (*left*) and 5-week postoperative photographs (*right*) of the 53-year-old woman whose preoperative and intraoperative photographs are shown in Figs. 8.5–8.13

Fig. 8.15 The scars are well-hidden on the frontal view of this 53-year-old woman 5 weeks after liposuction of the arms and brachioplasties. Posterior views are provided in Fig. 8.16

Fig. 8.16 The brachioplasty scars are inconspicuous from behind 5 weeks after surgery in this 53-year-old woman

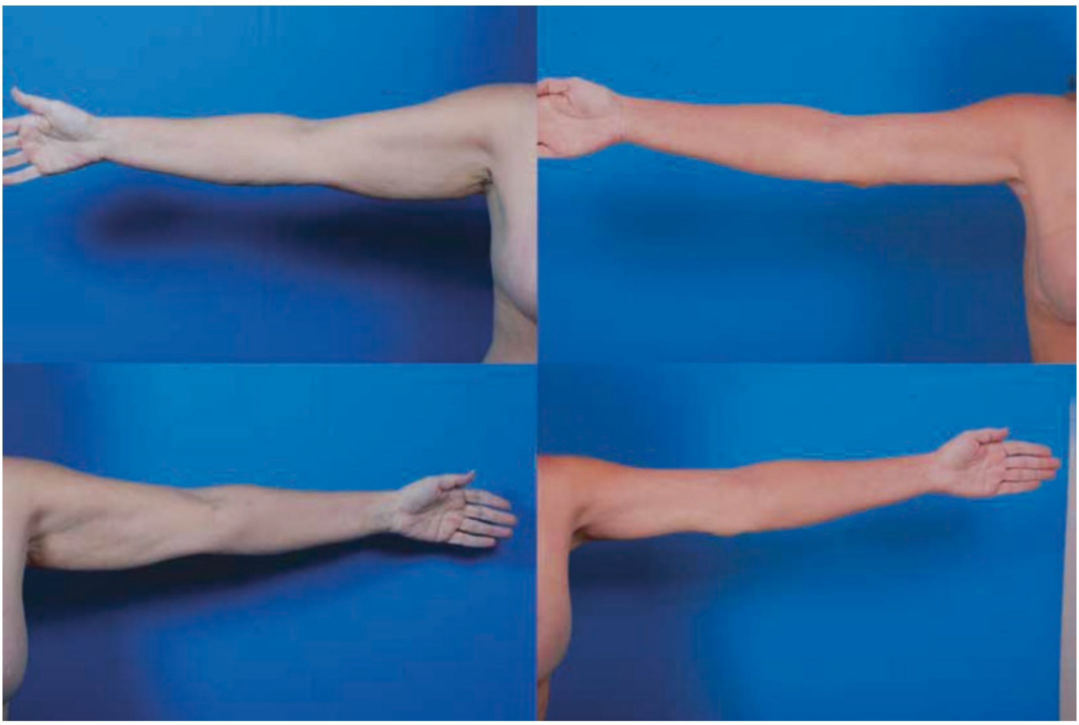

Fig. 8.17 This 52-year-old woman with a history of massive weight loss after bariatric surgery is seen before (*left*) and 2 years after (*right*) liposuction of the upper arms and brachioplasties. She has a small dog ear above the left elbow. Posterior views are provided in Figs. 8.18 and 8.19

out over a period of weeks. Normal day-to-day activities may be resumed right away. No garment is necessary [8]. However, some patients prefer the gentle compression of tight-fitting long-sleeved athletic wear. Nguyen and Rohrich [11] have their patients wear a compression garment for 3 weeks. The Steri-Strips come off at the 1-week follow-up appointment, or earlier. Vigorous physical activities are deferred for about 1 month.

Fig. 8.18 The patient in Fig. 8.17 is seen from behind 2 years after surgery. The scars are not visible with the arms raised

Fig. 8.19 This patient's scars have healed well but are still visible when the arms are relaxed at her sides. Ideally, the scars would be located more medially. The same patient is shown in Figs. 8.17 and 8.18

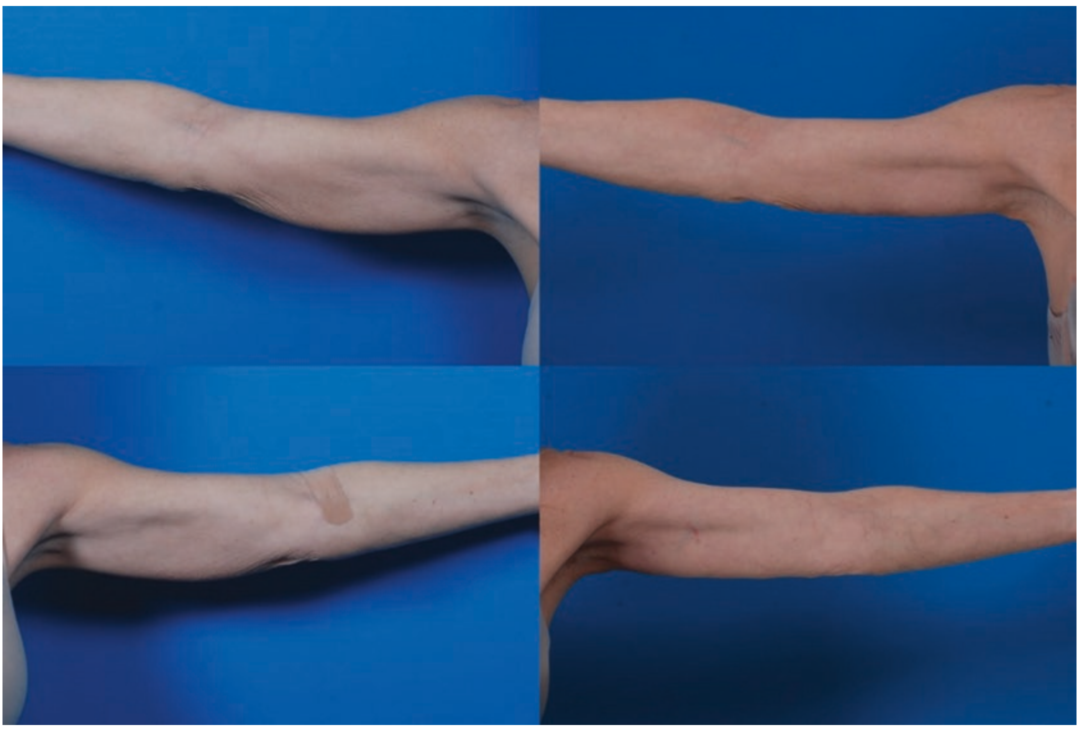

Fig. 8.20 This 54-year-old woman is seen before (*left*) and 2 years after (*right*) liposuction of the arms and brachioplasties. She was mildly overweight as a young woman but had otherwise maintained an ideal body weight

> The procedure is usually not painful. Patients are often pleased because they can already see the improvement the day after surgery.

Avoiding Complications

Operating Time

De Runz et al. [5] report a significant correlation between operating time and the complication rate. This association may reflect factors other

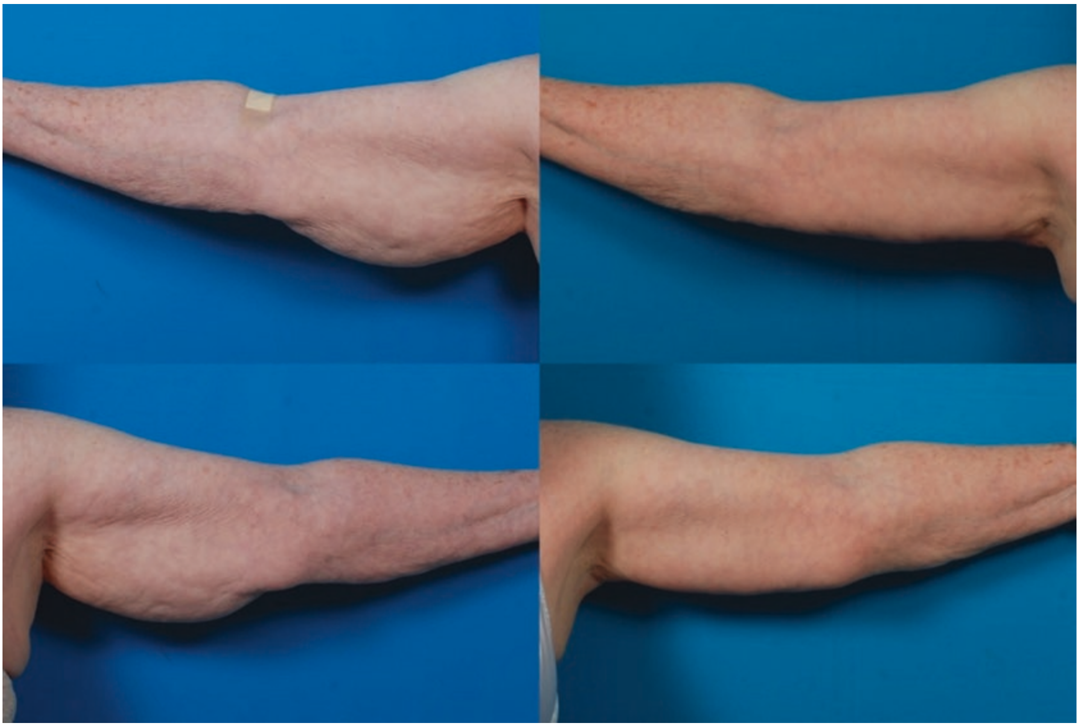

Fig. 8.21 This 66-year-old woman had never been substantially overweight. Nevertheless she developed major ptosis of the upper arm. She is seen before (*left*) and 3.5 months after (*right*) liposuction of the arms and axillae and brachioplasties

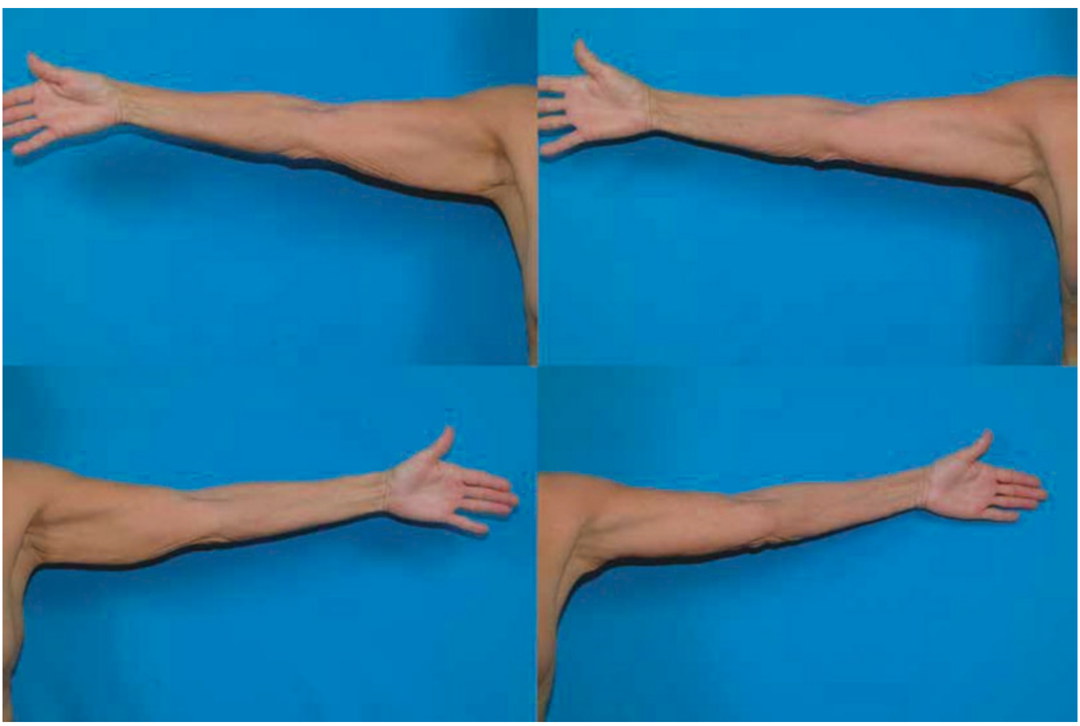

Fig. 8.22 This 65-year-old woman with no history of obesity underwent brachioplasties at the same time as an abdominoplasty and inner thigh lifts. She is seen before (*left*) and 3 months after surgery (*right*)

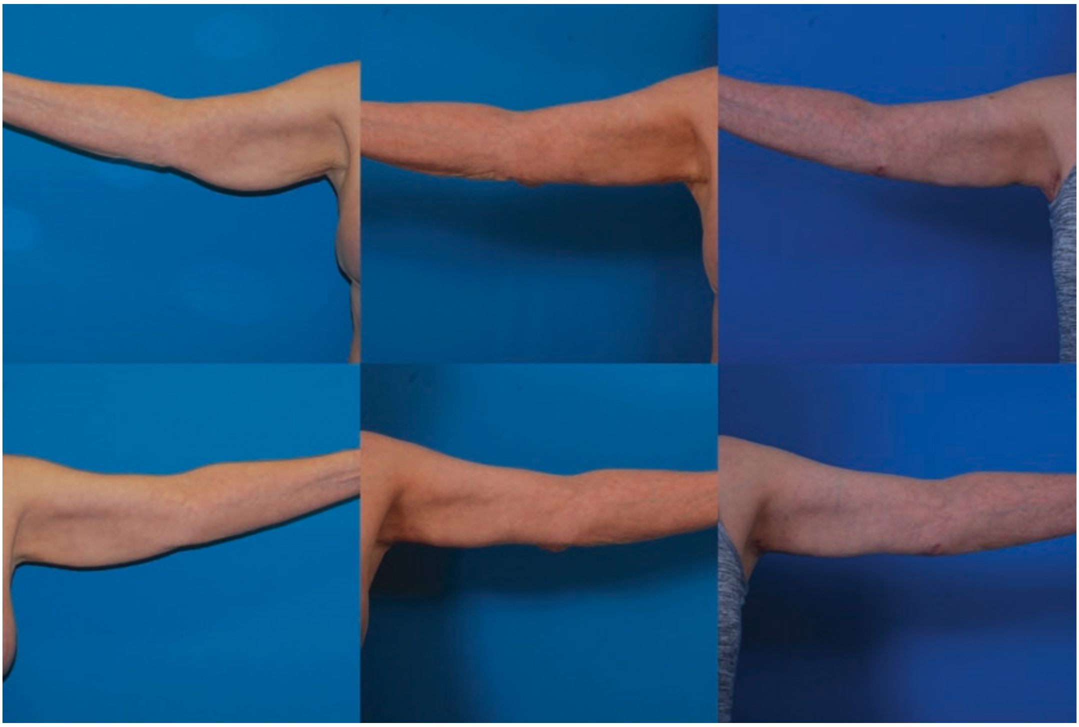

Fig. 8.23 This 67-year-old woman is seen before (*left*) and after liposuction of the arms and brachioplasties (*center, right*). She had no history of bariatric surgery or major weight loss. She was unhappy with puckers at the proximal and distal ends of the scars 2 years later (*center*). These dog ears were revised using horizontal resections. She is seen 5 weeks after the revision (*right*)

than strictly time, such as difficulty of the case (more difficult cases taking longer to perform). It is difficult to separate out operating time independently from other relevant factors such as blood loss. Gusenoff et al. [4] conclude that >8 h of operating time increases the risk of complications; however, these complications included problems from the concomitant procedures. The author does not schedule procedures that are anticipated to require >6 h, although this figure is arbitrary and may on some occasions be exceeded. Brachioplasties typically require 1 h of operating time for both sides, including liposuction. Blood loss is negligible. Consequently this operation is often done at the same time as other body contouring procedures.

Brachioplasties typically require 1 h of operating time for both sides, including liposuction. Blood loss is negligible.

Combining Procedures

Limiting the number of operations by combining procedures reduces a number of risk factors related to surgery simply by having fewer operations. Combining procedures also reduces the cost and patient inconvenience. Massive weight loss patients typically require multiple procedures, so that procedures are often done in combination—96% in the series reported by Gusenoff et al. [4]. However, this advantage needs to be balanced against anticipated blood loss and surgeon fatigue. Combining procedures is no longer an advantage if patients experience excessive and avoidable morbidity.

> Combining procedures is no longer an advantage if patients experience excessive and avoidable morbidity.

Zomerlei et al. [2] report a 53.1% complication rate in their review of 96 brachioplasty patients. The complication rate was significantly higher in patients who had previous bariatric surgery. These investigators found no increased risk of major complications for patients treated with concomitant procedures [2].

Smoking

Surprisingly, de Runz et al. [5] did not detect a significant correlation between smoking and the complication rate. Avoiding flap undermining optimizes blood supply to the flap margins.

Simultaneous Liposuction

Knotts et al. [12] report an overall complication rate of 50% after avulsion brachioplasty performed in conjunction with liposuction. Zomerlei et al. [2] find no difference in complication and revision rates comparing patients treated with or without simultaneous arm liposuction. Similarly, Bossert et al. [9] report a complication rate of 46% with no increased risk in patients treated simultaneously with liposuction, which was done in almost half (44.7%) of their patients, and no difference in revision rates, which averaged about 9%.

Nguyen and Rohrich [11] report one wound dehiscence and one hypertrophic scar among 21 patients treated with liposuction-assisted posterior brachioplasty, and no revisions. Pascal and Le Louarn [13] advocate circumferential arm liposuction with limited undermining and report a 4.7% revision rate and no seromas.

Over-Resection and Under-Resection

Over-resection is to be avoided because of the excessive wound tension that it may produce [8]. In the unlikely event that a wound cannot be approximated (an event to be avoided, obviously), a skin graft may be taken from the resection specimen. Under-resection may necessitate a second procedure. Tailor-tacking is used by many operators [3–6, 8, 9, 12, 19]. Knotts et al. [12] use a towel clamp to gauge the resection before making the incision. The author prefers not to tailor-tack so as to avoid any skin trauma from staples or towel clips. Simply gathering the skin in surgery and judging the correct resection width are sufficient (Fig. 8.8). De Runz et al. [5] report that 12.1% of their patients complained of under-resection or asymmetry.

Contour Irregularities (Dog Ears)

The skin deformity may extend distal to the elbow [3]. However, most operators do not extend the incision onto the forearm. Dog ears may persist either proximally or distally (Figs. 8.17 and 8.23). A longer scar is preferred over a residual contour irregularity [5]. If it is small, a longitudinal resection of the dog ear may be done under local anesthesia. If a larger amount of loose skin is present, a transverse resection may be used, so that the scar ends as a T both proximally and distally (Fig. 8.23). Existing transverse bands (resembling amniotic bands) are not corrected by brachioplasty and represent an unsolved problem. Release with Z-plasties may cause unacceptable scarring [8].

> A longer scar is preferred over a residual contour irregularity.

Wound Dehiscence

Variation exists in the incidence of wound dehiscence, and there is subjectivity in defining this complication. Bossert et al. [9] report a 2.6%

wound dehiscence rate, all superficial skin edge separations that were managed in the office with dressing changes. De Runz et al. [5] report that 9.1% of their patients developed a wound dehiscence, treated with local wound care and allowed to heal spontaneously. In their series of avulsion brachioplasties, Knotts et al. [12] report 14/44 (32%) patients with wound dehiscences. Similarly, Capella et al. [8] encountered this complication in 25% of their brachioplasties.

Scarring

Scar assessment is subjective, and revisions are largely dependent on the surgeon's level of perfectionism [12] and the cost to the patient. De Runz et al. [5] report a 41.7% rate of scar widening and a 20% rate of scar revision. Similarly, Zomerlei et al. [2] report hypertrophic scars in 24% of patients; 22.9% of patients underwent surgical revisions. Knotts et al. [12] performed 9 scar revisions in 44 patients (20%) treated with avulsion brachioplasty. Bossert et al. [9] report a revision rate of about 9%, usually for hypertrophic scarring and dog ears, and performed in the office under local anesthesia.

Seroma

Bossert et al. [9], treating exclusively postbariatric surgery patients, experienced a seroma rate of 23.1%, with no significant difference comparing patients treated with or without simultaneous liposuction. Most seromas resolved after a single or multiple aspirations in the office [9]. The authors attribute their high rate of seromas to lymphatic obstruction and shear stresses [9], although they use elastic bandage wraps for the first postoperative week and then transition to compression garments for 6 weeks. These authors also insert closed suction drains for 1 week in all patients [9]. Capella et al. [8] report a 10% seroma rate, occasionally requiring marsupialization of the seroma cavity.

Other operators encounter fewer seromas [2, 5, 12]. De Runz et al. [5] report no seromas in 66 brachioplasty patients. Knotts et al. [12] report one seroma in 44 patients (2%). This problem is minimized by avoiding aggressive liposuction. Limiting unnecessary tissue injury by limiting ultrasound times (if used), avoiding radiofrequency or laser assistance, and using scalpel dissection as opposed to electrodissection may also reduce the risk of seromas.

Drains are unnecessary [5]. Zomerlei et al. [2] found no difference comparing the seroma rates in patients treated with or without drains.

> Limiting unnecessary tissue injury by limiting ultrasound times (if used), avoiding radiofrequency or laser assistance, and using scalpel dissection as opposed to electrodissection may also reduce the risk of seromas.

Infection

Infections occurred in 2 of the 66 patients (3%) in the series reported by de Runz et al. [5] and 5.6% in the series of 144 brachioplasty patients reported by Bossert et al. [9].

Numbness

Knoetgen and Moran [10] report paresthesias in 2/40 (5%) of their patients. Injuries to the medial antebrachial cutaneous nerve were confirmed by nerve conduction studies [10]. Gusenoff et al. [4] report no injuries to this nerve in 101 brachioplasties.

Hematoma

Hematomas are unusual, occurring in approximately 2% of patients [5, 9]. The vessels are small and easily controlled with cautery. There is no skin undermining, so that there is no dead space.

Lymphedema

Bossert et al. [9] describe three patients (2%) who required prolonged compression therapy for upper extremity swelling.

Patient Satisfaction

De Runz et al. [5] report that 86.8% of their patients would repeat the surgery and 52% rated the aesthetic outcome as excellent or pleasing. The majority of brachioplasty patients (77%) experience an improvement in their quality of life.

> The majority of brachioplasty patients (77%) experience an improvement in their quality of life.

Brachioplasty Combined with Torsoplasty

De Runz et al. [5] combine brachioplasty with a torsoplasty in 18% of patients. These operators use a Z-plasty in the axillary groove to break the line of the incision and avoid a scar contracture across the joint, which may restrict arm abduction [9]. Other surgeons also use Z-plasties or small transposition flaps to break up the scar [8, 10, 12] before it extends inferiorly at a 90° angle onto the chest wall [6–10, 12]. Unfortunately these small flaps, located at the junction of two elliptical resection patterns, are subject to breakdown [8].

The author prefers to avoid an extension beyond the axilla, limiting the brachioplasty to the arm and accepting skin redundancy of the lateral chest, although the axilla and scapula are routinely treated with liposuction. This approach may be insufficient for some postbariatric surgery massive weight loss patients.

The axilla, along with the upper arm and adjacent chest are appreciated for femininity, beauty, and sensuality [7]. Longitudinal scars on the sides of the torso run against natural skin creases, and this area may intentionally be exposed by clothing [3]. Consequently, the cost/benefit analysis is less clearly in favor of these additional scars [22].

Scapular Lift

A common concern among women as they age is the lateral skin laxity of the mid-torso, often called the bra fat. There may be minimal fatty excess, particularly in women who have had this area treated previously with liposuction. An L-shaped scar may cause unacceptable scarring, as discussed above. An alternative option is a scapular lift, with (Figs. 8.24 and 8.25) or without a simultaneous brachioplasty (Fig. 8.26), placing the scar at (Fig. 8.25) or below the bra line (Fig. 8.26), in accordance with the patient's preference.

> An L-shaped scar may cause unacceptable scarring. An alternative option is a scapular lift, with or without a simultaneous brachioplasty, placing the scar at or below the bra line, in accordance with the patient's preference.

Hand Rejuvenation

Rejuvenation of the hands is becoming more popular. Hands can be a giveaway sign of aging. Fat injection provides a layer of cushioning between the skin and the underlying tendons and veins, making them less conspicuous. Laser resurfacing can be done simultaneously to treat brown spots. Coleman [23] believes that fat injection can also improve the texture of the overlying skin.

> Fat injection helps by providing a layer of cushioning between the skin and the underlying tendons and veins, making them less conspicuous.

Fig. 8.24 This 58-year-old woman wished to eliminate the loose skin and creases of her sides (*left*). She underwent scapular lifts simultaneously with brachioplasties. She had undergone previous liposuction of the arms and axillae. The scars were located along her bra line to make them easy to conceal. She is seen 3.5 months after surgery (*right*). Before-and-after brachioplasty photographs are provided in Fig. 8.25

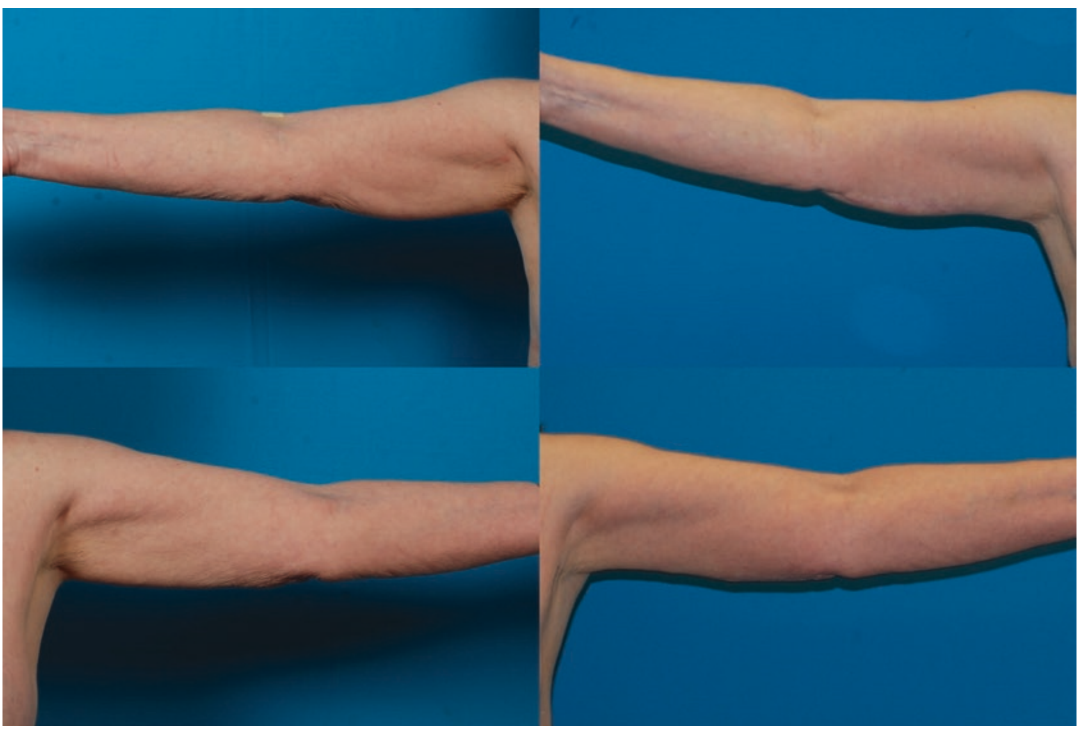

Fig. 8.25 This 58-year-old woman is seen before (*left*) and 9.5 months after (*right*) brachioplasties performed in combination with scapular lifts as shown in Fig. 8.24

Fig. 8.26 This 69-year-old woman (and Guns n' Roses fan) wanted to improve the skin tone of her sides. Her scars were positioned below the border of her halter top. She is seen before (*left*) and 3.5 months after (*right*) scapular lifts and liposuction of the arms and axillae

Surgery

The abdomen or, in very lean patients, the outer thighs, typically serves as the fat donor site. Frequently the face is injected simultaneously. The fat component is separated from the fluid using an inline filtration system. The author uses either the Lipivage (Genesis Biosystems, Lewisville, TX) system or, if a larger amount of fat is being harvested for simultaneous buttock fat transfer, the Tissu-Trans Filtron system (Shippert Medical Technologies, Centennial, CO). A 10-cc syringe is used. Smaller syringes may be used if preferred by the operator. Centrifugation is unnecessary if a closed filtration system is available. Using one or two incisions at the level of the wrist, the fat is injected in radial strokes over the dorsum of the hand. The access incision is repaired with a 6–0 Prolene (Ethicon, Somerville, NJ) suture. A blunt Coleman cannula (Mentor Worldwide LLC, Irvine, CA) is used so as not to puncture the veins. The fat is massaged gently to even it out. Typical volumes range from 10 to 15 cc. No dressing or garment is necessary.

Using one or two incisions at the level of the wrist, the fat is injected in radial strokes over the dorsum of the hand.

Clinical Examples of Fat Injection and Laser Resurfacing

Examples of fat injection of the hands are provided in Figs. 8.27–8.29. This method may be combined with laser resurfacing (Figs. 8.30 and 8.31).

Fig. 8.27 This 45-year-old woman is shown before (*above*), 10 days after (*center*), and 3 years after (*below*) fat injection using 7 cc per hand. She returned for a second fat injection procedure (6 cc per hand) 3 months before the 3-year follow-up photographs were taken (*below*)

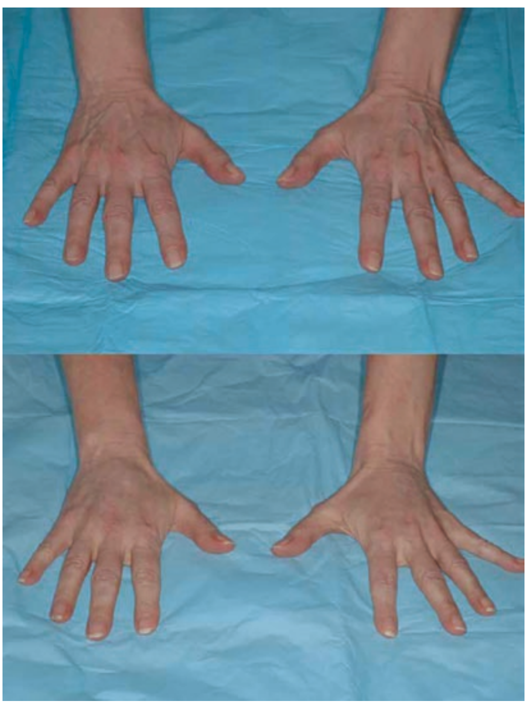

Fig. 8.28 This 50-year-old woman underwent fat injection of the hands (11 cc per hand). She is seen before (*above*) and 3 months after surgery (*below*)

Fig. 8.29 This 56-year-old woman is shown before (*above*) and 5 weeks after fat injection (*below*) using 10 cc per hand

Fig. 8.30 This 55-year-old woman had a youthful facial appearance but thought her hands gave away her age. She is seen before (*above, left*), 1 month after (*above, right*), 1 year after (*below, left*), and 3.5 years after (*below, right*) fat injection (11 cc per hand) and erbium:YAG laser resurfacing. She had no subsequent fat injection or laser procedures

Fig. 8.31 This 60-year-old woman is seen before (*above*) and 3.5 months after (*below*) fat injection of the hands (15 cc per hand) and simultaneous laser skin resurfacing using a carbon dioxide laser

Postoperative Care

Fat injection of the hands is not a painful procedure. Swelling and bruising are normal. Patients can wash their hands immediately. Patients are instructed to avoid manual activities such as gardening for at least 2 weeks. The sutures are removed in the office in 2 or 3 days. Patients are instructed to avoid sun exposure on any bruised areas so as to avoid hyperpigmentation.

Complications

The procedure may be repeated if necessary (Fig. 8.27). Infection is very unusual. Occasionally a persistent fat nodule may require excision in the office.

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Buttock Fat Transfer

9

Abstract

Buttock appearance is undeniably important to human attraction. A low (0.70) waist-to-hip ratio in women is regarded as ideal. Today, the Brazilian Butt Lift is one of the most requested cosmetic surgical procedures, even though it is a misnomer.

Buttock implants were popularized over a decade ago. However, despite greater experience with this technique, problems persisted, including infection, seroma, wound dehiscence, and implant malposition, causing an unnatural and often asymmetric buttock appearance.

Liposuction is an extremely popular cosmetic operation. Rather than discarding the aspirated fat, it may be transferred, reducing the role for thermal methods that destroy fat cells. The buttock is a suitable recipient site because it expands easily. Large syringes and cannulae have reduced the operating time. Centrifugation is unnecessary.

A study using ultrasound to measure fat thickness found that the calculated fat retention is about 66%. Local complications such as infection, seromas, or oily cysts are rare.

Overaggressive liposuction can produce contour deformities at the fat donor sites, and these problems are best avoided. Patients may benefit from a subsequent touchup fat injection procedure to achieve more volume.

Flap transposition, sometimes done at the time of a body lift, provides no net increase in buttock volume but adds to the operating time and blood loss. Fat injection is a simpler option and can provide lateral gluteal augmentation.

The most serious complication of buttock fat injection is fat embolism, which is often immediately fatal. This problem is caused by deep penetration of the cannula, with trauma to the gluteal veins. Surgeons may reduce the risk by injecting tangentially to the muscle, staying within the subcutaneous plane. The author does not use an incision in the gluteal fold and prefers side-to-side positioning in surgery.

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Introduction

Buttocks have some of the same qualities making them look good in men and women—full buttock cheeks, definition, and skin tone. Heidekrueger et al. [1] recently published the findings of an online survey, suggesting that a 0.70 waist-to-hip ratio was ideal. The authors used a volunteer model whose proportions were digitally altered to reflect different waist-to-hip ratios. Specifically, men prefer larger buttocks controlling for other covariates (profession, age, ethnicity, region), younger people perceived larger buttocks to be more attractive, and non-Caucasians perceived larger buttocks to be more attractive compared with Caucasians [1]. Buttock size preferences did not differ significantly across peoples' profession (surgeon or lay people), gender, and country of residence. Wong et al. [2] reported a slightly lower ratio in their contemporaneous study, 0.65, signaling a shift to a curvier ideal.

Fat injection of the buttocks has increased dramatically in popularity over the last decade [3] and is now frequently performed at the time of liposuction. In the author's practice, 20% of women undergoing liposuction also have buttock fat injection. In patients with sufficient donor sites, buttock fat transfer is preferred over silicone implants because of its lower risk of complications [4, 5]. Until recently [6], however, its efficacy had not been well-documented by measurement studies. To what degree does the fat survive the transfer, if any? To learn more about the efficacy of this method, the author undertook a measurement study, using both photographic measurements and ultrasound measurements [6].

> In patients with sufficient donor sites, buttock fat transfer is preferred over silicone implants because of its lower risk of complications.

Some operators have expressed concern that large-volume syringes, such as 60 cc, used by many operators today, may deposit too much fat with each injection stroke, leading to nonviable fat and the formation of oily cysts. This study offered a method—ultrasound imaging—to evaluate this possibility. The findings were surprising.

In recent years, the dangers of fat emboli have become widely publicized [7, 8]. Operators are learning to use caution not to inject the fat too deeply in the area of the large gluteal veins.

Gluteal Landmarks

Buttock shapes include the A shape, V shape, square shape, and round buttock [9]. A sacral triangle is defined by the sacral dimples (posterior superior iliac spines) and the coccyx [10]. The upper border of the buttock is at the level of the iliac crest, and the lower margin is defined by the gluteal fold [10]. The lateral gluteal (or trochanteric) depression is labeled the C-point [10]. Many patients wish to have this depression filled in at the time of buttock fat transfer. Patients sit on the ischial tuberosities, located below the buttocks [10].

Liposuction

Properly performed liposuction can improve the appearance of the buttocks by reducing excess fat from adjacent areas. For both women and men, reduction of the flanks and lower back accentuates the buttocks. This is an illusion that works well to give more of an hourglass figure in women and improves the appearance of the male butt. Liposuction is discussed in Chap. 3. The new term "relative buttock projection" takes into account the decrease in volume of the flank and lower back, contributing to the appearance of buttock projection [6].

Fat Cell Preservation

In the past, fat obtained by liposuction was usually discarded. We now recognize that there is a limited amount of fat cells available and it is a shame to discard this limited resource if it can be put to good use. It is becoming much more common now to save this fat and inject it where we want it. The appeal of techniques that destroy fat cells, such as heat from ultrasound or laser energy, has largely been lost in favor of methods that preserve the integrity of fat cells. Patients readily grasp the logic of saving fat and using it either in the face or buttocks. Patients recognize that, with aging, the buttocks tend to lose their youthful fullness. Fat injection may help to offset future flattening of the buttocks. In the author's experience, some women are very pleased to be offered this option. Many women are unaware that this option is available and may not ask about it. It is best not to try to judge who is interested and who is not and simply offer buttock fat injection routinely as an adjunctive procedure.

> Patients recognize that, with aging, the buttocks tend to lose their youthful fullness. Fat injection may help to offset future flattening of the buttocks.

Prospective Controlled Study of Buttock Fat Transfer

Ultrasound imaging has been previously used to assess the thickness of the subcutaneous fat layer in other applications [11, 12]. Ultrasound imaging has been compared to anthropometric measurements and CT scans and found to be similar in accuracy and sensitivity for measuring changes in gluteal projection [13]. Measurements on standardized photographs may also be used to assess changes in fat thickness [14].

Twenty-five consecutive patients underwent buttock fat injection [6]. The inclusion criteria were simply patients having buttock fat injection and returning in follow-up at least 3 months after surgery. The inclusion rate was 84%. A separate group of 30 patients undergoing cosmetic surgery without buttock fat transfer during the same study period served as a control group for ultrasound measurements. Twenty-five control patients returned in follow-up at least 3 months after surgery (inclusion rate, 83%). Eight of the control patients underwent liposuction. The eight patients treated with liposuction served as controls for the photographic analysis. Liposuction donor sites always included the abdomen and flanks. The outer thighs were treated in six patients.

Photographic Measurements

Patient photographs were matched using the Canfield 7.4.1 imaging software (Canfield Scientific, Fairfield, NJ). The surface area of each buttock within the treatment area was measured (Fig. 9.1). This area corresponded to the region marked preoperatively, extending from the lateral gluteal border to the intergluteal cleft, superiorly to the transitional area between the buttock and the flank and inferiorly to the gluteal fold. The horizontal distance from the anterior margin of the mons pubis to the point of greatest buttock projection ("buttock projection") was recorded (Fig. 9.2). In addition, the horizontal distance from the level of maximum lumbar lordosis to the point of greatest buttock projection was measured ("relative buttock projection"). To ensure photographic standardization, the same examining room, lighting, focal distance, Nikon D80 digital camera, and fixed 60 mm lens (Nikon, Tokyo, Japan) were used for all patients.

> The horizontal distance from the level of maximum lumbar lordosis to the point of greatest buttock projection was measured ("relative buttock projection").

Ultrasound Measurements

A single linear measurement was made in the central gluteal area with patient positioned prone (Fig. 9.3), at the point of greatest fat thickness of each buttock [6]. All ultrasound measurements were made in the office by the same full-time sonographer employed by the author. The caliper function was used on the Terason t3200 software (Terason Ultrasound, Burlington, MA) (Fig. 9.4).

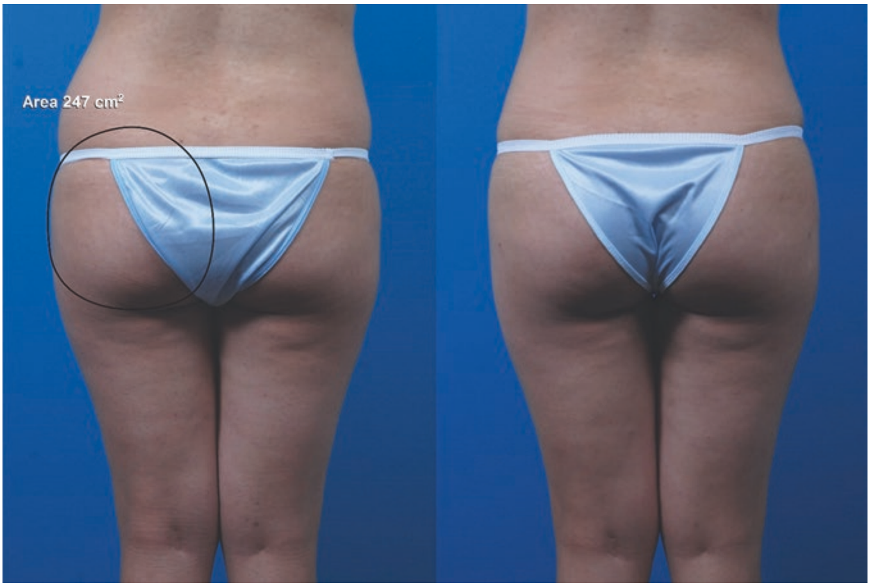

Fig. 9.1 Posterior photographs of a 25-year-old woman before (*left*) and 6 months after (*right*) liposuction of the abdomen, flanks, inner thighs, arms and axillae. A volume of 285 cc of lipoaspirate was injected into the subcutaneous tissue plane in each buttock. This patient's fat injection volume was very similar to the mean injection volume (287 cc) for study patients. The photographs were matched for size and orientation using the Canfield 7.4.1 imaging software (Canfield Scientific, Fairfield, NJ). The treated gluteal area was measured on both sides using the area measurement function of the imaging software. The surface area (247 cm^2) is indicated for the left buttock. The combination of liposuction of the flanks and buttock augmentation with fat produce a more aesthetic, rounder appearance. There is no contour deformity of the flank donor sites [Reprinted from Prospective controlled study of buttock fat transfer using ultrasound and photographic measurements. Plast Reconstr Surg Glob Open 2016;4:e697. With permission from Wolters Kluwer Health, Inc.]

Ultrasound measurements were recorded at the time of the preoperative appointment (usually 2 weeks before surgery) and ≥3 months after surgery so as to allow time for the swelling to resolve. Patient weights were recorded simultaneously using the same hospital scales. Fat retention was calculated using the formula:

Fat retention = buttock area (cm^2) × difference in buttock fat thickness (cm)/fat injection volume (cc).

Patients also underwent Doppler ultrasound evaluation as part of surveillance for deep venous thromboses. This subject is discussed in detail in Chap. 13. Patients undergoing liposuction of the abdomen or abdominoplasty are also screened for abdominal wall defects.

Study Findings

There was one male patient in the treatment group and two males in the control group; all other patients were female [6]. Age, sex, smoking status, and body mass index (BMI) were similar for the treatment and control groups. The mean follow-up time for treated patients was 5.8 months (range, 3–15.5 months). The mean fat volume injected per buttock was 287 cc (range, 70–550 cc). Photographs of the patient with lipoinjection volumes (285 cc per buttock) closest to the mean are provided (Figs. 9.1 and 9.2).

Ultrasound measurements detected a significant change in the thickness of the subcutaneous fat layer after surgery ($p \leq 0.001$), with a mean increase of 0.66 cm for the right buttock and 0.86 cm for the left buttock, corrected for a slight postoperative decrease in body mass index. The mean calculated fat retention was 66%. Photographic measurements revealed a significant increase ($p < 0.01$) in buttock projection (right, 0.44 cm; left, 0.54 cm) and relative buttock projection (0.69 cm and 0.73 cm, respectively) for treated patients, corrected for change in body mass index. There were no significant changes for control patients.

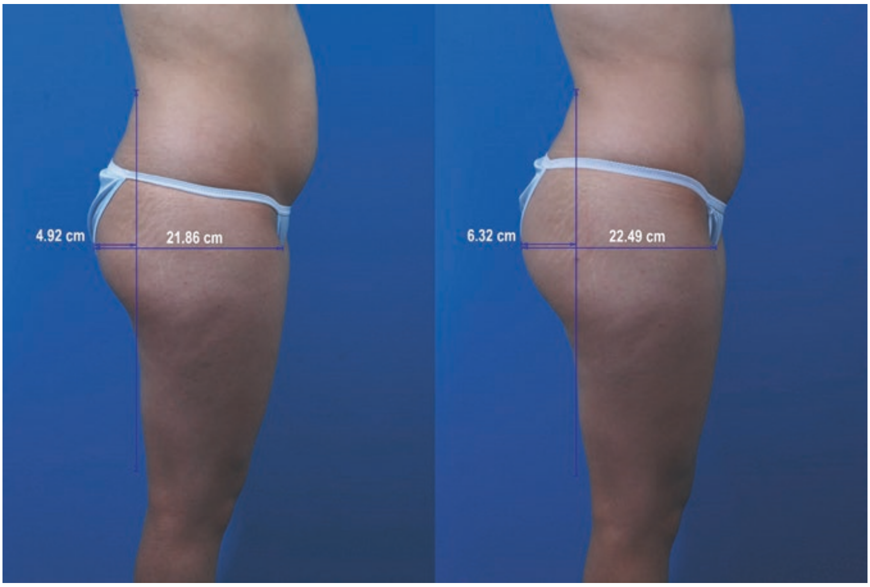

Fig. 9.2 Lateral photographs of the same patient depicted in Fig. 9.1, before (*left*) and 6 months after (*right*) liposuction and buttock fat injection. Photographs are matched for size and orientation. Buttock projection is defined as the horizontal dimension connecting the mons pubis with the point of greatest buttock projection. This measurement has increased approximately 0.6 cm. Relative projection is measured from the level of the lumbar lordosis to the same point of maximum buttock projection. The difference is 1.4 cm in this patient. An increased relative projection is provided by simultaneous liposuction of the flank and lower back [Reprinted from Prospective controlled study of buttock fat transfer using ultrasound and photographic measurements. Plast Reconstr Surg Glob Open 2016;4:e697. With permission from Wolters Kluwer Health, Inc.]

Fig. 9.3 Buttock fat thickness is measured at the point of greatest fat thickness of each buttock with the patient lying prone. This measurement is made before surgery and at ≥3 months after surgery

The mean calculated fat retention was 66%.

Preoperative Marking

Patients are marked in a standing position before surgery. The recipient area is bordered by the lateral gluteal border laterally and the intergluteal cleft medially, superiorly by the transitional area between the buttock and the flank and inferiorly by the gluteal fold (Fig. 9.1). Many patients prefer lateral gluteal (trochanteric) fullness to accentuate the hourglass shape [4, 10, 15], and this area is routinely treated with the rest of the buttock during lipoinjection. Also, the donor sites are marked, which almost always include the flanks and lower back because subtraction of fat from these areas accentuates the curve of the buttocks. The other typical donor areas are the abdomen and thighs.

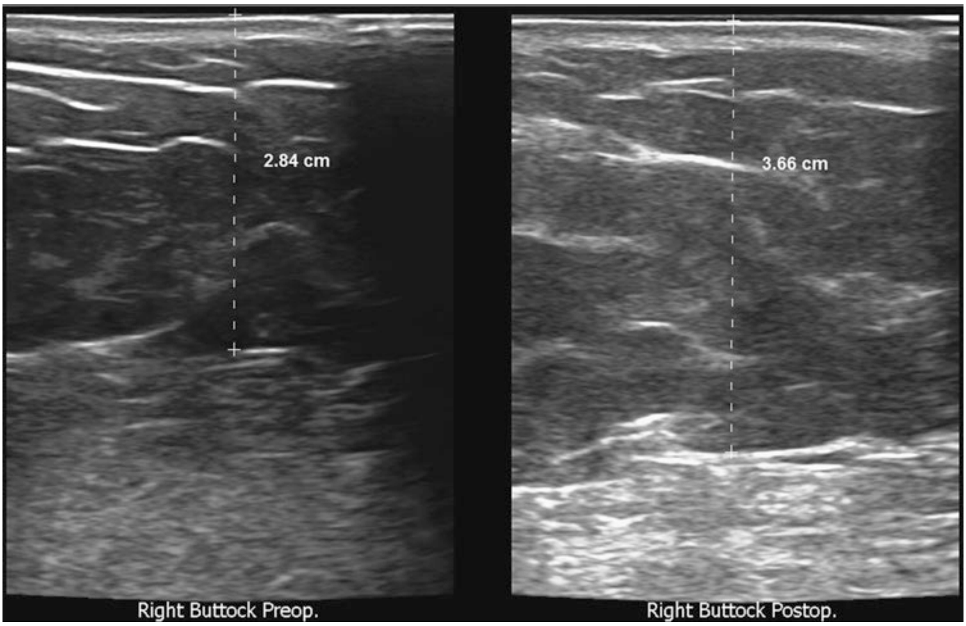

Fig. 9.4 Preoperative ultrasound image of the right buttock for the patient depicted in Figs. 9.1 and 9.2 (*left*). The thickness of the fat layer, measured from the muscle fascia to the skin surface, is 2.84 cm. Ultrasound image of the right buttock in the same patient 6 months after surgery (*right*). The thickness of the fat layer is 3.66 cm, a gain of 0.82 cm. The patient's weight is unchanged [Reprinted from Prospective controlled study of buttock fat transfer using ultrasound and photographic measurements. Plast Reconstr Surg Glob Open 2016;4:e697. With permission from Wolters Kluwer Health, Inc.]

The donor sites are marked, which almost always include the flanks and lower back because subtraction of fat from these areas accentuates the curve of the buttocks. The other typical donor areas are the abdomen and thighs.

Anesthesia and Patient Positioning

In keeping with SAFE anesthesia, all patients are treated under total intravenous sedation using a propofol infusion [16]. Details are provided in Chap. 5. Patients are prepped with warmed chlorhexidine solution circumferentially in a standing position. Patients are first positioned supine on the operating table and are then turned from side to side to perform the infusion [16] (Figs. 9.5 and 9.6) using a superwet (approximately 1:1 ratio of infusion/aspirate volume) technique. The wetting solution consists of 1 L normal saline with 500 mg (0.05%) lidocaine and 2 mL of epinephrine (1:526,000). Prone positioning is never used. The sequence is repeated for liposuction, giving the lidocaine and epinephrine at least 15 min to work and providing movement of the lower extremities (Fig. 9.7). A video that demonstrates local anesthetic injection, fat harvesting, and fat injection is available at http://journals.lww.com/prsgo/Pages/videogallery.aspx?videoId=45&autoPlay=true

Antibiotic prophylaxis consists of a single dose of cefazolin 1 g IV immediately before surgery followed by three doses of cephalexin 500 mg p.o. q12h.

Fat Collection

Liposuction is performed using a 4-mm-diameter blunt 3-hole ("Las Vegas tip") cannula and a 4-mm 1-hole spatula-tipped cannula. No other devices such as ultrasound, laser assistance, or

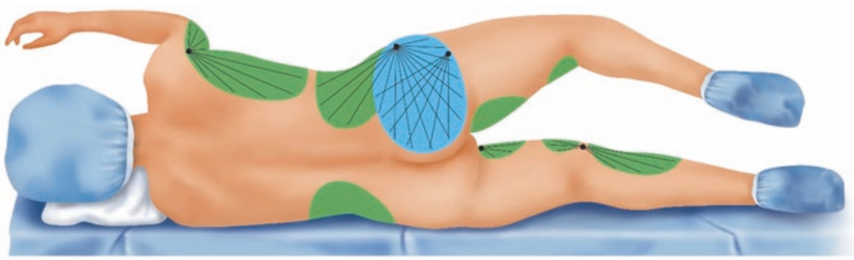

Fig. 9.5 Illustration of liposuction (*green*) and fat injection treatment areas (*blue*) with the patient positioned on her left side for liposuction of the right flank, arm, axilla (including the scapular area), and left medial knee. The abdomen and inner thighs have already been treated with the patient in the supine position. In some cases, the left medial calf and right lateral calf are also treated while the patient is in on her side. The outer thigh may be treated if desired (*not illustrated*). The patient is then turned onto her right side and the contralateral areas are treated in the same sequence, completing the liposuction. Prone positioning is not used. After liposuction to harvest the fat, the fat is injected subcutaneously into each buttock using two access incisions located laterally, with cross-hatching over the central buttock [Reprinted from Prospective controlled study of buttock fat transfer using ultrasound and photographic measurements. Plast Reconstr Surg Glob Open 2016;4:e697. With permission from Wolters Kluwer Health, Inc.]

Fig. 9.6 A 43-year-old woman is undergoing infusion of the buttock using 100 mL of a wetting solution that consists of 1 L of normal saline, 500 mg lidocaine (0.05%), and 2 mL 1:1000 epinephrine (1:526,000). She is positioned on her left side. She has already undergone a breast reduction and abdominoplasty while in a supine position. She is breathing spontaneously using a laryngeal mask airway and total intravenous anesthesia

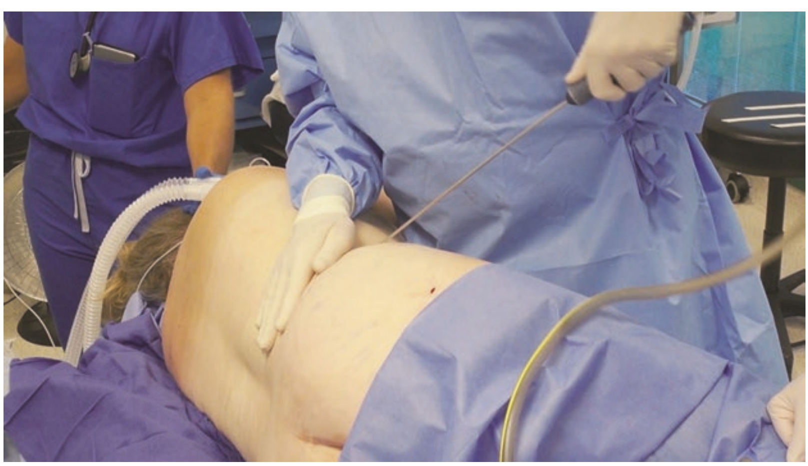

Fig. 9.7 The donor sites have been infused. The right flank is being treated with liposuction. In this patient, fat was harvested from the abdomen (prior to the abdominoplasty), flanks, arms, axillae, inner thighs, and medial knees

Fig. 9.8 The Filtron closed filtration device is used to separate the fat, allowing the filtrate to pass through

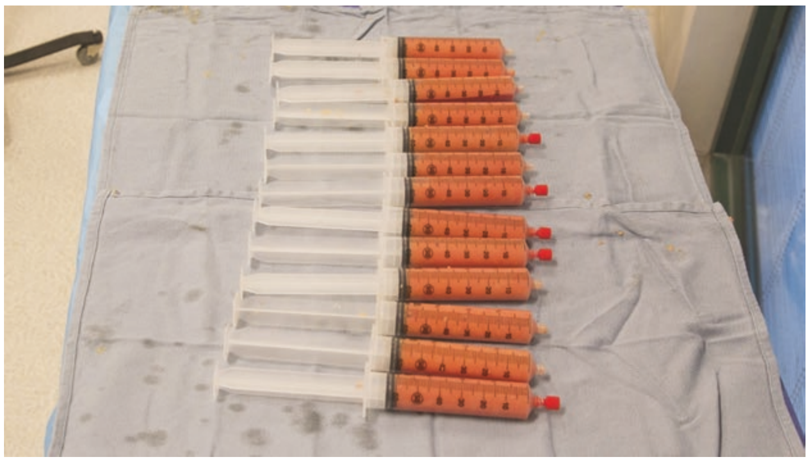

Fig. 9.9 The fat is transferred to 60-cc syringes. In this patient, 820 cc of fat were used for transfer, 410 cc for each buttock

radiofrequency are used so as to maximize adipocyte viability [17].

The author presently uses a Tissu-Trans Filtron 500 closed inline filtration system (Shippert Medical Technologies, Centennial, CO) to collect the fat without centrifugation (Fig. 9.8). There is no need to handle the fat, improving efficiency, and optimizing sterility. The lower abdomen can be aggressively treated with liposuction if the patient is simultaneously having an abdominoplasty (Fig. 9.7), and this is an advantage of the combined procedure.

After collection, the fat is used to fill 60-cc syringes (Fig. 9.9). The fat is then injected into the buttocks and lateral gluteal regions using a blunt 4-mm cannula with a side hole (Genesis Biosystems, Lewisville, TX) (Figs. 9.10, 9.11, and 9.12). This is a relatively large cannula that will not bend and enter unintended tissue planes. The same incision used for liposuction of the flanks is reused for fat injection (Fig. 9.10). A separate incision is made inferolaterally to allow cross-hatching (Fig. 9.11). No drains are used. Care must be taken when using Luer Lock connections to secure these snugly so that the cannula angle does not inadvertently angulate during injection passes.

Avoiding Gluteal Veins

Mofid et al. [8] conclude that patient positioning and incision location affect the trajectories a cannula might follow and could be very important regarding the risk of gluteal vein injury and

Fig. 9.10 The buttock is injected using the same right hip incision that was used previously for infusion and for liposuction of the right flank. The fat is injected in a grid pattern subcutaneously into the central buttock

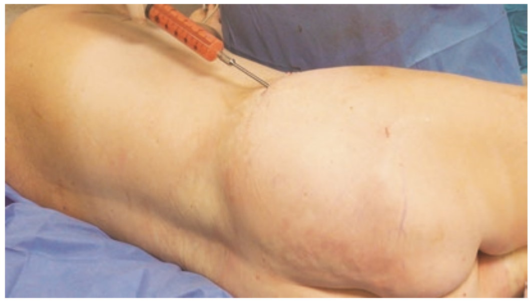

Fig. 9.12 The last area to be injected is the lateral gluteal area. The lower gluteal incision is sutured prior to injection so that fat does not escape during lipoinjection

Fig. 9.11 Fat is injected subcutaneously in to the lower right gluteal area using radial passes and a lower lateral gluteal incision

pulmonary fat emboli. In a cadaveric study, Ramirez-Montanana [18] illustrates the importance of keeping the injection angle shallow to avoid penetration of the deep veins.

To avoid injury to the superior and inferior gluteal veins, the author injects only in the subcutaneous plane (verified by postoperative ultrasound examinations in study patients [6]). Lateral positioning facilitates a subcutaneous injection because the cannula tends to travel tangentially above the gluteus maximus muscle within this low-resistance tissue plane (although it is still possible to inject deeply even from a lateral approach [18]). No incision is made inferiorly in the gluteal fold [19]. An inferior approach and excessive deep angulation [18] raise the risk of vascular penetration.

Lateral positioning facilitates a subcutaneous injection because the cannula tends to travel tangentially above the gluteus maximus muscle within this low-resistance tissue plane.

Postoperative Care

Patients wear a compression girdle postoperatively for 1 month. This girdle provides uniform compression of the buttocks and donor sites. Patients return to full activities including exercising in 1 month. Patients are not instructed to avoid sitting but rather to minimize sitting, bearing weight preferentially on the ischial areas and getting up frequently. Patients sleep supine.

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Fig. 9.13 This 32-year-old Hispanic woman is seen before (*left*) and 7 months after liposuction of the abdomen and flanks and buttock fat transfer (*right*). The liposuction volume was 1120 cc. A volume of 320 cc of fat was injected into each buttock. She had one treatment. The treatments work together to correct a square buttock appearance and enhance her hourglass figure. Her weight was 140.5 lb before surgery and 142 lb at the time of her follow-up appointment. Images are matched for size and orientation [Reprinted from Swanson E. Buttock augmentation with silicone implants: a multicenter survey review of 2226 patients. Plast Reconstr Surg. 2013;132:681e–683e. With permission from Wolters Kluwer Health, Inc.]

Clinical Examples and Long-Term Follow-Up

Clinical examples are provided in Figs. 9.13, 9.14, and 9.15, including long-term follow-up (Fig. 9.14). Figure 9.13 shows a patient with a modest improvement in proportions after injection of 320 cc of fat per buttock. Her preoperative waist-to-hip ratio was 0.82; after surgery, it measured 0.78. These ratios are based on linear measurements rather than circumferences. Circumference is linearly related to diameter, making the ratios comparable. The lateral view (Fig. 9.13) shows an enhanced S-shaped curve of the lower back and buttock. Maximum buttock projection is located appropriately at the level of the mons pubis. This operative outcome might be considered average and reproducible. The patient shown in Fig. 9.15 demonstrates a greater degree of augmentation, consistent with a larger volume of fat injected per buttock (660 cc).

Fig. 9.14 The patient shown in Fig. 9.13 is seen 4.5 years after surgery

Complications

No infections were encountered among the 25 consecutive patients in the author's study [6]. No patient developed symptoms or signs of fat necrosis. No evidence of fat necrosis (oily cysts) was detected on any of the ultrasound examinations. This was a welcome finding in view of the large syringes used. There were no seromas or hematomas. There were no cases of fat embolism. No deep venous thromboses were detected at any of the ultrasound examinations. No patient required hospitalization or a blood transfusion. All patients were treated with fat injection once. No patient underwent reoperation. There were no cases of sciatic neuropathy or painful paresthesias. There were no donor site complications and no contour deformities.

> There were no donor site complications and no contour deformities.

Safety Considerations

The patient is not paralyzed or intubated. A laryngeal mask airway is used and the patient breathes spontaneously [16]. This airway has proved to be safe with the patient in the lateral position, provided it is secured using tape. In a departure from traditional prone patient positioning [4, 15, 20–22], the author never uses prone positioning for liposuction or lipoinjection or any other procedure [6]. The author prefers to infuse the recipient site with a solution containing 1:526,000 epinephrine [16] rather than the traditional 1:1,000,000 concentration [4, 15, 23] so as to provide more vasoconstrictive effect on the small blood vessels. No incision is made in the gluteal fold so as to avoid neurovascular injury.

Previous studies report mean injection volumes in the range of 350–700 cc per buttock [20–25]. Some investigators use aggressive liposuction in an effort to obtain more fat for grafting [4, 24]. However, aggressive liposuction increases the risk of wound complications, such as seromas [4, 21, 24]. Murillo [24], who

Fig. 9.15 This 26-year-old woman is seen before (*left*) and 3 months after (*right*) liposuction of the abdomen, flanks, inner thighs, arms, and axillae with buttock fat transfer. The fat volume was 660 cc per buttock

injects an average of 700 cc of fat per buttock, reports a donor site (abdomen and sacrum) seroma rate of 40%. Drains may be needed [4, 15, 24]. Painful paresthesias of the flanks and gluteal regions are sometimes encountered [22, 25]. Contour irregularities may occur, especially in thin women. Such deformities, which may be underreported, can be difficult or impossible to correct. Clearly, any improvement in buttock projection should not come at the cost of a contour deformity elsewhere that may be difficult to conceal.

> Any improvement in buttock projection should not come at the cost of a contour deformity elsewhere that may be difficult to conceal.

Fat Embolism

In 2015, Cárdenas-Camarena et al. [7] reported 13 deaths in Mexico (survey data) over a period of 10 years and 9 in Columbia (autopsy registry) over

15 years in a sobering article titled "Deaths Caused by Gluteal Lipoinjection: What Are We Doing Wrong?" Deaths occurred during surgery or within the first 24 h. The reported fat injection volumes were surprisingly modest, with a mean volume of 214 cc and a range of 120–300 cc. Autopsies showed macroscopic fat embolism to the right heart and lungs, causing mechanical blockage of blood flow, in combination with injuries to the gluteal veins. These authors recommend keeping the injection cannula parallel to the gluteal surface to avoid entering the subpiriformis or suprapiriformis channels where the gluteal vessels are located [7].

The findings of a worldwide survey were recently published by Mofid et al. [8]. Respondents reported 32 fatalities from pulmonary fat emboli and 103 nonfatal pulmonary fat emboli. Three percent of respondents experienced a patient fatality and 7% of respondents reported at least one pulmonary fat embolism in a patient over their careers. Twenty-five fatalities were confirmed in the United States over a 5-year period through autopsy reports and interviews with surgeons and medical examiners. Four deaths were reported from 2014 to 2015 from pulmonary fat emboli in facilities accredited by the American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF) [8]. The authors [8] calculated a rate of both fatal and nonfatal pulmonary fat emboli over a 1-year period, 1:1030 cases. The risk was significantly increased in surgeons who injected fat into the deep muscle or angled the cannula downward during fat grafting. Smaller-diameter cannulae (<4.1 mm) and multiple-hole cannulae (as opposed to a single hole) were identified as risk factors [8]. The authors [8] speculate that a blunt cannula tip reduces the likelihood of injury to vessels, and a stiffer cannula may make it less likely to bend and follow a deeper path than intended. Larger-diameter cannulae deposit larger parcels of fat that may be less likely to enter the circulation [8].

> The risk was significantly increased in surgeons who injected fat into the deep muscle or angled the cannula downward during fat grafting.

An early experimental study [26] showed improved fat retention for intramuscular injection compared with subcutaneous injection in rats. Intramuscular fat injection was once preferred [4, 20, 23, 25]. However, recent investigators have injected the subcutaneous plane instead [22].

Fat Viability

Injection in multiple tunnels is a well-known measure [4, 15, 21, 22] to maximize fat vascularization. The use of 60-cc syringes may be challenged by surgeons who believe that too much fat is injected with each pass of the infusion cannula. This concern is based on the work of Carpaneda and Ribeiro [27, 28], who report that greater fat necrosis is likely if fat is injected in tunnels that exceed a diameter of 3 mm. Shear stress is minimized by using large infusion cannulae [29], which are less likely to impair adipocyte viability [30, 31].

Despite theoretical concerns about fat necrosis using large syringes and cannulae to inject fat, there were no clinical cases of fat necrosis in the author's series [6]. Moreover, there was no evidence of fat necrosis on the ultrasound scans, which are highly sensitive for the detection of oily cysts caused by fat necrosis [32]. Although early investigators used 3-cc syringes [23], the time commitment was substantial (e.g., 2–4 h for harvesting plus 1–1.5 h for injection [23]). In the last decade, most plastic surgeons [4, 15, 20–22] have adopted 60-cc syringes for large-volume fat transfer.

Centrifugation

Centrifugation is cumbersome and time-consuming, especially for large fat volumes [4]. Smith et al. [33] report no advantage in cell viability from washing the fat or centrifuging it and recommend against unnecessary manipulation or delayed reinjection.

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Negative pressures delivered by a vacuum pump do not appear to compromise the viability of adipocytes and adipose mesenchymal stem cells [29, 33, 34]. Any epinephrine toxicity to the fat is negligible [35]. Gerth et al. [36] report that a closed-membrane filtration system provides greater fat retention than centrifuged fat when injected in the face. Fisher et al. [37] find that filtration (using the same Filtron device used in the author's study [6]) and centrifugation both effectively remove fluid fractions and result in comparable graft retention, with minimal loss of the stromal vascular fraction in the discarded filtrate. Any fat that passes through the filter seems to have negligible viability [37].

Closed Filtration System

A closed filtration system differs from traditional collection methods that include centrifugation [23], a steel strainer [4], decanting [15, 20, 21, 23, 24], and placement of the fat on an absorbent pad [22]. Decanting (allowing the fat to separate by gravity) requires at least 20–30 min [20, 21]. The dilution of the lipoaspirate is variable, depending on whether a superwet (1:1 ratio) or tumescent (3:1 ratio) method is used [16]. The supranatant typically represents 40–50% of the lipoaspirate volume [4, 23]. Recognizing that fluid is injected with fat, some operators recommend overcorrection [22, 25]. However, Del Vecchio and Del Vecchio [38] caution that higher graft-to-capacity ratios can reduce volume maintenance (fat retention).

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A superwet infusion and a filtration system that separates the fat from the wetting solution may account for the relatively small lipoinjection volumes used by the author. Moreover, for many patients, buttock fat transfer is not their main objective but rather an adjunctive procedure. If offered the option, many patients (20% in the author's experience) elect to have some fat obtained by liposuction injected in their buttocks, even if only an incremental benefit is expected [6].

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Using closed filtration, buttock fat transfer typically adds <20 min to a liposuction procedure [6]. The typical operative time for liposuction of the abdomen and flanks and simultaneous buttock fat injection is 60–90 min. Efficient use of operating time lowers the cost and permits the procedure to be done in conjunction with other body contouring procedures including breast surgery and abdominoplasty [6].

Objective Measurements

Although several studies provide clinical data and subjective evaluation of buttock fat transfer [4, 15, 20–24], objective measurements are seldom reported. Murillo [24] used magnetic resonance imaging to document a qualitative increase in buttock fullness in six patients undergoing intramuscular buttock fat injection. Magnetic resonance imaging was also used by Wolf et al. [20] in a quantitative study of ten patients undergoing gluteal muscle injection, but only muscle areas were measured, not subcutaneous fat thickness, despite fat injection in both locations. Neither study [20, 24] controlled for postoperative changes in body mass index.

Magnetic resonance imaging is prohibitively inconvenient and expensive to use in a large number of patients [6]. Ultrasound examinations are more practical and were already being administered to these patients as part of surveillance for deep venous thromboses. A minimum follow-up time of 3 months is based on previous studies of fat injection using magnetic resonance imaging [39, 40] that reveal little change in the fat layer thickness beyond 3 months, suggesting that swelling has resolved at that time.

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Fat Retention

Evaluation of the percentage of fat that survives the transfer is notoriously difficult and is affected by numerous factors [38]. Estimates by plastic surgeons of fat retention after buttock fat transfer vary from 50 to >90% [4, 23–25] but are subjective. Khouri Jr. and Khouri [41] believe that a small volume of fat distributed evenly into a recipient site may achieve a high level of fat retention but minimal increment in volume. These authors [41] recommend a comparison of the final volume after augmentation with the initial recipient site volume as the more relevant ratio. However, the buttock typically starts with a much higher recipient site volume than the breast (Khouri Jr. and Khouri estimate 2000 cc [41]). Therefore, a 20% increase in buttock volume (i.e., 400 cc) may meet one's therapeutic goal for buttock augmentation, whereas a 20% increase in breast size in a patient with very hypoplastic breasts (e.g., increasing from 100 to 120 cc) would be insufficient. The graftable recipient space is likely to be important at very high (e.g., >700 cc) buttock injection volumes (which may become counterproductive [38]), but for more moderate volumes, the quality of the fat graft and surgical technique are likely to affect volume maintenance and are worthy considerations.

An increase in fat thickness of <1 cm is admittedly modest, but is complemented by fat reduction of the flanks, as demonstrated by the increase in relative buttock projection [6]. Even if fat retention were 100%, one could expect only about 1 cm of increased projection from 287 cc of fat distributed over an area of 250 cm^2. Accepting a lesser degree of augmentation is preferable to donor site deformities, seromas, and paresthesias caused by overly aggressive harvesting. Abboud et al. [22] reinject 20% of their patients. The author has a similar reoperation rate.

Moscatiello et al. [42] report the use of cryopreserved fat in a case report with before and after photographs that appear to show improved buttock fullness in a 42-year-old male 1 year after injection of fat that had been frozen slowly, first to −80 °C and then to −196 °C (liquid nitrogen) in a suspension of saline and 10% dimethylsulfoxide for 3 months. No measurement data are available.

Everett et al. [43] recently reported their experience using a roller pump method to inject an average volume of 1807 cc (900 cc per buttock). The authors report few complications (1.1%). One patient had a large oil cyst that drained 155 cc and required additional fat grafting.

Realistic Expectations

Unfortunately, there is a credibility problem in buttock augmentation surgery, starting with the name [5]. "Brazilian Butt Lift" is the third most popular item on the popular website RealSelf.com, with a "Worth It" score of 92% [44]. Why it is linked with Brazil is unclear. Fournier, a French surgeon, pioneered buttock fat injection (Gonzalez R, personal communication 25 July, 2017) along with plastic surgeons in Argentina [45] and Brazil [46, 47] in the 1980s. It is not a butt lift.

At their consultations, prospective patients often show photographs of dramatic results that they have found on the Internet. These photographs are typically quite different from those published in our professional journals, demonstrating exaggerated results [5]. There is often no indication of how many fat injection and liposuction treatments were used or the postoperative time interval. Sometimes adhesive strips and bruising reveal that the photographs were taken shortly after surgery, at the time of maximum swelling. Photographs are seldom standardized, so that different body positions (e.g., the patient flexed at the hips in the after photo and the waist rotated) contribute to the appearance of a reduced waist-to-hip ratio, even less than the idealized 0.70 figure [5]. Exaggerated results promote unrealistic patient expectations and make good outcomes appear inadequate. Nowhere is the mantra of underpromising and overdelivering more applicable.

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Silicone Buttock Implants

Buttock augmentation was originally accomplished using silicone implants [4, 48, 49]. However, the complication rate is very high (38.1% among surveyed surgeons [48]). Mendieta [4], who was an early proponent of gluteal implants, has abandoned them [50]. Centeno [51] has recalled all his patients for removal of their buttock implants. Indeed, greater surgeon experience does not seem to reduce the long-term problems associated with these devices. Many operators believe that the buttocks, subjected to the daily stress of sitting, lack an easy dissection plane, and, with additional challenges regarding sterility and malposition, are simply not a good site for silicone implants, unlike the breasts. Unfortunately, many women simply do not have sufficient fat stores to make buttock fat transfer worthwhile. These women may seek out surgeons who do perform buttock implants but must be aware of the complications.

> Many operators believe that the buttocks, subjected to the daily stress of sitting, lack an easy dissection plane, and, with additional challenges regarding sterility and malposition, are simply not a good site for silicone implants, unlike the breasts.

Complications of Silicone Buttock Implants

With the important exception of fat emboli after buttock fat transfer, the clinical safety of buttock fat transfer stands in stark contrast to the high complication rate of buttock implants [48]. In 2003, Mendieta reported a 30% wound dehiscence rate [4]. Senderoff [49] reported a 28% seroma rate and a 6.5% infection rate. Reoperation rates are seldom reported. Senderoff [52] recently reported revisions in 43 patients including implant removal (*n* = 24), implant replacement (*n* = 19), implant exchange (*n* = 18), capsulotomy (*n* = 6), site change (*n* = 5), and capsulorrhaphy (*n* = 1).

The patient or surgeon may be reluctant to remove an infected implant, leading to further complications [52]. Oral antibiotics are rarely effective [52]. Underdissection of the lower pole can lead to superior malposition and asymmetry after intramuscular buttock augmentation with implants [51, 52]. Subcutaneous implants appear and feel unnatural, with insufficient tissue cover [51]. Analogous to symmastia, implants may displace across the midline ("sympygia" [52]). Staged procedures may be safer in patients desiring larger implant sizes [52]. Parasacral incisions may reduce the risk of wound dehiscence [48] but at the cost of additional scars [5].

> Underdissection of the lower pole can lead to superior malposition and asymmetry after intramuscular buttock augmentation with implants.

Daniel and Junior [53] reported an alarming 97% rupture rate of silicone gel buttock implants (not available in the United States) at reoperation.

A systematic review of 44 articles by Sinno et al. [54] compared silicone implants and fat grafting. The most common reported complications among 2375 patients treated with silicone implants were wound dehiscence (9.6%), seroma (4.6%), infection (1.9%), and sciatic paresthesias (1.0%), with an overall complication rate of 21.6%. The most commonly reported complications in 3567 patients receiving fat injection were seroma (3.5%), undercorrection (2.2%), infection (2.0%), and pain or sciatalgia (1.7%), with an overall complication rate of 9.9%. The data did not include sufficient patient satisfaction scores to allow a quantitative comparison. Patient satisfaction has not been subjected to patient-reported outcome surveys in a large number of consecutive patients treated with either fat injection or implants.

Because of its lower risk profile (with the notable exception of fat embolism), fat injection is much more commonly performed by plastic surgeons than buttock implants today [3].

Gluteal Augmentation Using Local Tissue Flaps

Transposition flaps (Fig. 9.16) may be used to augment the buttocks. Hunstad and Repta [55] describe a "purse-string" gluteoplasty. Srivastava et al. [56] compared no autoaugmentation to autoaugmentation using a dermal/fat flap transposed 45°and inset into a pocket over the gluteus maximus. The authors reported a significantly higher complication rate (42.5%), particularly wound dehiscences, in the group treated with dermal/fat transpositional flaps compared with nonaugmented patients (20%) [56]. Patient satisfaction regarding buttock projection was similar in both groups (75% and 71.4%, respectively).

Bertheuil et al. [57] recently described their "lipo-body lift," reporting a 40% rate of wound dehiscence. Bertheuil et al. [58] believe that transpositional buttock flaps increase the risk of complications such as hematomas and add to the operating time. The authors claim that their "flapless" technique, which elevates the flaps superomedially without undermining, improves buttock projection [57, 58]. However, measurements on photographs matched for size and orientation show no difference (Fig. 9.17).

Sozer et al. [59] describe a split gluteal muscle flap, flipping the gluteus maximus muscle 180°. However, lateral photographs do not appear to show increased gluteal projection.

These techniques do not provide lateral gluteal fullness. The degree of augmentation has not been quantified and may be minimal because there is no net increase in volume but rather a redistribution. Whether "autoaugmentation" is effective has not been put to the test with measurements. There is an obvious analogy in breast surgery. Numerous attempts have been made to create volume without a breast implant using transpositional flaps [60]. Measurements show no difference in postoperative projection despite surgeons' claims [60, 61].

Flap transposition increases the surgery time, adds to the dissection and blood loss [58], and creates more deadspace, increasing the complication rate. Although the author has used tissue transposition in the past (Fig. 9.16), fat injection has replaced it.

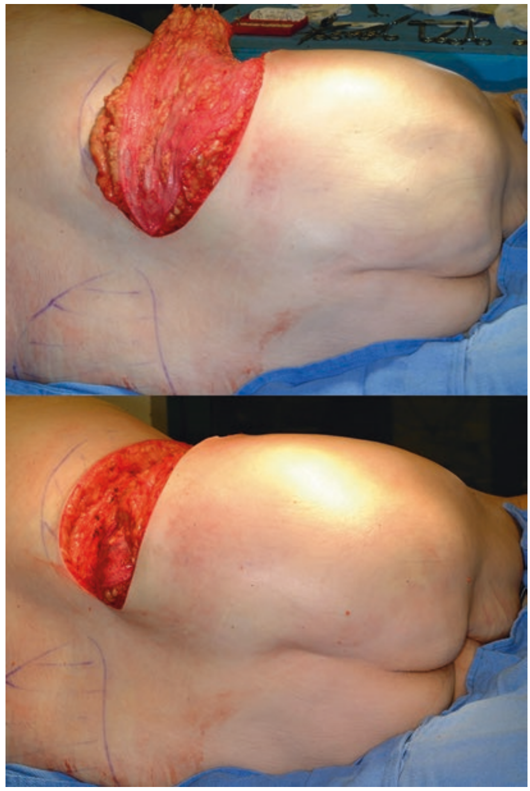

Fig. 9.16 Intraoperative photographs of a 48-year-old woman undergoing a lower body lift in combination with buttock augmentation using a deepithelialized transpositional dermal/fat flap raised from the flank and inset into a pocket overlying the gluteal muscles

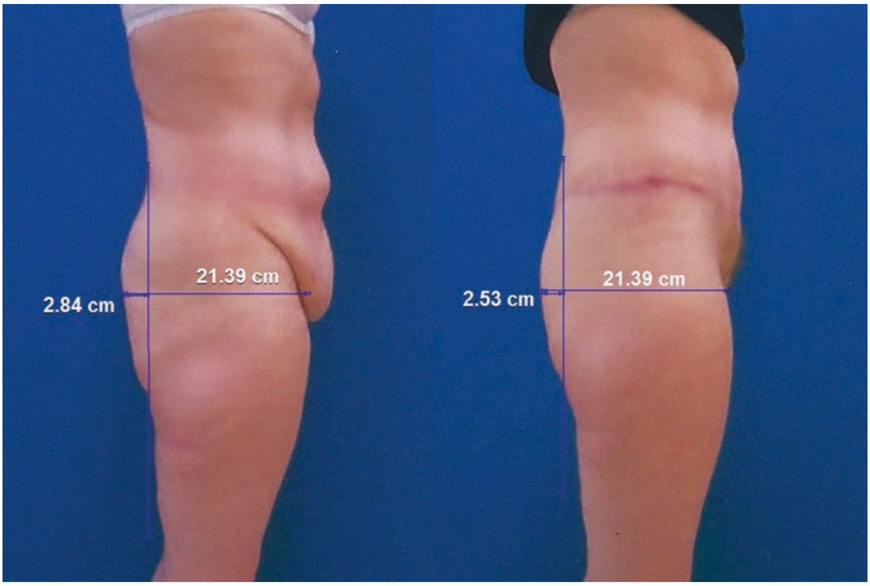

Fig. 9.17 Published lateral photographs of a patient before (*left*) and 6 months after (*right*) a lipo-body lift. Differences in magnification and tilt have been corrected using the Canfield Mirror 7.4.1 imaging software (Canfield Scientific, Fairfield, NJ). A 33-cm hip width was used for calibration. Despite the authors' claims of improved buttock projection, measurements show essentially no difference in buttock projection or relative buttock projection [Adapted from Reprinted from Bertheuil N, Chaput B, De Runz A, Girard P, Carloni R, Watier E. The lipo-bodylift: a new circumferential body-contouring technique useful after bariatric surgery. Plast Reconstr Surg. 2017;139:38e–49e. With permission from Wolters Kluwer Health, Inc.]

> Flap transposition increases the surgery time, adds to the dissection and blood loss, and creates more deadspace, increasing the complication rate.

Systematic Reviews

A meta-analysis by Condé-Green et al. [62] included 18 articles that reported complications from fat injection. The overall complication rate was 7%. The most common reported complications were seromas (2.4%), erythema (1.3%), pain (0.76%), contour irregularities (0.64%), and fat necrosis (0.56%). Most articles reported fat injection into both subcutaneous and intramuscular planes (46.7%). Others reported exclusively intramuscular injections (26.7%), subcutaneous only (20%), or injection of the subfascial and subcutaneous planes (6.7%). With increased awareness of the risk of pulmonary fat emboli, the prudent surgeon will avoid deep intramuscular injection. As in all of cosmetic surgery, any potential benefit in appearance must outweigh the risk [62].

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Calf Augmentation

10

Abstract

Although hypoplastic calves can be caused by unusual disorders that affect muscle development and spinal cord problems, most cases are presumed genetic and are resistant to the patient's efforts to bulk up with exercising.

Solid or gel-filled implants (not available in the United States) can be inserted in the posterior compartment of the leg to augment the medial calf. Some operators also use implants for lateral calf augmentation.

A posteromedial transverse incision along the popliteal crease provides access. The medial sural cutaneous nerve is preserved. The scar tends to be well concealed, although it may hypertrophy or become hyperpigmented. The subfascial plane is ideal for implant insertion. This plane is located between the muscle investing fascia and the thin epimysium on the muscle surface.

Fat injection is a useful alternative to implants and can provide a modest degree of improvement. Frequently the author uses subcutaneous fat injection simultaneously with an implant.

Calf skin typically has little capacity to stretch. The surgeon must be cautious to balance implant size with tissue tolerance or face serious complications that include skin necrosis, extrusion, and compartment syndrome. Superior malposition is avoided by adequate distal blunt dissection of the pocket. Infection is unusual.

Patients wear an Ace wrap for 1 month. Patients typically return to nonphysical jobs in 1–2 weeks and exercising in 1 month.

E. Swanson, *Evidence-Based Body Contouring Surgery and VTE Prevention*,
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Introduction

Underdeveloped calves may be an inherited trait or result from disorders that affect muscle development [1–11]. Historically, poliomyelitis was the single most common cause for calf underdevelopment [7]. Charcot-Marie-Tooth neuropathy is an inherited condition that causes peroneal muscular atrophy. Club foot is another genetic cause. Spinal cord problems such as spina bifida, sciatic nerve injuries, or spinal cord injuries can cause leg atrophy. Trauma, tumor resection, or burns can lead to muscle loss or contraction.

Often there is no such history of an underlying medical condition. Calf underdevelopment is simply an inherited trait. Women complain that they have "chicken legs" and are reluctant to expose them. Both men and women may refuse to wear shorts. Women may avoid wearing a short skirt [8]. The bow-legged appearance has been called a pseudo-varus deformity, despite a normal bony alignment, caused by the lack of medial calf fullness [10]. One patient of mine wore three layers of socks drawn up over his calves to help camouflage his "stick legs." Despite working as a manager at a golf club, he would never wear shorts, even in the middle of the summer. Exercise has little effect in adding bulk [6]. The problem appears to be more common in African-Americans. Many patients in the author's practice are bodybuilders, often men who have no trouble developing their thigh muscles but cannot seem to bulk up the calves. Men typically desire a more bulky, muscular appearance of the legs than women [10].

Calf implants share some of the traits of breast implants in providing almost immediate gratification [11]. Their risk profile is better than gluteal implants in that they are not subject to the daily trauma of sitting, infection is rare (like breast implants), and dehiscence is unusual (like breast implants), as long as the implant does not displace superiorly on wound closure. The plane is essentially bloodless with no muscle elevation (unlike subpectoral breast implants) so that a hematoma is unlikely. Despite the common indications and favorable clinical experience [1–8, 11], calf augmentation remains a sparsely performed procedure. The subject is rarely included in plastic surgery texts. The 2016 cosmetic surgery statistics published by the American Society of Plastic Surgeons [12] include only 419 cases, compared with 2999 for buttock implants.

Their risk profile is better than gluteal implants in that they are not subject to the daily trauma of sitting, infection is rare (like breast implants), and dehiscence is unusual (like breast implants).

Plastic surgery residents may not receive training in this method. Few plastic surgeons offer this procedure. Fortunately, I received training in calf augmentation from Lloyd Carlsen as a resident and fellow in the 1980s. Glicenstein and Carlsen first described this operation independently in 1979 [1, 2], although both operators had already been using this method for years. Andjelkov et al. [11] recently published a large retrospective case series.

The Golden ratio (1.618:1), also called the divine proportion, has been applied to leg aesthetics [13] but lacks a scientific foundation.

Fat Injection of the Calf

Today, fat injection offers an alternative to calf augmentation with implants [9, 10]. It is possible to do both—augment the posterior compartment with an implant and also inject fat laterally to provide lateral fullness. This combination makes a second implant placed over the lateral head of the gastrocnemius, as described by Aiache [5], unnecessary. The combination of an implant and fat injection is safe, with no increase in the complication rate, provided excessive fill volumes are avoided.

> The combination of an implant and fat injection is safe, with no increase in the complication rate, provided excessive fill volumes are avoided.

Fat injection avoids risks associated with implants, of course, and may be quite suitable for patients who require a modest increment in calf fullness. It can be done easily at the time of liposuction under total intravenous anesthesia with the patient positioned supine [10]. In this way it is quite analogous to buttock fat injection. However, the graft-to-capacity ratio is much higher in the calf, limiting the volume of fat that can be safely injected [10]. Two or more treatments may be necessary to achieve the desired fullness [10]. In lean, athletic patients, there may be little fat available for injection.

Erol et al. [9] use either fat or a cocktail that also includes bits of dermis, fascia, and fat that are prepared from excised scar tissue or tissue removed during an abdominoplasty or breast reduction. The authors freeze the remaining fat and perform future injections at 3-month intervals, with up to four injections. However, the results are modest [14].

Mundinger and Vogel [10] inject 157 cc of fat per leg (range, 78–330 cc), 58% into the medial calf and 42% into the lateral calf, on average. Four of their 13 patients (31%) underwent additional fat grafting at a second procedure. These surgeons [10] inject both directly into the calf muscles and subcutaneously. Mundinger and Vogel [10] believe the appearance stabilizes by 4 months, although measurements are lacking.

The medial knee may be treated with liposuction to lessen the disproportion, analogous to liposuction of the flank in buttock fat transfer [10]. The author uses a single incision at the level of the knee medially and laterally for both infusion of local anesthesia and access for the fat injection. The injection cannula is sufficiently long to allow full treatment using a single proximal incision on either side of the knee. Care is taken to keep the lateral incision superficial so as not to injure the underlying common peroneal nerve. My practice has been to only inject fat subcutaneously, not into the muscle. Infection after fat grafting is rare [10]. The incisions may become hyperpigmented, like liposuction incisions elsewhere [10].

> The injection cannula is sufficiently long to allow full treatment using a single proximal incision on either side of the knee.

Anesthesia

The full spectrum of anesthesia has been used for calf augmentation, including general anesthesia [2–4, 11], spinal block [7], intravenous anesthesia [10], and local anesthesia with sedation [4].

The author prefers total intravenous anesthesia (Chap. 5). No tourniquet is used. The lower extremities are prepped with dilute chlorhexidine solution. Local anesthetic solution (0.25% lidocaine, 0.125% bupivacaine, and 1:300,000 epinephrine) is injected, typically about 50 cc per calf. The patient remains supine. By contrast, Andjelkov et al. [11] exclusively use general endotracheal anesthesia and prone positioning in surgery. Systemic antibiotic prophylaxis is typically administered in the form of cefazolin 1 g IV immediately before surgery and cephalexin 500 mg p.o. b.i.d. for three doses postoperatively.

The Incision

Each lower extremity is externally rotated from a supine position to allow exposure of the popliteal fossa [2] An incision is made medially in the popliteal crease [2, 3]. The skin incision length is typically 5–7 cm. A straight incision is used. Andjelkov et al. [11] prefer a zigzag incision so as to avoid a linear scar at the level of the knee joint, which certainly makes sense for a longitudinal incision. However, a horizontal incision within the medial popliteal skin crease is well concealed and will not create a scar contracture, although scar hypertrophy and hyperpigmentation do occur in some patients. These problems tend to improve with time.

> An incision is made medially in the popliteal crease. The skin incision length is typically 5–7 cm.

In making the incision, the surgeon must be careful to avoid the medial sural cutaneous nerve, a sensory branch of the tibial nerve [3, 5, 11]. The small saphenous vein is preserved [3, 5, 11]. The midline fascia between the medial and lateral gastrocnemius muscle represents the lateral dissection boundary [3, 7, 11].

Dissection Plane

There are three possible dissection planes—supraperiosteal, submuscular, and subfascial. The supraperiosteal approach requires an unnecessarily deep dissection with fasciotomies [15]. Analogous to breast or gluteal augmentation, subcutaneous implants are likely to be too superficial and cause unnatural boundaries [1, 11]. The implant may be palpable in this location [1], and Aiache [3] cautions that the risk of visible deformities and skin loss is greater with superficial implant placement. Kalixto and Vergara [16] describe submuscular (i.e., sub-gastrocnemius) placement of the implant between the gastrocnemius and soleus muscles. This method offers more implant camouflaging, but the dissection is more difficult. Patients experience more pain, and the recovery period is longer than patients treated with a subfascial plane. Most operators use a subfascial plane [1, 2, 7, 11]. The investing (or "crural") fascia is opened horizontally, approximately 3 cm distal to the skin incision, on the surface of the medial gastrocnemius muscle [11]. Vertical incisions in the investing fascia (fascial scoring) are unnecessary [3, 7].

> Most operators use a subfascial plane.

The pocket is developed deep to the investing fascia of the muscle [2, 7, 11], preserving the thin epimysium on the muscle surface [7, 11]. A variety of dissecting instruments are available, including simply an old (8 mm) large blunt liposuction cannula [6]. The author uses a curved blunt 30-cm Emory Style Breast Dissector (Carnegie Surgical, Hightstown, NJ) to assist with this blunt dissection. This is a largely bloodless plane, making electrocautery unnecessary within the pocket itself.

The Implant

In his original communication, Carlsen [2] described using custom-made solid silicone implants, having abandoned silicone gel implants in 1974 because of implant disintegration. In 1984, von Szalay [3] introduced firmer silicone gel-filled torpedo-shaped implants. Andjelkov et al. [11] favor cohesive silicone gel implants. These implants are unavailable for calf augmentation in the United States. A concern regarding solid implants is unnatural firmness, although this problem is mitigated using soft low-durometer implants. These soft implants are friable, and care is needed not to traumatize the implants on insertion. Because the implant is placed under the muscle sheath and has a consistency mimicking muscle, it appears and feels natural.

> Because the implant is placed under the muscle sheath and has a consistency mimicking muscle, it appears and feels natural.

Although they favor silicone gel implants, Andjelkov et al. [11] mention some disadvantages. These implants are available in a limited number of sizes, and the shapes may not correspond with average gastrocnemius muscle sizes. Most implants are 19 cm long [3] or longer [7]. Andjelkov et al. [11] believe that incorrectly sized implants are responsible for unnatural appearances in some of their patients. Aiache [4, 5] frequently used two cigar-shaped implants side by side. The implants were originally elon-

Fig. 10.1 Intraoperative photographs of a 58-year-old woman undergoing calf augmentation with implants. For demonstration purposes, the implants are placed over the areas to be augmented (*left*). An incision in the popliteal crease is made, allowing insertion of the implant into a pocket between the fascia and the gastrocnemius muscle in the posterior compartment. This patient's before-and-after photographs are provided in Figs. 10.2 and 10.3

gated gel-filled devices that came in only three sizes, 15, 55, and 75 cc. After encountering a 5% capsular contracture rate, Aiache [5] started inserting solid implants rather than silicone gel implants. Implant stacking has been described as a secondary procedure, but not for primary calf augmentation [6].

The author uses a single soft silicone implant (AART Inc., Carson City, NV). Typically a Style 1, size 4 or 5, is used. The size 5 implant, the largest size, is 17.3 cm long, 11.3 cm wide, and projects 2.7 cm. Generally the largest implant size that will fit snugly within the pocket is chosen. The implant is often tapered as needed in surgery [2]. The large portion of the implant is oriented distally to produce a more muscular appearance (Fig. 10.1). My preference is to place one implant medially in the posterior compartment where the deficiency is most obvious. If any additional augmentation is needed laterally, I prefer to use fat injection rather than a second implant.

My preference is to place one implant medially in the posterior compartment where the deficiency is most obvious. If any additional augmentation is needed laterally, I prefer to use fat injection rather than a second implant.

Calf implants do not fill the lower third of the leg. For more distal augmentation, Gutstein [8] invented a solid silicone calf implant that has a distal extension, called a "calf-tibial" implant, reaching to just above the medial malleolus.

Wound Closure

The muscle fascia is closed with two 2-0 Vicryl (Ethicon Inc., Somerville, NJ) sutures. The skin is closed using 3-0 Vicryl dermal sutures

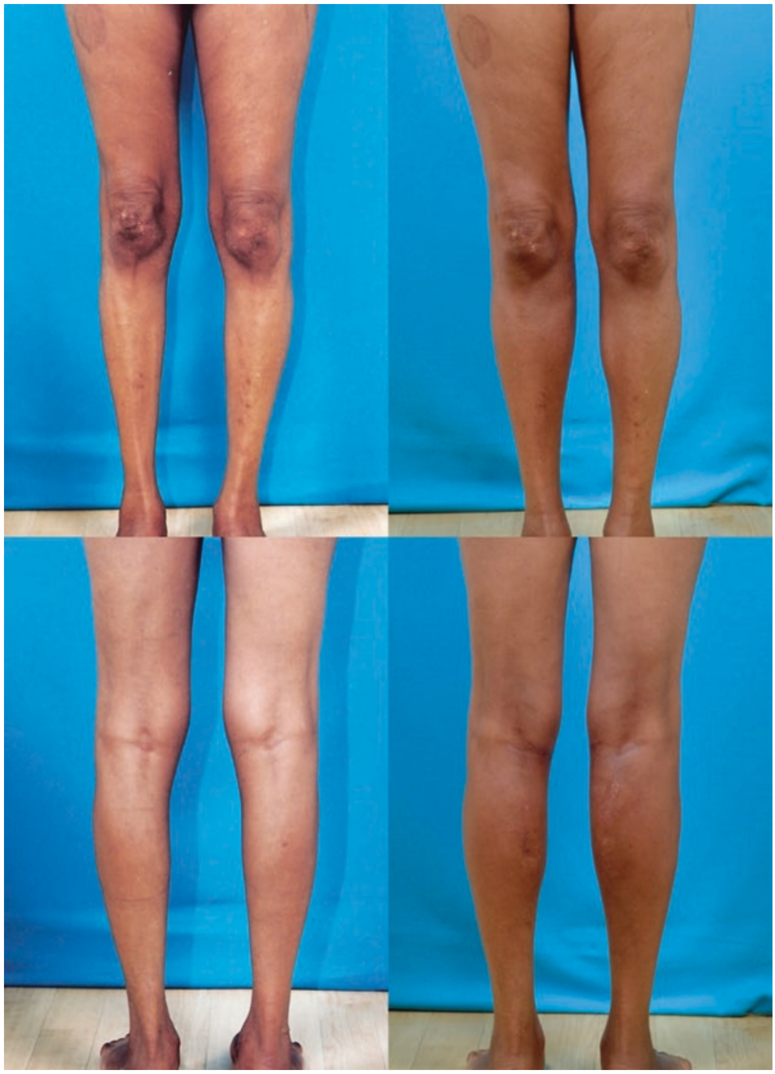

Fig. 10.2 This 58-year-old woman would never show her "chicken legs" in public. She would not wear shorts, even in the middle of summer. She is seen before (*left*) and 6 weeks after surgery (*right*). Her scars are already inconspicuous. She returned to office work 2 weeks after surgery. At first, she found heels more comfortable because it was hard to stretch out her legs completely. Her calf circumference increased from 11″ to 12¾″

and a 4-0 Vicryl intradermal suture. No drains are inserted [2]. The surgery usually takes 1–1½ h. A wraparound gauze dressing is applied, covered by an Ace wrap that includes the ankle [2].

Clinical Examples

Clinical examples are provided in Figs. 10.2, 10.3, 10.4, 10.5, 10.6, and 10.7.

Calf Augmentation and Fat Injection

Postoperative Care

Patients are ambulatory immediately after surgery, wearing Ace wraps from the feet to the knees and elevating the legs when they are sitting. Minimal walking during the first week after

Fig. 10.3 This patient is now comfortable wearing a dress and showing off her legs for the first time. She is seen 2 months after surgery. Intraoperative and preoperative photographs are provided in Figs. 10.1 and 10.2

surgery is recommended. Most people take 1–2 weeks off work. Ace wraps are worn for 3–6 weeks [2–5]. Patients usually return to full exercise 1 month after surgery [2]. Carlsen [3] allows patients to return to sports 6 weeks after surgery.

Complications

In their series of 108 primary cases treated with silicone gel implants, Andjelkov et al. [11] reported only two complications, one infection necessitating implant removal and replacement 6 months later and one scar deformity. Calf implants neither impair nor improve leg function [7].

Infection

Infection is unusual [7, 17]. Like a breast augmentation, an infection may require removal of the implant to clear the infection. Von Szalay [3] successfully treated an infected implant by removal and replacement 6 months later. Pérez-García et al. [18] report a case of necrotizing fasciitis after calf augmentation, successfully managed with implant removal, extensive debridement, and antibiotics effective against *Enterococcus faecalis* and *Candida albicans*.

Hematoma

The surgical dissection is remarkably bloodless, so the risk of bleeding is low. A hematoma would cause excessive swelling and pain shortly after surgery and would require a return trip to the operating room for evacuation. Aiache [4] reported one hematoma in his series of 121 patients (0.8%).

Numbness

The sural nerve is at risk in this operation [4, 11]. Nerve injury at surgery would cause numbness over the dorsum of the foot. Of course, this nerve often serves as a donor nerve in reconstructive surgery because the consequences of such numbness are minimal. Nevertheless, care is taken to preserve this sensory nerve.

Implant Malposition and Extrusion

Inadequate distal dissection may allow the implant to displace superiorly into the popliteal fossa [6, 7]. This problem may be corrected secondarily by bluntly dissecting the pocket more distally and allowing the implant to drop [6]. Excessive implant length can also cause this problem. Implant extrusion has occurred [2]. Niechajev [7] reported a bulge of the upper calf in one woman, requiring replacement of her gel implants with a narrower cigar-shaped model.

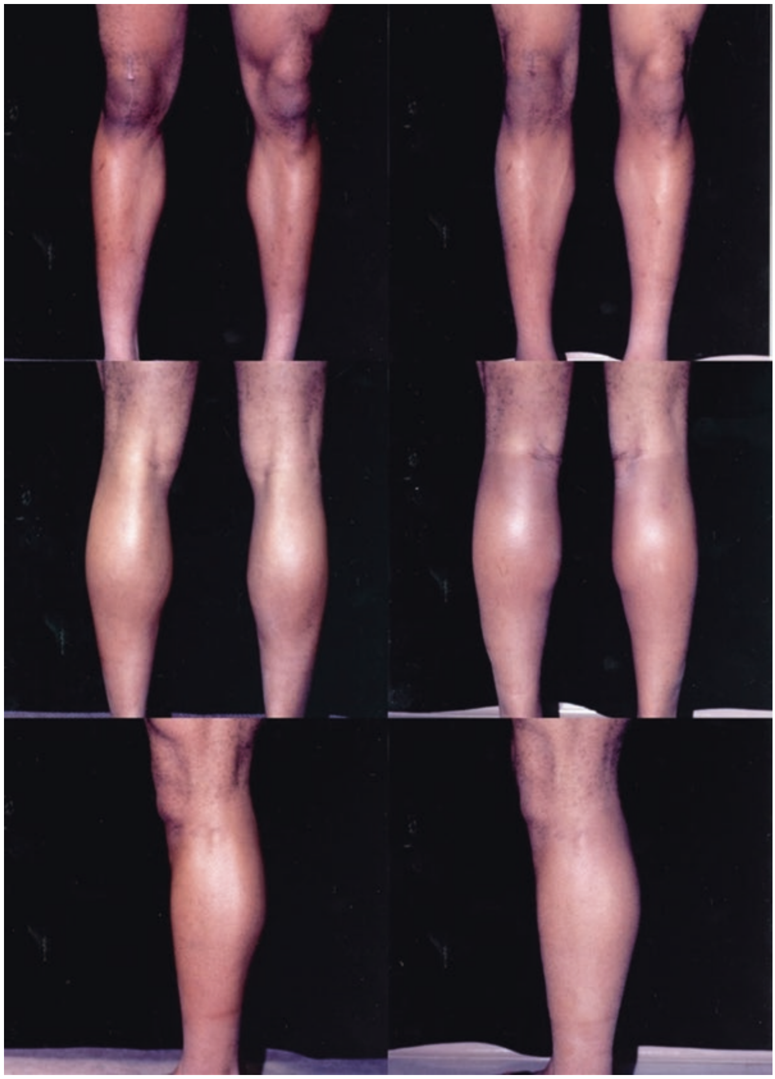

Fig. 10.4 This 25-year-old bodybuilder was unable to develop his calves despite aggressive exercising. He is seen before (*left*) and 10 days after surgery (*right*). At this point he was ambulating without difficulty

Undercorrection

About 10% of postoperative patients would prefer a greater degree of calf augmentation [17].

Seroma

Carlsen [2] reported that 7/38 patients (18%) developed a seroma. Of the seven patients, five had gel implants. Five were aspirated with resolution, and one seroma did not recur after replacement with a solid implant [2].

Capsular Contracture

Aiache [4] identified four capsular contractures among 121 patients (3%). Lemperle and Kostka [19] report a 23% capsular contracture rate in 17 patients with soft gel implants. By contrast, Andjelkov et al. [11] report no capsular contractures, attributing their favorable experience to subfascial placement and a massage effect from the adjacent muscle. Niechajev [7] also reports no capsular contractures in 18 patients.

Fig. 10.5 This 53-year-old woman had polio as a child, causing a right hypoplastic calf. She was treated with an implant in the posterior compartment, plus fat grafting to the lateral (60 cc) and medial calf (140 cc). She is seen before (*left*) and 1 month after surgery (*right*). The abdomen served as the fat donor site

Fig. 10.6 Weight training had been ineffective for this 39-year-old man with hypoplastic calves. Calf implants were used in combination with fat injection to correct the disproportion. His calf circumference increased from 13.5 in. to 15.1 in. He is seen before (*left*) and 3 months after surgery (*right*)

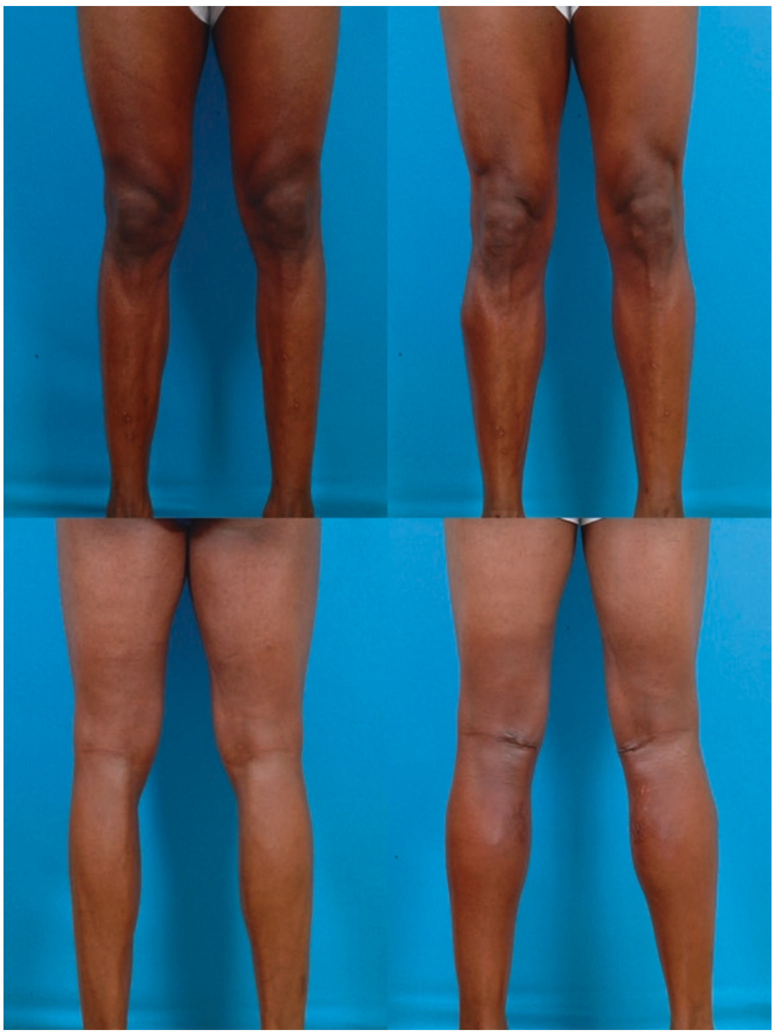

Fig. 10.7 This 27-year-old bodybuilder is seen before (*left*) and 3 weeks after (*right*) calf injection with implants and lateral fat injection (right, 32 cc; left, 50 cc). He developed two areas of blisters that healed without scarring or hyperpigmentation

Implant Rupture

Implant rupture has been reported [2]. Of course, implant rupture cannot occur if solid implants are inserted.

Compartment Syndrome

Compartment syndrome is the most severe local complication. This complication is signaled by excessive pain, caused by muscle ischemia under the implant. Other clinical findings include weakness and pain elicited by stretching the muscles of the posterior compartment, numbness, and tenseness of the compartment [11]. This serious complication requires immediate surgical attention to release the tension so as to avoid tissue loss. Hallock [20] reports a case of myonecrosis, causing disfigurement, likely caused by compartment syndrome.

> Compartment syndrome requires immediate surgical attention to release the tension so as to avoid tissue loss.

Scar Deformities

Scar deformities do occur, including hypertrophy and hyperpigmentation [7, 10, 11]. Scars tend to soften and lighten over about 1 year [7, 10, 11].

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Evaluating New Technologies

11

Abstract

Plastic surgeons are frequently confronted with new devices. Manufacturers provide rosy predictions of increased revenue. Few experienced plastic surgeons have resisted the pressure to buy an expensive device that did not live up to expectations.

My own criteria when evaluating new methods or technologies are simple. The device must make sense scientifically and there must be solid evidence of results. Surprisingly, these simple standards are rarely met.

The separation between science and commerce is increasingly blurred. Manufacturers develop financial ties with plastic surgeon/investigators and with our professional societies. Research and even journal articles may be funded by corporations. Conflicts may be indirect. A company may provide a machine at a substantial discount or even at no charge to its investigators.

This chapter provides several examples of articles that have been published in our scientific journals evaluating new technologies. One study was assigned a level 1 level of evidence, the gold standard, despite its many flaws that undermine the conclusions. Scientific considerations are contrasted with marketing concerns. New cellulite treatments, microfocused ultrasound for skin tightening, implantable mesh for breast surgery, and, recently, vaginal tightening are other technologies that merit scrutiny.

Plastic surgeons receive scientific training. That scientific background can be put to use in deciding which new products to introduce to one's practice. Critical thinking allows us to separate the wheat from the chaff.

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Introduction

One of the most viewed publications on the *Aesthetic Surgery Journal's* website is an article that was published in 2013 titled "Broad Overview of a Clinical and Commercial Experience with CoolSculpting" [1]. To the author's knowledge, this communication represents the first original article in the *Aesthetic Surgery Journal* to focus on "commercial experience" [2]. It may be the first article in the *Journal* to quantitate cross-selling. Cryolipolysis represents a case study in the evaluation of a new technique in plastic surgery and is discussed in this chapter. Other examples include skin tightening technologies and treatments to reduce scarring.

Nonsurgeons emphasize surgical and anesthesia risks. Such concerns are often assuaged by a frank discussion of the extremely low surgical risk using SAFE anesthesia principles in healthy patients (Chap. 5). The average time off work after liposuction is a modest 5.7 days [3]. Most patients are willing to trade a reasonable recovery period for a superior outcome [3].

Today, many patients benefit from simultaneous (surgical) fat injection of the face or buttocks. Indeed, fat cells are a limited resource in nonobese individuals. Instead of freezing them, they may be transferred to other areas of the body where they are deficient.

> Today, many patients benefit from simultaneous (surgical) fat injection of the face or buttocks.

The conventional wisdom is that there is a steady march toward nonsurgical methods instead of surgery. Companies selling nonsurgical alternatives take advantage of the public's fear of surgery. Investigators are usually conflicted. Plastic surgeons may be lured by the promise of financial reward.

Many plastic surgeons envisage a future in which they manage a spa, employing nonphysicians who administer various treatments, while they successfully run a small business. The spa generates surgical referrals for patients who fail the nonsurgical methods. These patients may never have come to the office otherwise. Skeptics may call this approach "bait and switch." Plastic surgeons are not immune to financial pressure or the importance of marketing. Business considerations may interfere with a clear judgment of the efficacy of a new technology. If plastic surgeons fail to "jump on board" with at least a few of these innovations, how do they distinguish themselves from their competitors?

> Business considerations may interfere with a clear judgment of the efficacy of a new technology.

It has been said that surgeons enjoy surgery much more than their patients do. Fortunately for surgeons who enjoy their craft, it is unlikely that a nonsurgical method will replace many of the surgical options used in body contouring surgery such as abdominoplasty, at least in the near future. The skin is simply too stretched to contract adequately. Stretch marks are histologically scar tissue, not the skin. No surface treatment will eliminate them.

It remains to be seen whether nonsurgical treatments will eventually replace liposuction. This perennial topic is discussed below. The importance of scientific evaluation of new technologies is emphasized so as to avoid patient and physician disillusionment.

> The importance of scientific evaluation of new technologies is emphasized so as to avoid patient and physician disillusionment.

Plastic surgeons are familiar with the recommendation of science first and marketing second. We have a duty to our patients to resist marketing pressures and insist on scientifically sound evaluation of efficacy and safety. This approach is not incompatible with good business. There is no more credible salesperson than the plastic surgeon who, through careful research using the scientific method, is persuaded of the validity of his or her treatment recommendations.

Cryolipolysis

In their article promoting Coolsculpting, Stevens et al. [1] present no measurement data and no patient-reported outcomes data. In their review of 528 consecutive patients, the authors claim no adverse events and, after four initially dissatisfied patients were retreated, there were no unhappy patients. No plastic surgery procedure can claim a 100% patient satisfaction rate. This reality is especially true of liposuction, because some patients inevitably have unrealistic expectations and cellulite is usually not eliminated by liposuction [3]. Even after liposuction, reported patient satisfaction is approximately 80% [3, 4], respectable but certainly not 100%.

The new verb "coolsculpting" serves the interests of the manufacturer because both coolsculpting and cryolipolysis (a name that seems generic) are registered trademarks of the manufacturer (Zeltiq Aesthetics, Pleasanton, CA, recently purchased by Allergan plc, Dublin, Ireland) [5]. Today, cryolipolysis is one of the most discussed treatments on the popular website RealSelf.com [6]. Experienced plastic surgeons, however, have witnessed these bubbles of interest before (e.g., LipoDissolve) and will take a measured view of product claims.

Experienced plastic surgeons, however, have witnessed these bubbles of interest before (e.g., LipoDissolve) and will take a measured view of product claims.

First, one needs to consider the standard to which the new treatment is compared. Magnetic resonance imaging reveals that liposuction reduces the subcutaneous fat thickness approximately 45% [7]. Liposuction removes, on average, 2420 cc of fat from multiple sites in one treatment [3]. Liposuction permits three-dimensional fat removal from confluent areas with subtle, controlled differences in aspirate volumes. Numerous examples are provided in Chap. 3. The fat does not return or redistribute [8, 9] (see Chap. 2), and there are favorable changes in circulating triglyceride and leukocyte levels [10] (Chap. 4). Outcome studies are supportive, with 82.5% patient satisfaction and 93.5% of patients reporting that they would do it again [3]. These findings hold up to scientific scrutiny and are powerful selling points to patients, no doubt explaining the enduring popularity of liposuction. In 2016, liposuction was the most common [11] or second most common (after breast augmentation) [12] cosmetic surgery operation according to national data banks. Importantly, supportive studies are free of commercial bias [3, 4, 7–10].

How does cryolipolysis compare to this standard? Shek et al. [13] measured skin folds in nonconsecutive patients undergoing one or two treatments. Calipers [13] are not sufficiently precise for reliable comparisons [8]. The authors disclosed no financial conflict [13]. However, an erratum published subsequently revealed that one of the authors had received a fee from Zeltiq [14]. Garibyan et al. [15] reported a 39.6 cc reduction in treated areas. This volume equates to <2% of the average fat volume removed by liposuction [4]. Distributed over a typical treatment area, this volume represents a 3-mm decrease in thickness [2]. Another study of cryolipolysis, funded by the manufacturer, documented a 25.5% reduction in fat thickness in six of ten treated patients using ultrasound [16], a technique known to be affected by pressure on the transducer [2, 15]. Some of the authors of both studies were either employed by [16] or had financial ties [13–15] to Zeltiq.

Garibyan et al. reported a 39.6 cc reduction in treated areas. This volume equates to <2% of the average fat volume removed by liposuction.

Although noninvasive, cryolipolysis is not painless or entirely without risk [13, 15–22]. Bruising and temporary numbness are common [13, 15–17, 19]. Nodules can occur [17]. Skin necrosis has been reported [18]. Adjadj et al. [19] report erythema in 62.5% of patients undergoing saddlebag treatments, lasting 15 h, on average. Paradoxical adipose hyperplasia (enlarging fat deposits after treatment) may occur [20–22]. The mechanism for this complication, unique to cryolipolysis, remains unclear [20–22]. Additional cryolipolysis treatments are ineffective and possibly counterproductive [21]. Fortunately this condition may be remedied by liposuction [21]. Stefani [21] cautions that med spas offering nonsurgical procedures may not have a plastic surgeon on staff, leading to a delay in recognition and surgical treatment of this complication.

Paradoxical adipose hyperplasia (enlarging fat deposits after treatment) may occur. The mechanism for this complication, unique to cryolipolysis, remains unclear.

Adjadj et al. [19], working in France, recently reported an 8.33% incidence of postinflammatory hyperpigmentation. These lesions consist of thick-bordered ovals with unaffected central areas. These areas are likely caused by the vacuum cup used in the Cryoslim (BFP Electronique, Montrodat, France) cryolipolysis device [23]. Kilmer [23] questions whether cooling to −2 °C, as opposed to −10 °C, is effective. She believes that the lateral thigh tissue does not make contact with the cooling surface, explaining the unaffected central regions [23]. The Cryoslim device lacks a skin-protecting gel and a freeze detection algorithm, and this device is not cleared by the US Food and Drug Administration [23]. Kilmer is on the Medical Advisory Board for numerous companies including Zeltiq and has received research funding from these companies [23]. Although cryolipolysis has been largely performed using the Zeltiq device, other less expensive devices are available [23, 24]. Stevens et al. [24] caution operators regarding "counterfeit" medical devices.

Systematic reviews note the lack of uniformity in study designs and measurements [25, 26]. Derrick et al. [26] report the potential for selection bias, publication bias, and financial conflicts. These investigators caution that much of the information in emerging aesthetic innovations is generated by advertising, making high-quality prospective controlled studies mandatory [26].

Like LipoDissolve before it, cryolipolysis revives the old notion of spot treatments. There is no real-time feedback, such as a palpable reduction in the thickness of the fat layer, visual cues as the fat fills the tubing and canister, or comparison of aspirate volumes removed from each site [2]. The operator is often a nonphysician [1]. Treatment sites immediately swell from inflammation [17, 27]. How can one truly sculpt body areas when the tissues swell right away? "Cooling" is a euphemism for freezing (i.e., the formation of lipid ice) [27]. Indeed, "spot freezing" might be a more accurate description than "cool sculpting" [2]. The adipocytes crystallize, undergo apoptosis, and are then eliminated by macrophages [28]. The inflammatory process is believed to peak at 2–4 weeks and last about 3 months [29]. The devitalized fat cell products are left to enter circulation.

Operators concede that the results of cryolipolysis do not match liposuction [27, 30], and the procedure costs approximately the same as liposuction if multiple areas are treated [30]. Sasaki et al. [27] report <5% improvement 6 weeks posttreatment as judged by independent evaluators. Dierickx et al. [17] found little or no treatment benefit for the thighs, buttocks, and knees.

Sasaki et al. report <5% improvement 6 weeks posttreatment as judged by independent evaluators. Dierickx et al. found little or no treatment benefit for the thighs, buttocks, and knees.

Fig. 11.1 Comparison of nonscientific and scientific considerations in evaluation of a new method [Reprinted from Swanson E. Cryolipolysis: the importance of scientific evaluation of a new technique. Aesthet Surg J. 2015;35:NP116–NP119. With permission from Oxford University Press]

Nonscientific	Scientific
Promoted by a well-known plastic surgeon	Objective measurements
Lots of buzz	Consecutive patients
Featured on television	Adequate statistical power
Optimistic revenue projections	No financial conflict
Thousands of patients treated	High inclusion rate
Study performed at a respected institution	Eligibility criteria
Attractive sales force	Consideration of confounders
Large booth at meeting	Control group
Prospects for cross-selling	Prospective study
High "worth it" score on Realself.com	High level of evidence
Catchy name	Patient-reported outcomes
Large number of Google hits	Patient satisfaction and quality of life
A dynamic speaker	Statistical significance
Exaggerated claims	High-grade reliability
Conversion rates	Reproducibility
Recovery times <24 hours	Recovery times >24 hours
Complication rates <1%	Complication rates >1%

Centeno [30] believes that if a device features a "worth it" rating of 68% or more on RealSelf.com, then it has some validity. Coolsculpting, with a rating of 81%, meets this criterion (liposuction has a rating of 90%) [6]. Are such ratings reliable? Acupuncture patients also provide favorable ratings of their treatments [31]. Cognitive dissonance [32] makes it difficult for patients to admit to themselves that they spent their money on an ineffective treatment [2]. Plastic surgeons are no different. Spending six figures on a device and making continuing payments to the manufacturer after the purchase colors their judgment [2].

In their review of noninvasive alternatives to liposuction, Raphael and Wasserman [33] conclude, "commercial acceptance appears to have outpaced their scientific scrutiny." Such scrutiny should include patient-reported outcome studies, magnetic resonance imaging of the fat layer, and photographic measurements by investigators who do not have a financial conflict. Such studies are conspicuously lacking for cryolipolysis. Figure 11.1 compares nonscientific and scientific considerations [2].

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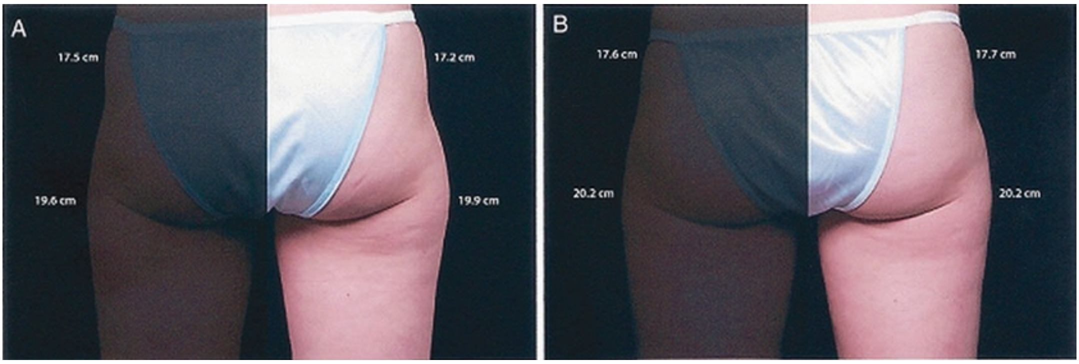

Fig. 11.2 Pretreatment (*left*) and 16-week posttreatment (*right*) images of the 33-year-old woman depicted in the authors' Figure 3 have been measured from the midline using the Canfield 7.1.1 Mirror imaging software (Canfield Scientific, Fairfield, NJ). All of the dimensions are increased slightly, including the treated right outer thigh, consistent with the patient's 1-lb weight gain. The folds in the patient's panties do not appear to match in the pretreatment image (*left*). A 34-cm width at the level of the hips is used for calibration [Adapted from Stevens WG, Bachelor EP. Cryolipolysis conformable-surface applicator for nonsurgical fat reduction in lateral thighs. Aesthet Surg J. 2015;35:66–71. With permission from Oxford University Press]

Photographic Integrity

Stevens and Bachelor [34] demonstrate the effect of cryolipolysis on the outer thigh. Stevens [35] claims skin tightening based on two patients who also lost weight, calling this effect "cryodermadstringo." However, the evidence is questionable [36].

Measurements reveal an increase in width of the treated right saddlebag, from 19.9 to 20.2 cm in a patient who gained 1 lb after treatment (Fig. 11.2). The authors also depict a woman who gained 5 lb in the 8 weeks after her treatment [34]. Surprisingly, the width of the saddlebag and hip appears to be unchanged on the control side (one would expect an increase in view of her weight gain). Remarkably, the *untreated* left hip is reduced 0.4 cm despite her substantial weight gain (Fig. 11.3). These findings contrast with the increased dimensions recorded after only a 1-lb weight gain in another patient (Fig. 11.2). The image overlap shows a 0.9 cm change in the thickness of the treated left saddlebag. Although the left medial thigh border and gluteal fold match almost perfectly, the skin lesions show variable differences in their position before and after treatment (Fig. 11.3). It is not clear from the photographic overlay which image is the before image and which is the after image. Some panty fold patterns do not appear to match up well

Fig. 11.3 The superimposed pretreatment and 8-week-posttreatment images of the 41-year-old woman depicted in the authors' Figure 4 have been measured from the midline using the Canfield 7.1.1 Mirror imaging software. The width measurements on the untreated right side are identical and the untreated left hip is reduced 0.4 cm despite a 5-lb weight gain. Pigmented skin lesions are variably aligned. A distinctive pair of small skin lesions located on the untreated posterior thigh just below the left gluteal fold appears to have moved 1.4 cm. A 34-cm width at the level of the hips is used for calibration [Adapted from Stevens WG, Bachelor EP. Cryolipolysis conformable-surface applicator for nonsurgical fat reduction in lateral thighs. Aesthet Surg J. 2015;35:66–71. With permission from Oxford University Press]

(Fig. 11.2), but it is difficult to be certain because of the unexplained darkening of the control side.

The photographic treatments create questions. Why shade the control side? Such a practice does not belong in a scientific publication

[36]. Why is there a black margin running down the middle of the illustrations? The photographs should be continuous. Why not simply present two standardized photographs side by side that are not digitally edited? The funding statement [34] discloses that the manufacturer provided photographic services. Such outsourcing is highly unusual in scientific studies and invites photographic manipulations, both known (e.g., background color change) and unknown [36]. A company that has invested heavily in research and development of its product, including fees paid to investigators [2], should not be entrusted with photographs, which are of essential importance in treatment evaluation [36].

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In addition to photographs, the manufacturer also provided ultrasound services [34]. The reported standard error, 0.39 mm, is much lower than the error in photographic measurements [15] and contrasts with another study using ultrasound documenting highly variable changes in fat thickness [16]. A 2.6-mm mean reduction in fat thickness is similar to the calculated 3 mm reduction [2] based on a 39.6 cc decrease in volume of a treatment area [15] and is likely to be within the range of measurement error that is inevitable when making measurements on sonograms, which are sensitive to transducer pressure, site selection, and the effect of subtracting any change on the control side [16], as was done in this study [34].

Plastic surgeons need to be diligent to protect the integrity of the scientific process and ensure that our journal publications do not become simply a marketing tool [36, 38]. It is not clear that the cost/benefit ratio favors a method that reduces the fat thickness 2.6 mm (1/10 in.) in 16 weeks [34].

> Plastic surgeons need to be diligent to protect the integrity of the scientific process and ensure that our journal publications do not become simply a marketing tool.

Conflict of Interest

Conflict of interest (COI) is a hot topic in plastic surgery and deservedly so. A close and mutually dependent financial relationship may exist between an investigator and manufacturer. Although this issue may be a sensitive one to those affected, conflict of interest is simply a reality that is now well-documented in plastic surgery [37, 38].

The manufacturer, Zeltiq Aesthetics (Pleasanton, CA), provided equipment and supplies and compensated both patients and the study site for treatment and follow-up visits [34]. Unfortunately, once investigators accept reimbursement, whether directly or indirectly, objectivity is lost [2, 37, 38]. It is becoming increasingly clear that plastic surgeons may function as highly-paid consultants or objective researchers, but not both [36].

> It is becoming increasingly clear that plastic surgeons may function as highly-paid consultants or objective researchers, but not both.

Stevens and Bachelor [34] reported that their findings contributed to the April 2014 clearance by the US Food and Drug Administration of cryolipolysis for reduction of fat in the thighs.

Stevens [34] originally disclosed that he was a medical luminary, investigator, and speaker for the manufacturer (Zeltiq Aesthetics, Pleasanton, CA). He was also a paid consultant and shareholder [39]. Plastic surgeons have privately informed me that they are underwhelmed by the results of cryolipolysis. Unfortunately, many practices have already purchased this very expensive equipment and have entered a continuing payment arrangement with the manufacturer. It is not clear that the benefits justify the cost and time investment on the part of patients or surgeons. Measurements on standardized photographs are mandatory for evaluation of results. Making important acquisitions based on commercial or marketing considerations alone is risky [2].

Does Radiofrequency Assistance Improve Skin Contraction after Liposuction?

Chia et al. [40] conclude that radiofrequency-assisted liposuction provides greater skin contraction of the arms than aggressive superficial liposuction. Unfortunately, no measurement data are presented, only the percentage changes in ten patients. Two patients underwent skin excisions. The authors do not report the inclusion rate or whether their study was prospective or retrospective. BodyTite (Invasix, Yokanem, Israel) is not for sale in the United States and has not been cleared by the US Food and Drug Administration [41].

Area varies as the square of any linear dimension of an equilateral triangle (Fig. 11.4). If the height decreases approximately 20% [40], one would expect the surface area to drop 36% [100 − (80 × 80%)]. Surprisingly, the reported reduction in triangular surface area (8.1–15.0% [40]) is less than the reduction in height, the opposite of what is expected. This discrepancy is impossible to reconcile with basic geometry [42].

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It is risky to suggest that a larger sample would have demonstrated a significant treatment benefit [40]. Observational error is unavoidable when measuring the sides of small triangles on the skin [42]. Distances are likely to shorten simply as a result of reducing bulk. If the skin is subjected to the same degree of stretch, any perceived contraction might disappear.

Aggressive superficial liposuction is not generally recommended because of an increased risk of complications [43]. If one side is treated more aggressively and more superficially [40], the contractility of the skin may be impaired, creating a confounder that undermines the comparison.

Using traditional liposuction cannulae, the entire upper arm and axilla can be accessed from a single axillary incision (Fig. 11.4), avoiding unnecessary scars. The learning curve clearly favors traditional (not aggressive, superficial) liposuction [42].

Chia et al. do not discuss limitations of their study, which are remarkably similar to those of another commercially sponsored study [44, 45] (discussed below) claiming improved skin contraction after ultrasonic liposuction.

Does VASER Lipoplasty Improve Skin Contraction?

Nagy and Vanek [44] report a 17% benefit in skin contraction for VASER (vibration amplification of sound energy at resonance) compared with an 11% improvement for traditional liposuction, a difference of 6%. Comparing percentages with a percentage, they cite a 53% relative benefit in skin tightening from this form of ultrasonic assistance. Titled a multicenter study [44], it involved two surgeons operating on 20 nonconsecutive patients.

The first question to ask is whether 20 women and 33 sites are sufficient to detect a 6% difference in treatment effects [45]. Standard deviations would have to be unusually small. The measurements—the crux of the paper—are not included in the authors' Table 1. The authors do illustrate bars representing 95% confidence intervals in Figure 2 of their study, deleting the bars on one side so they do not overlap. Such wide overlapping confidence intervals are difficult to reconcile with a *p* value of 0.003. A power analysis for 80% power, with an alpha

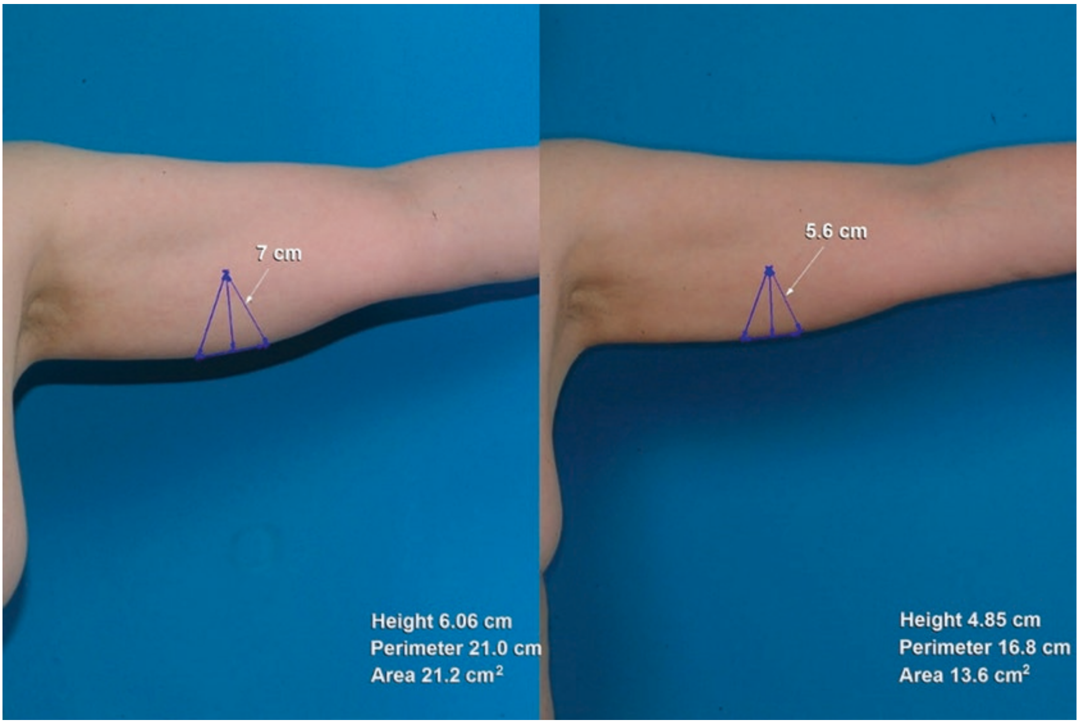

Fig. 11.4 A 58-year-old woman is seen before (*left*) and 1 year after (*right*) ultrasonic liposuction of the arms and axillae using a single axillary incision and superwet infiltration. The liposuction aspirate volume was 125 cc from the left upper arm. An equilateral triangle has been superimposed. Side measurements are shown. The height is depicted as a vertical line from the base of the triangle to its apex. This height measurement is analogous to the point of maximum dependency measurement used by the authors. The authors reported that after surgery the point of maximum dependency decreased approximately 20% (*right*). For an equilateral triangle, area = (side length)2$\sqrt{3}$/4. Height = (side length)$\sqrt{3}$/2 and varies in a squared relationship with area. A 20% decrease in this linear measurement produces a 36% reduction in the area (*right*). Note that these triangles are for illustration purposes only. They do not reflect any real difference in skin landmarks in this patient. The photographs are matched for size and orientation using the Canfield Mirror 7.4.1 imaging software (Canfield Scientific, Fairfield, NJ) (Reprinted from Swanson [42]. With permission from Wolters Kluwer Health)

level of 0.05, using a two-tailed, matched pairs *t*-test, would require a sample size of 199 to detect a small treatment effect (Cohen's $d = 0.20$) [46, 47] or in this case a small difference in treatment effects.

The authors divide the measured skin retraction by the volume of aspirate and call the adjusted values "normalized." No foundation is offered to justify this alteration that penalizes the non-VASER sides (because their mean aspirate volumes were greater), apart from a comment about achieving a cosmetic endpoint. Evidently the authors believe a correction is needed because there should be more skin contraction if more volume is removed.

However, it is also possible that the sides treated with liposuction alone may have been more aggressively treated compared with the

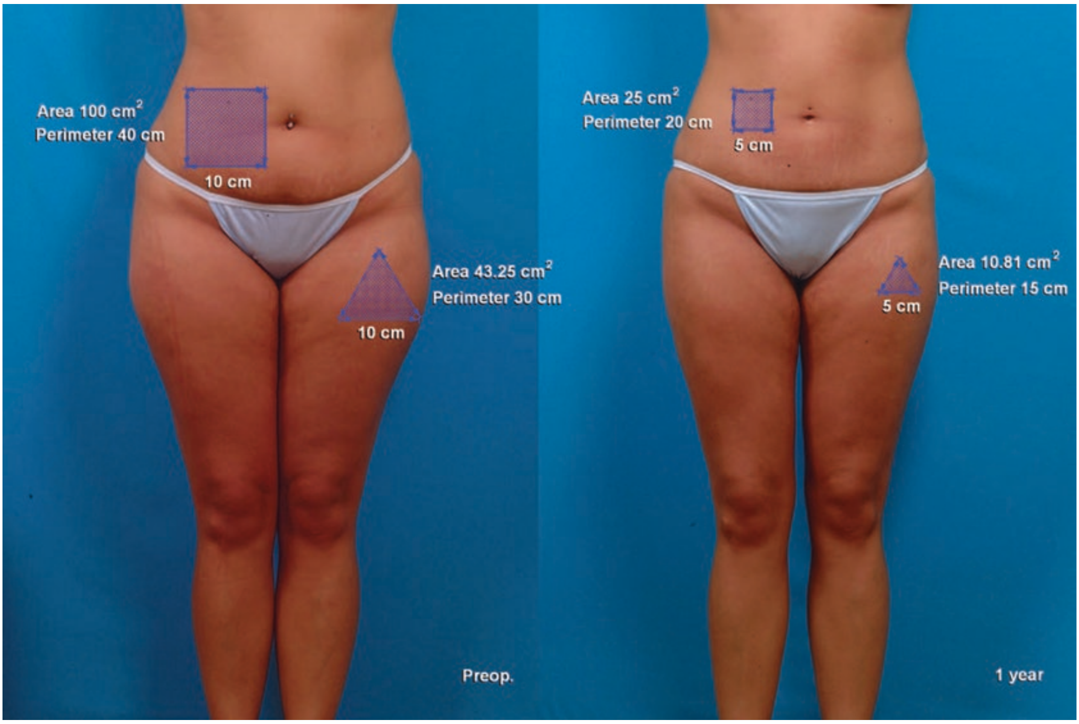

Fig. 11.5 Size-matched photographs of a 24-year-old woman before (*left*) and 1 year after (*right*) liposuction of her lower body, arms and axillae, and a breast augmentation. The total aspirate volume was 3250 cc. The superimposed shapes and measurements are for the purpose of illustrating changes in perimeter and area and do not correspond to any real change in skin measurements (indeed they would greatly exaggerate any such changes). The shapes are also enlarged for clarity. A preoperative side length of 5 cm would be more appropriate in the clinical setting. The area measurements are made using a mouse and the Canfield Mirror software (Canfield Scientific, Fairfield, NJ). The relationship between perimeter length, or side length, and area is exponential. For a square, area = (side length)^2. For an equilateral triangle, area = $\sqrt{3}/4$ (side length)^2. A 50% reduction in the perimeter of a square or a triangle corresponds to a 75% reduction in area (Reprinted from Swanson [45]. With permission from Wolters Kluwer Health)

VASER sides, causing more tissue trauma and possibly interfering with skin contraction. Indeed, the higher aspirate volumes, despite a lower infusion:aspirate ratio, and higher lipocrits on the non-VASER sides are consistent with greater tissue trauma. Ideally, and this would not have been difficult to do, the infusion:aspirate ratios and aspirate volumes would have been equal on both sides, allowing an apples-to-apples comparison [45].

To justify the authors' adjustment of their measurement data, a proportionate relationship between aspirate volume and skin retraction would need to be established. None is provided. Clinical experience suggests that there is an ideal aspirate volume for a particular area, with optimal skin contraction, and either undertreatment or overtreatment (compromising elasticity) results in lesser degrees of skin contraction, making a proportionate relationship unlikely [45].

Another crucial study question is what parameter to measure. The correct parameter for evaluating skin tightening is the skin area [45]. Instead, the authors measure perimeters. Skin retraction is represented as the change in the perimeter of a tattooed equilateral triangle. The authors make no mention of the squared relationship between the area contained in a triangle and its perimeter (Fig. 11.5) and how this difference relates to their adjustment for aspirate volume. Their adjustment contemplates that the skin will contract to one-fourth of its original area if the aspirate volume is doubled—the consequence of reducing the perimeter by half. Such a dramatic reduction would be physically impossible in view of the unchanging musculoskeletal dimensions of the treated area. Even if a proportionate relationship between skin retraction and aspirate volume exists, the authors are imposing an exponential adjustment on changes in area based on linear changes in aspirate volume and in so doing are overcorrecting.

> The authors make no mention of the squared relationship between the area contained in a triangle and its perimeter and how this difference relates to their adjustment for aspirate volume.

The authors state that the difference in mean aspirate volumes between the two groups (671 cc versus 781 cc) was a nonsignificant 6.4% [44]. This difference is evidently a typographical error and should read 16.4%. However, not only is the difference incorrect, these means are also erroneous. My calculations based on the data in the authors' Table 1 reveal means of 702.27 and 757.58 and a significant difference (7.9% greater for the non-VASER group, $p = 0.04$ using a two-tailed t-test). If the authors' adjustment is removed, whether it is 7.9% or 16.4%, the degree of skin retraction comes out in favor of the non-VASER sides.

> If the authors' adjustment is removed, the degree of skin retraction comes out in favor of the non-VASER sides.

One problem using triangles is that the area can vary even if the perimeter is unchanged, depending on the orientation of the three dots [48]. This geometric fact makes it impossible to convert triangular perimeters to areas, unlike squares. The summation of three such measurements, evidently made by the surgeons using a ruler on the skin under ultraviolet light, increases the potential for error. Computer-assisted area measurements, possibly using the simpler geometry of squares, made from calibrated and size-matched photographs (Fig. 11.5) would likely make the measurements easier, avoid summation, reduce measurement error, and more accurately represent skin contraction as a two-dimensional process (setting aside the implications of three-dimensional contraction).

There are other issues to consider: the use of different cannulae, unreported postoperative weights, insufficient sample sizes to justify inter-operator comparisons and questionnaires, and no control group to assess measurement reproducibility in untreated areas. The control group is really an alternative treatment group. There is no information on the inclusion rate. Did the 33 sites represent all tattooed sites, or were some excluded from evaluation? Conclusions regarding blood loss and early postoperative swelling are undermined by the differences in aspirate volumes and infusion:aspirate ratios between groups [45].

Although the financial disclosure states that the authors were not paid, the company sponsor paid for patient recruiting and surgeon fees and no doubt made these expensive machines available to the authors at reduced cost. As for commercial bias, Nagy has spoken extensively on behalf of VASER [49]. Both authors have been advertised to patients as VASER physicians on the company website, www.vaser.com, which also highlighted the study findings. According to Nagy's website, Grant Palmer, Ph.D., of Sound Surgical Technologies was originally credited as one of the study authors [49]. Along with a commercial VASER video, the word VASER appeared 20 times on a single page of Dr. Vanek's website [50].

This study is an example of a high-level statistical design, but one with weaknesses in methodology, error, financial conflicts of interest, and commercial bias, all of which undermine the authors' conclusions [45]. With adequate sample sizes, consistency of technique, statistical safeguards, and impartial investigators, this ultraviolet tattooing measurement technique holds promise for future studies. In the meantime, it is important to avoid making clinical recommendations (and major investments) on the basis of unreliable data [45].

This study is an example of a high-level statistical design, but one with weaknesses in methodology, error, financial conflicts of interest, and commercial bias, all of which undermine the authors' conclusions.

Fig. 11.6 Canister showing lipoaspirate after ultrasound-assisted superwet liposuction (approximately 1:1 infusion/aspirate ratio). The total lipoaspirate volume is 3000 cc. The infranatant volume is 200 cc. The mean hematocrit level of the infranatant fluid ("lipocrit") is 1.76%. In a patient with a hematocrit of 40%, this fluid represents an external blood loss of only 8.8 cc (1.76%/40% × 200 cc) (Reprinted from Swanson [61]. With permission from Oxford University Press)

Does Laser Assistance Reduce Blood Loss after Liposuction?

Abdelaal and Aboelatta [51] compare hemoglobin levels in the infranatant component of the liposuction aspirate and conclude that laser lipolysis reduces blood loss more than 50% compared with traditional liposuction. If their conclusion is correct, such a substantial difference might represent a real therapeutic benefit for laser lipolysis. Is it time for plastic surgeons to finally invest in laser-assisted liposuction?

Until recently [52], plastic surgeons have reported very low levels of blood loss associated with tumescent or superwet liposuction [53–55]. It is tempting to conclude that blood loss is minimal based on observations of the small amount of blood in the aspirate and the dilute hematocrits ("lipocrits") of the infranatant fluid, typically in the range of 1–2% [52, 56–58], and no other evidence of external blood loss. However, it is impossible to reconcile such small amounts of blood loss with the well-documented drops in hemoglobin levels after liposuction [52, 57, 59, 60]. Indeed, if the blood loss associated with superwet liposuction were truly trivial, there would be no basis for state medical boards and the American Society of Plastic Surgeons [53, 54] to impose safety limits on aspirate volume [61]. An under-recognized third space blood loss (i.e., blood loss into the tissues) accounts for this discrepancy [52]. Blood loss after liposuction is discussed in Chap. 5.

The average change in hemoglobin level after liposuction is a reduction of 1.9 g/dL on the day after surgery and a decrease of 2.0 g/dL 1 week after surgery [52]. These findings are similar to those of Apfelberg [59] in his original study of patients treated with conventional liposuction on one side of the body and laser-assisted liposuction on the other side. These measurements support recommendations to limit aspirate volumes to 5 L [53, 54], particularly when liposuction is performed in combination with other operations, as is commonly done today [52]. Fortunately, in nonobese patients, there is seldom a need to exceed an aspirate volume of 5 L, provided that a superwet infusion is used to maximize the proportion of aspirated fat (Fig. 11.6).

After superwet infusions, fat represents 87.5% of the aspirate volume, on average, and only 9.8% of the infusion fluid is removed by suctioning [52]. There is no evidence of an advantage in efficacy or safety for tumescent (i.e., >1:1 infusion/aspirate volume) infusions [55]. The infranatant volumes are not provided in the article by Abdelaal and Aboelatta [51] but appear to be <100 cc in three of the four canisters illustrated in the authors' Figure 1;

yet, in the authors' Table 8, the authors calculate that 254.9 cc of whole blood was collected, on average, from patients treated with conventional liposuction [61]. If true, this means that 30% of the liposuction aspirate (mean volume, 846 cc) was whole blood, greatly exceeding the expected blood loss in the aspirate using the superwet method (Fig. 11.6) [52]. The authors state that the blood loss after traditional liposuction of the limbs was 292 cc; the authors' Table 8 records the loss as 424.75 cc [51]. The referenced equation for calculating aspirate blood volume does not include "×100" [60]. Clarification is needed as to whether this error is simply a typographical mistake or one that contributed to falsely elevated blood loss calculations.

The referenced equation for calculating aspirate blood volume does not include "×100". Clarification is needed as to whether this error is simply a typographical mistake or one that contributed to falsely elevated blood loss calculations.

When estimating blood loss, the infranatant red blood cell count is less reliable than the hemoglobin level because the red blood cell count may be affected by hemolysis [61]. The authors' Table 2 shows that the average red blood cell count was reduced to 81.4%, compared with a reduction of 55% in hemoglobin level. This difference might be caused by the known cellular destructive effect of laser energy [62]. When hemoglobin levels are measured, the red blood cells are lysed. Measuring hemoglobin levels rather than red blood cell counts avoids the confounding effect of differences in cellular integrity [61].

The reported infranatant hemoglobin levels were remarkably high, 1.57 g/dL for the laser-assisted side and 3.5 g/dL for the side treated with traditional liposuction. A level of 3.5 g/dL is only about 3.5 times less concentrated than whole blood (normal hemoglobin level: 11.7–15.5 g/dL). By comparison, Karmo et al. [60] reported a mean hemoglobin concentration in the aspirate of 0.42 g/dL after superwet liposuction. Lipocrits from other studies [52, 56–58] measure 1–2% (normal hematocrit: 35–45%).

To estimate blood loss from laser lipolysis, Abdelaal and Aboelatta1 would need to check hemoglobin levels in their patients before and after liposuction, as was done by other investigators [52, 57, 59, 60]. Different patient groups would be needed of course, patients treated with conventional liposuction in one group and laser assistance in the other. If the findings of Apfelberg [59] are any indication (drops in hemoglobin level >1 g/dL despite laser treatment on one side), it may be difficult to detect a treatment difference. Moreover, the clinical significance of a small difference in blood loss is questionable, especially when weighed against the known disadvantages [59, 62, 63] of laser assistance.

To estimate blood loss from laser lipolysis, Abdelaal and Aboelatta would need to check hemoglobin levels in their patients before and after liposuction.

In their randomized controlled study, Prado et al. [62] were unable to find a treatment benefit that would justify the additional expense and operating time of laser assistance and a formidable learning curve. With recognition of the value of transposing fat cells to other areas of the body and the destructive effects of the laser on adipocytes [62], the trend today is away from methods that compromise the viability of fat cells that are either aspirated or left in the patient. Laser devices are marketed with catchy names. Plastic surgeons must remain vigilant to avoid prioritizing commerce over research [62]. Treatment recommendations must be based on sound science and not just marketing appeal [61].

In their randomized controlled study, Prado et al. were unable to find a treatment benefit that would justify the additional expense and operating time of laser assistance.

Does Tension Shielding with the embrace Device Really Improve Scars?

Lim et al. [64] claim that the "embrace" device significantly decreases scarring. If true, this product represents a monumental advance. As the authors note [64], no previous treatment has been proven effective in minimizing scars. Is it time for all plastic surgeons to order this product?

Although the study has a high-level design, methodological considerations merit scrutiny [65]. The investigators did not evaluate consecutive patients. There is no reported inclusion rate. These deficiencies invite selection bias [66]. The authors concede that their patient volume, only ten patients who completed the study, is "relatively small" [64].

The measuring device was qualitative. Photographic measurements of scar dimensions might have been helpful. It is risky to dismiss objective measures by saying that in the end it is the patient's opinion that matters [64]. Hopefully we aspire to a real benefit and not just a perceived one [65]. "Tension shielding" [64] sounds desirable. It would be useful for the authors to demonstrate that their device really does minimize wound tension. Other investigators [67] have used a tensiometer to measure skin response to surface tension.

> It is risky to dismiss objective measures by saying that in the end it is the patient's opinion that matters. Hopefully we aspire to a real benefit and not just a perceived one.

There are problems with the figure legends. The legends to the authors' figures 3, 4, and 5 all state that the upper left photographs represent preoperative photographs and the remaining photographs are all taken post-revision [64]. However, the appearance of the scars and adjacent skin markings reveal that the photographs depict the same scar [65].

If only ten patients are being evaluated, the methodology needs to be pristine [65]. Photographs given to a panel for evaluation must be standardized, including identical lighting and the same degree of magnification so as to make the comparison a fair one. Unfortunately, this is not the case. The control scar appears wider than the embrace-treated scar in the authors' Figure 4. However, this untreated scar is also magnified much more than the embrace-treated scar, as revealed by skin markings (Fig. 11.7). The exposure is also darker for the control scar. In the authors' Figure 5, a pigmented skin lesion disappears in a postoperative photograph, evidently removed by photoshopping (Fig. 11.8). Inaccurate figure legends, nonstandardized photographs, and undisclosed digital editing all detract from the credibility of the images [65].

> Inaccurate figure legends, nonstandardized photographs, and undisclosed digital editing all detract from the credibility of the images.

Apart from photographic inconsistencies, there are other confounders. The authors studied scars at different anatomical sites. Three surgeons performed the surgery using three suturing techniques. Treatment of the control side was variable. It would have been preferable to treat the control side with a noncontracting silicone gel sheet to rule out any possible effects of a silicone gel dressing, which some investigators claim is helpful for scars in itself [68].

Patients seeking scar revisions are a selected patient group (obviously not good scar formers) that may not be comparable to first-time surgical patients. Such scars may not be symmetrical. Previous surgery and scarring over different body sites introduce other variables that may affect the analysis [65].

This device is supposed to work by displacing wound tension to the surrounding skin, isolating the wound from tension [64]. However, the surrounding skin tension is likely to relax quickly. It is not clear from this study whether this device can maintain a tension-free wound for any length of time. The skin exhibits a high degree of stress relaxation (i.e., stress is relieved

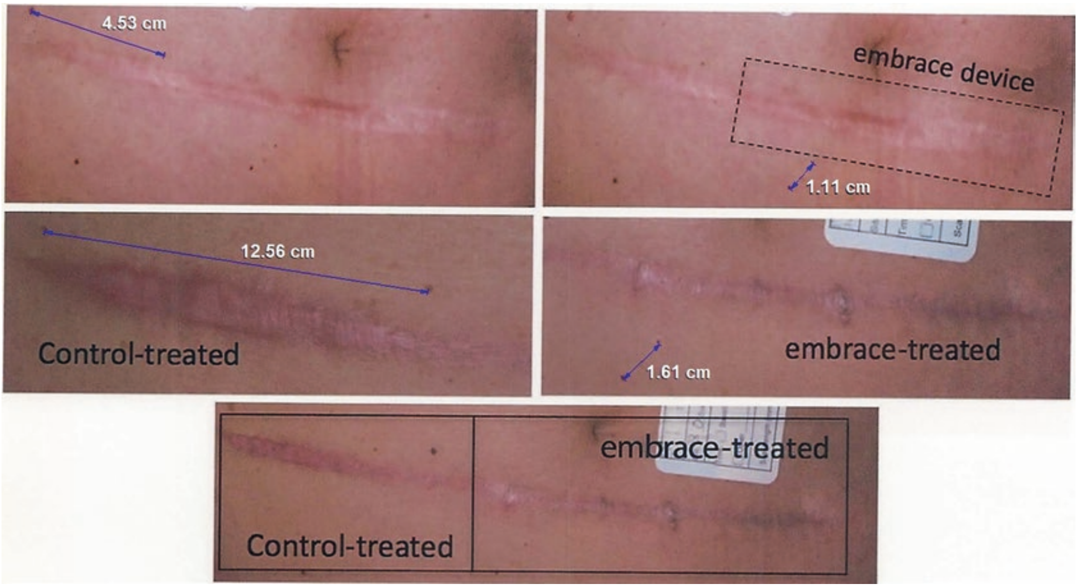

Fig. 11.7 The authors' Figure 4 is depicted. The individual photograph of the control scar (*center, left*) has been magnified by a factor of 7.7 compared with the photograph depicting both scars (*above, left*). The exposure is also darker. The individual photograph of the embrace-treated scar (*center, right*) is enlarged by a factor of 2.1. This difference in magnification makes the control scar appear much larger than the embrace-treated scar. Skin markings are used for reference. The units are calibrated based on a 5-cm width of the partially visible treatment identifying marker. The units are arbitrary [Adapted from Lim AF, Weintraub J, Kaplan EN, et al. The embrace device significantly decreases scarring following scar revision surgery in a randomized controlled trial. Plast Reconstr Surg. 2014;133:398–405. With permission from Wolters Kluwer Health, Inc.]

quickly when stretched) [69], a phenomenon that occurs within minutes [67]. Scar maturation and remodeling occur over a period of months, up to a year [70]. Patients are unlikely to be compliant with a device that must be worn for extended periods [65]. It is unknown how patient movement affects the device. The financial considerations for a product that is replaced each week are relevant [65].

The most serious problem with this study is commercial bias [65]. Five authors are also investors. Longaker is the senior and corresponding author. The disclosure paragraph [64] states that Longaker has equity in the sponsoring company, but he is more than just an investor. He is also the chairman of the board and founder of Neodyne Biosciences, Inc. [71]. According to the company's website (accessed in 2014) [71], he started this company in 2007, before the scientific studies supporting the method were conducted. Another study author, Bill Beasley, is listed in the disclosure as either a consultant or employee of the company [64]. In fact, he is the company president [71]. It is one thing to be a passive investor; it is quite another to be an officer of a company with a fiduciary responsibility [65, 72]. The company website is devoted exclusively to scar treatment [73]. It seems that its economic viability relies largely on this device. As the saying goes, failure (to find treatment efficacy) is not an option. Already, this product is advertised to minimize scars after common procedures such as breast augmentations and tummy tucks [74].

It is one thing to be a passive investor; it is quite another to be an officer of a company with a fiduciary responsibility.

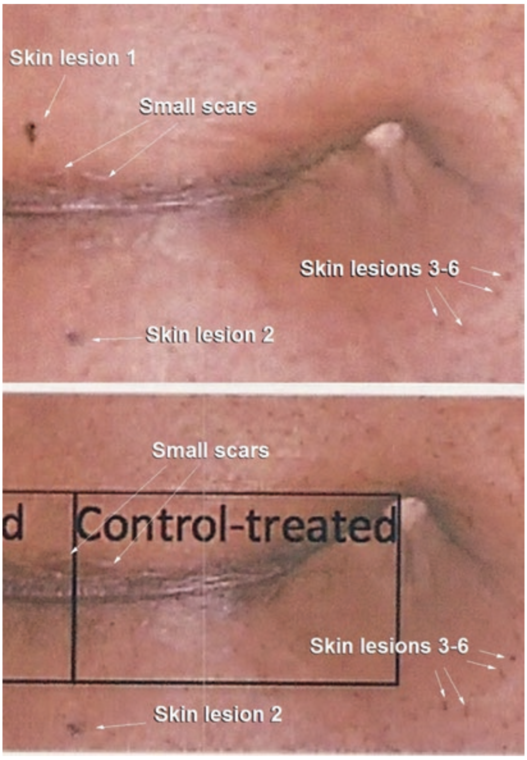

Fig. 11.8 The authors' Figure 5 is examined. The authors' above, left (*above*), and below illustrations (*below*) are enlarged and size-matched. The figure legend states that the authors' above, left photograph is a preoperative photograph, and the photograph below represents the result 6 months after the scar revision. However, the labeled skin markings appear to show no evidence of a scar revision. The largest of the skin lesions (*skin lesion 1*) is missing in the photograph below [Adapted from Lim AF, Weintraub J, Kaplan EN, et al. The embrace device significantly decreases scarring following scar revision surgery in a randomized controlled trial. Plast Reconstr Surg. 2014;133:398–405. With permission from Wolters Kluwer Health, Inc.]

Unfortunately, scar formation is a complicated problem [70], unlikely to be solved with a simple fix. We are reminded of the importance of "science before marketing." Only by following the scientific method [66] can we expect to avoid adopting unsound treatments. A method that decreases scar formation is an extraordinary claim. If true, virtually all scars would benefit from this treatment. The commercial implications are mind-boggling. However, as Carl Sagan put it [75], "Extraordinary claims require extraordinary evidence."

In their defense, Gurtner and Longaker [76] note that their product represents the culmination of a 20-year journey funded by grants from the National Institutes of Health, the US Department of Defense, and numerous private foundations. Studies have been conducted at the world's leading academic medical centers and published in the highest impact scientific and surgical journals [76]. The authors attach 33 references to their reply. They point out that scar evaluations were performed by three board-certified surgeons. Gurtner and Longaker [76] insist their disclosure was thorough and complete.

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The Fallacy of Individual Risk Stratification and Chemoprophylaxis

12

Abstract

In an effort to identify patients at greater risk of venous thromboembolism (VTE), individual risk assessment using Caprini scores has been promoted. The Venous Thromboembolism Prevention Study, published in 2011, claims that patients with higher Caprini scores are at greater risk for VTE and the risk may be reduced by administering enoxaparin, despite an equal VTE incidence, 1.2%, in both control and anticoagulated patients overall, and no significant difference comparing anticoagulated and control patients with higher Caprini scores. Many VTEs occur in patients with low Caprini scores. Unfortunately, some plastic surgeons have testified that risk stratification and chemoprophylaxis represent the standard of care.

Caprini scores were not developed scientifically and do not correlate with relative risk values. Affected patients cannot be reliably predicted (97% false-positive rate). Caprini has numerous financial conflicts with anticoagulant manufacturers. Subsequent studies and meta-analyses fail to support risk stratification and chemoprophylaxis as an effective means to reduce VTE risk.

The same meta-analyses show that chemoprophylaxis increases the risk of bleeding. Oral anticoagulants are not FDA approved for VTE prophylaxis in plastic surgery patients and also increase the risk of hematomas.

Sequential compression devices are widely used and perceived to reduce risk, but there is little evidence of their efficacy. Alternative methods to reduce risk for all patients include recognition of the need to preserve the calf muscle pump during surgery by avoiding general endotracheal anesthesia with paralysis. Surgeons using intravenous sedation report lower VTE rates. Clinical findings are notoriously unreliable. Doppler ultrasound surveillance can be used to detect deep venous thromboses, replacing ineffective risk models.

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The Controversy

Chemoprophylaxis is a controversial topic in plastic surgery today. The seriousness of venous thromboembolism (VTE) and the need to reduce risk are not in dispute. Articles published in the *Journal of Plastic and Reconstructive Surgery* uniformly support chemoprophylaxis to reduce VTE rates in plastic surgery patients deemed to be at greater risk [1–7].

Risk Assessment Models

Pannucci [8] and other proponents of chemoprophylaxis believe that individual risk assessment using Caprini scores is now part of the standard of care for plastic surgery inpatients. According to its proponents [2, 4], plastic surgeons who do not subscribe to risk stratification are noncompliant, uninformed, and their practices are "inadequate."

The points in Caprini's 2005 scoring system [9] add up quickly. A healthy 61-year-old woman (2 points) with a body mass index of 26 kg/m^2 (1 point) undergoing surgery lasting >45 min (2 points) is assigned 5 points. The 2010 Caprini scoring system adds a point for surgery lasting 2–3 h (3 points) [10]. Operations lasting >3 h are assigned 5 points.

The American Society of Plastic Surgeons Venous Thromboembolism Task Force Report [5] recommends that plastic surgeons consider chemoprophylaxis for patients with 2005 Caprini scores between 3 and 6. To its credit, this Task Force [5] does not conclude that individual risk stratification and chemoprophylaxis represent the standard of care. However, using the word "consider" indicates a preference for Caprini scores and anticoagulation, obligating those who disagree with these methods (and therefore do not consider them) to defend their practices [11].

Caprini Scores

Although they are widely used, Caprini scores are not universally accepted. The lead author of the American College of Chest Physicians (ACCP) 2004 and 2008 Guidelines on Antithrombotic and Thrombolytic Therapy recommends against using Caprini scores to risk stratify plastic surgery patients (Geerts WH, 16 April 2013, personal communication). Geerts also cautions against extrapolating the ACCP guidelines to elective plastic surgery patients.

Geerts candidly comments that Caprini scores are based on "GOBSAT," which stands for "Good Ole Boys Sitting Around a Table" (Geerts W, 15 October, 2015, personal communication). The Caprini scoring system [9] was published in *Disease-A-Month*, a journal for primary care physicians, with an impact factor of 1.279 [12]. Forty proposed risk factors are assigned values ranging from 1 to 5 points [9]. No relative risk data are provided to support the point assignments. Only 24 references are cited [9]. Caprini's follow-up 2010 publication [10] contains 14 references and, again, no relative risk data. In determining risk scores, Caprini admits that he applies logic, emotion, experience, and intuition [9, 10].

> In determining risk scores, Caprini admits that he applies logic, emotion, experience, and intuition.

The inadequacy of such nonscientific considerations is the very foundation for evidence-based medicine [13]. The use of this scoring system in articles published subsequently in high-impact journals such as the *Journal of the American College of Surgeons* [14], *Journal of Plastic and Reconstructive Surgery* [2], *Chest* [15], and *Annals of Surgery* [16] cannot compensate for the lack of a scientifically sound foundation.

Geerts adds: "Although there is some evidence about risk factors across the board (age, cancer, immobility), the weight of each risk factor depends on the clinical context." Geerts does not support individual risk stratification and recommends no chemoprophylaxis for outpatients having elective plastic surgery, regardless of their Caprini score.

Guidelines of the American College of Chest Physicians

Caprini scores were not referenced in the 2004 or 2008 ACCP guidelines. The 2012 Guidelines for prevention of VTE in surgical patients were divided into two sections, nonorthopedic and orthopedic, with different authors and different recommendations [15, 17]. Caprini scores were referenced in the guidelines published by Gould et al. [15], which were intended for the prevention of VTE in nonorthopedic patients. Geerts (Geerts WH, 15 October 2015, personal communication), who did not participate in the 2012 publication, differs with the 2012 recommendations by Gould et al., finding insufficient validity in Caprini scores. Geerts believes that chemoprophylaxis is more effectively based on the diagnosis (e.g., major trauma) or procedure (e.g., hip replacement) as opposed to individual risk assessment, which he also believes is not likely to be done consistently.

Surgeons familiar with patient risk assessment forms are aware of the lack of compliance in filling them out. Today, guidelines used in hospitals and surgery centers, including those credentialed by the American Association for Accreditation of Ambulatory Surgery Facilities [18], often call for the inclusion of a risk assessment score in the medical record. However, surgeons are still free to use their judgment in deciding whether to prescribe anticoagulation.

Caprini scores are not referenced in the 2012 Guidelines for prevention of VTE in orthopedic patients [17]. This omission is notable because joint replacement patients have traditionally been considered at high risk for VTE. The 2012 guidelines [17] conclude that for major orthopedic surgery, the surgery-specific risk far outweighs the contribution of patient-specific factors. The authors recognize that although individualized risk factor assessment carries considerable appeal, this method is limited by a lack of validation and is "not sufficiently secure to mandate different risk strata" and the interaction of risk factors in a given patient is not well understood [17].

> The authors of the orthopedic chapter of the 2012 ACCP guidelines recognize that individualized risk factor assessment is limited by a lack of validation.

Caprini Scores and Relative Risk

Figure 12.1 compares Caprini scores with known levels of relative risk [19–23]. Advancing age is by far the most important risk factor [19, 20]. The mean relative risk for other factors assigned Caprini scores between 3 and 5 is 5.1-fold. For patients with lower scores, between 0 and 2, the mean relative risk is actually higher, 6.3-fold. Using Pearson correlations, the correlation coefficient is 0.07, and the p value is 0.81, indicating no correlation between individual Caprini scores and relative risk values [11].

> Pearson correlations indicate no correlation between individual Caprini scores and relative risk values.

Both the Venous Thromboembolism Prevention (VTEP) Study [2] and a recent publication using the National Surgical Quality Improvement database [24] identify "high-risk" patients, whose likelihood of a VTE is approximately 3%, as opposed to an overall risk of ≤1%. Shaikh et al. [25] attempted to use Caprini scores (≥5) and American Society of Anesthesiology scores (≥3) to identify affected patients but could not improve upon a 97% false-positive rate. In the VTEP study, almost half of all VTEs occur in patients deemed less risky (Caprini scores <7) because these patients are more numerous [26]. Wilkins and Pannucci [27] suggest that there is "predictive value" in risk assessments, which is true only if one accepts that 97% of such predictions are wrong.

> Wilkins and Pannucci suggest that there is predictive value in risk assessments, despite a 97% false-positive rate.

Fig. 12.1 Comparison of 2010 Caprini scores with relative risk factors [Adapted from Swanson E. Caprini scores, risk stratification, and rivaroxaban in plastic surgery: time to reconsider our strategy. Plast Reconstr Surg Glob Open 2016;4:e733. With permission from Wolters Kluwer Health, Inc.]

	Caprini score*	Relative risk†
Age ≥75 years [20]	3	90
Postpartum [22]	1	20
Major trauma [22]	5	13
Hospitalization on a medical service [22]	0	8
Cancer [22]	3	6.5
Surgery [22]	3	6
Pregnancy [22]	1	5.5
Prolonged bedrest [22]	1	5.5
Oral contraception [22]	1	4
Factor V Leiden [21,23]	3	4
Hormone replacement therapy [22]	1	3
Prothrombin 20210G [21,23]	3	2.5
Obesity (BMI >30 kg/m^2) [22]	1	2.5
Family history [22]	3	2.5
Travel >4h [22]	0	2
Elevated homocysteine level [21]	3	1.1

BMI, body mass index
*Zero values are assigned if Caprini does not include the parameter as a risk factor.
†Mean values are used when ranges are provided

Caprini's updated assignment of 5 points for a >3-h operation is inexplicably high, matching his point assignment for a recent hip, pelvis, or leg fracture, elective major lower extremity arthroplasty, or an acute spinal cord injury [10]. When the revised 2010 Caprini scoring values [10] are substituted for the 2005 values, additional patients are added to the higher-risk categories, and the difference in complication rates among highest-risk patients (already nonsignificant using the 2005 scores) is reduced. The authors do not question the basis for these changes, which they acknowledge as improvements [4]. Regardless, the same study and the same data, using either the 2005 or 2010 Caprini risk assessment models, support a conclusion that chemoprophylaxis is ineffective.

Pannucci et al. [4] agree with Caprini's 2010 updates but favor his older 2005 scoring system because the newer scores are not supportive of individual risk assessment as determined in the VTEP study. This would seem to be a contradiction. If the newer scores are truly more accurate, but implementation of this updated scoring system makes the VTEP data comparison "more nonsignificant," the conclusion should be that there is a fundamental problem with individual risk stratification. An analogy would be a cosmologist using an older formula for expansion of the universe because it agrees better with his or her theory.

The Caprini scoring system overrates several risk factors [11]. A positive family history (3 points) and prothrombin G20210A mutation (3 points) are modest risk factors for VTE, raising the risk 2–3 times [21–23]. Factor V Leiden (3 points) raises the risk 2–5 times [21, 23]. Serum homocysteine is given 3 points despite a barely measurable relative risk [21]. Advanced age is grossly underrated. Three points are assigned for age >75 years despite a 90-fold increased risk between ages 45 and 80 [19, 20]. Immobilization and bedrest (1 point) are underrated. Hospitalization and long periods of travel are omitted. The Caprini scoring system does not recognize the type of anesthesia as a factor despite strong empirical evidence [28–32]. Pannucci et al. [6] acknowledge the importance of anesthesia as a risk factor, particularly in its effect on the calf muscle pump, but this vital consideration is not considered in this risk assessment model.

Undisclosed Financial Conflicts

In their 2009 publication, Venturi et al. [33] discuss risk factors for VTE. The disclosure paragraph states that "the authors have no financial interest in and received no compensation from manufacturers of products mentioned in this article." The article mentions such products as enoxaparin, fondaparinux, heparin, and sequential compression devices. However, a separate manuscript by Caprini, dated November 4, 2006, and posted on his venousdisease.com website [34], reveals that this coauthor received writing support and funding from Sanofi-Aventis (Bridgewater, NJ) and is on the speaker's bureau and a consultant for Tyco, Sanofi-Aventis, GSK, and Eisai pharmaceuticals. Covidien (formerly Tyco, Dublin, Ireland) manufactures Kendall sequential compression devices; Sanofi US (Bridgewater, NJ) produces Lovenox (enoxaparin); and GlaxoSmithKline (Brentford, London) manufactures Arixtra (fondaparinux) [11].

Another 2006 manuscript posted on Caprini's website [35] was funded by Sanofi and GlaxoSmithKline and includes a disclosure paragraph stating that Caprini and coauthors served as consultants and paid speakers for "all companies involved in the development of antithrombotic agents." Surprisingly, this paragraph is missing in the published article [36]. Eisai (Tokyo, Japan) manufactures Fragmin (dalteparin). Other nondisclosed sponsors include Pfizer (New York City, NY), maker of Eliquis (apixaban) [37]; Leo Pharma (Ballerup, Denmark), maker of heparin [38]; AstraZeneca (London, UK) [39], manufacturer of a withdrawn warfarin alternative; and Boehringer Ingelheim (Ingelheim, Germany) [40], maker of tissue plasminogen activator. Remarkably, Caprini's 2005 and 2010 publications [9, 10] and the majority of the articles available on his website include no disclosure of any conflicts of interest. Caprini (Caprini JA, 5 October 2015, personal communication) believes that financial conflicts are irrelevant because his scores have been "validated in thousands of patients." However, there is no longer any doubt that a financial conflict influences investigators [41, 42].

> Caprini's 2005 and 2010 publications include no disclosure of any conflicts of interest.

The Venous Thromboembolism Prevention Study

Only one large controlled study investigates the use of anticoagulation in plastic surgery patients, the Venous Thromboembolism Prevention Study, published in the *Journal of Plastic and*

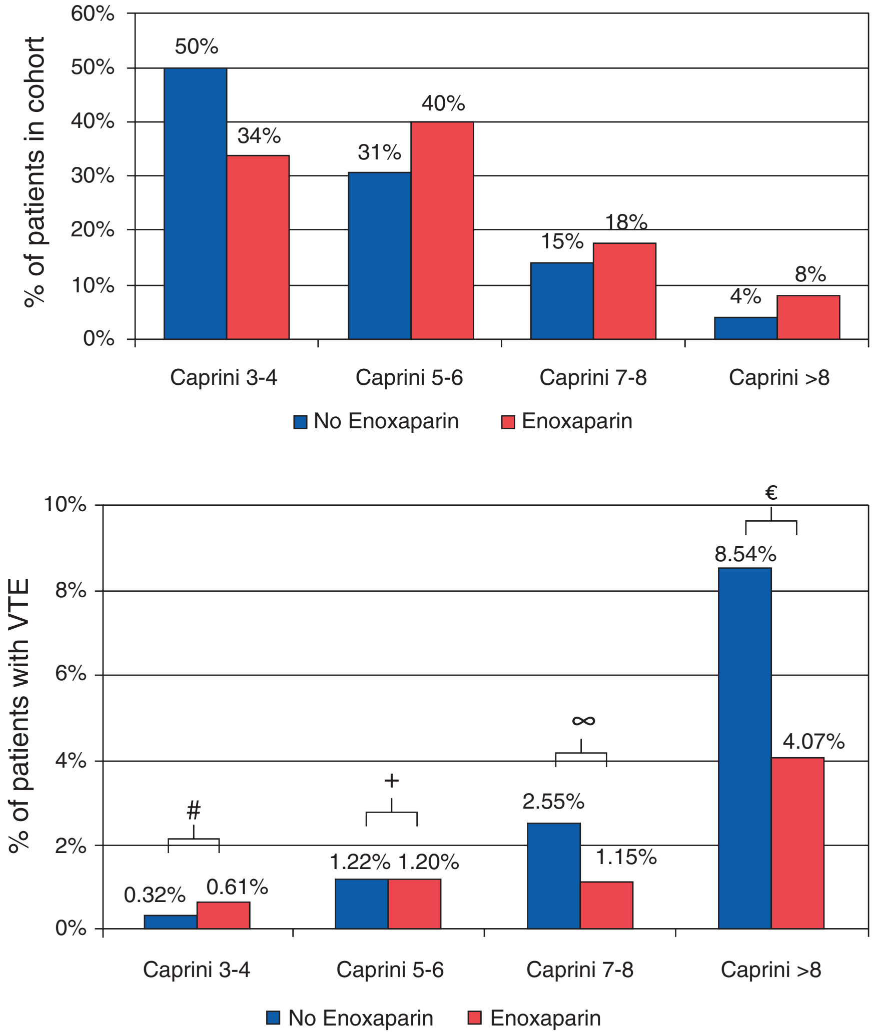

Fig. 12.2 These figures from the authors' publication may be used to determine the actual number of patients who experienced VTEs. The percentages in the top histogram are multiplied by the known number of patients in the treatment ($n = 1458$) and control groups ($n = 1876$). These numbers are then multiplied by the percentages in the bottom graph to arrive at actual patient numbers, depicted in Fig. 12.3. The bottom graph appears to show an overall greater incidence of VTE among control (*blue*) patients and greater treatment effectiveness in higher-risk patients [Reprinted from Pannucci CJ, Dreszer G, Fisher Wachtman C, et al. Postoperative enoxaparin prevents symptomatic venous thromboembolism in high-risk plastic surgery patients. Plast Reconstr Surg. 2011;128:1093–1103]

Reconstructive Surgery in 2011 [2]. Its title leaves little room for doubt about the conclusions: "Postoperative enoxaparin prevents symptomatic venous thromboembolism in high-risk plastic surgery patients." This study evaluated only plastic surgery inpatients. It is risky to extrapolate any conclusions to the outpatient population because of differences in patient characteristics, types of surgery, anesthesia, and level of mobility [26].

The VTEP study data are summarized in the authors' illustrations, reproduced here in Fig. 12.2. Surprisingly, the actual numbers of VTEs in the control and treatment groups are not disclosed in the article. To discover this information, the reader must multiply the percentages in the upper histogram by the known group sizes and then multiply these numbers by the percentages in the lower graph. The results are presented in Fig. 12.3. The data reveal that VTEs occur in patients across a

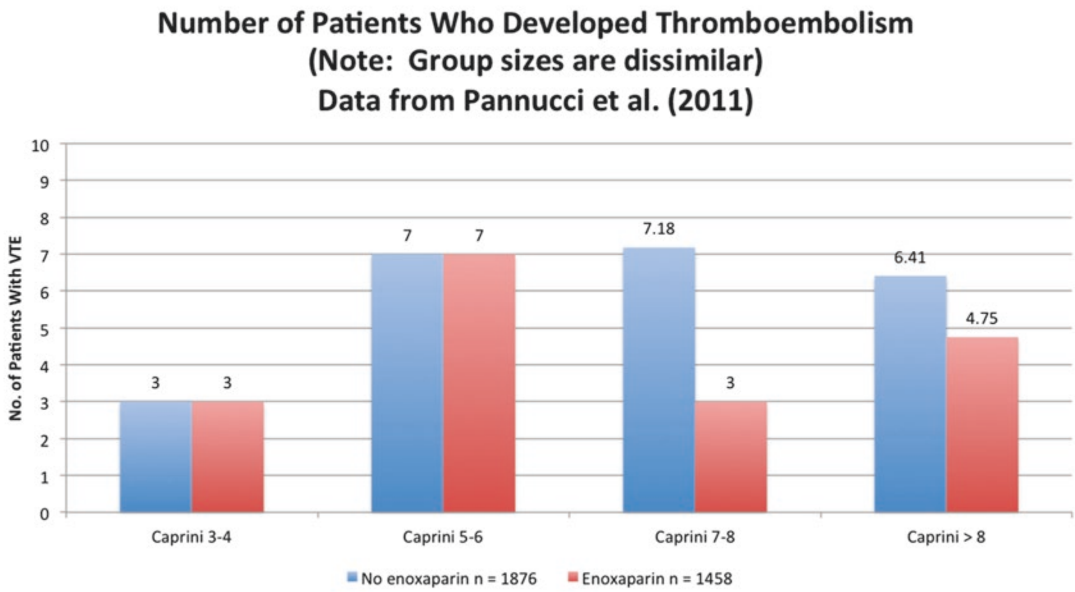

Fig. 12.3 Histogram showing the distribution of patients as derived from the authors' data. The number of control patients in the highest Caprini subgroup was 6.41, compared with 4.75 patients in the treatment group. It is unclear why the numbers are not whole. Almost half of the patients have scores <7. This illustration shows actual patient numbers. It does not account for the 29% difference in sample sizes. A histogram that shows percentages, eliminating group size as a factor, is provided in Fig. 12.5. [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

range of Caprini scores; almost as many (47.6%) occur in patients with scores <7 as in patients with scores ≥7. Figures 12.4 and 12.5 reveal that the incidence of this complication in treatment and control groups is the same, 1.2%. Pannucci conceded this important point at a debate with me in 2015 [43]. Figure 12.5 is a true histogram (percentages contained within the bars add up to 100%) that accounts for the difference in sample sizes; there is no evidence of a treatment benefit for patients with the highest Caprini scores [26].

It is informative to compare the published graphic (the bottom illustration in Fig. 12.2) with a true histogram (Fig. 12.5). The data are the same, but the presentations are very different. This difference is caused by the distortion that occurs when different group sizes are presented on the same graph as percentages—small differences (such as a difference of one or two patients) appear much larger when the number of patients is very small. The presentation can mislead the reader into thinking (1) more VTEs occur in control patients, (2) more VTEs occur in patients with higher Caprini scores, and (3) the treatment benefit is greatest for patients with the highest

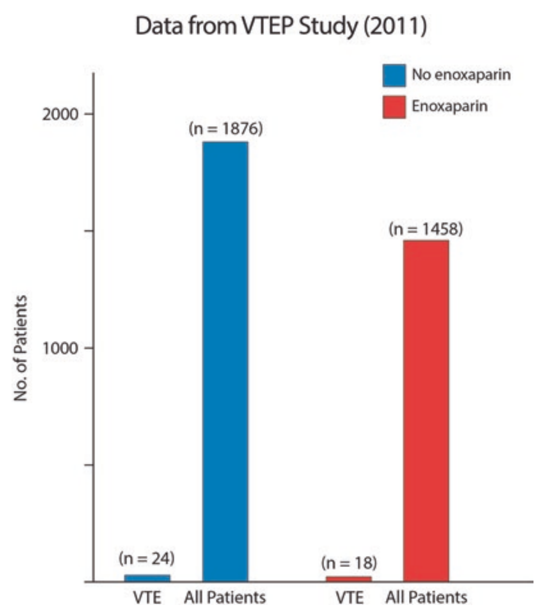

Fig. 12.4 Numbers of patients in the historical control group (*blue*) and patients who received postoperative enoxaparin (*red*) in the Venous Thromboembolism Prevention Study. The number of patients in the control group was 29% larger (1876 versus 1458) than the number of patients in the treatment group. The incidence of VTE was the same in both groups, 1.2%

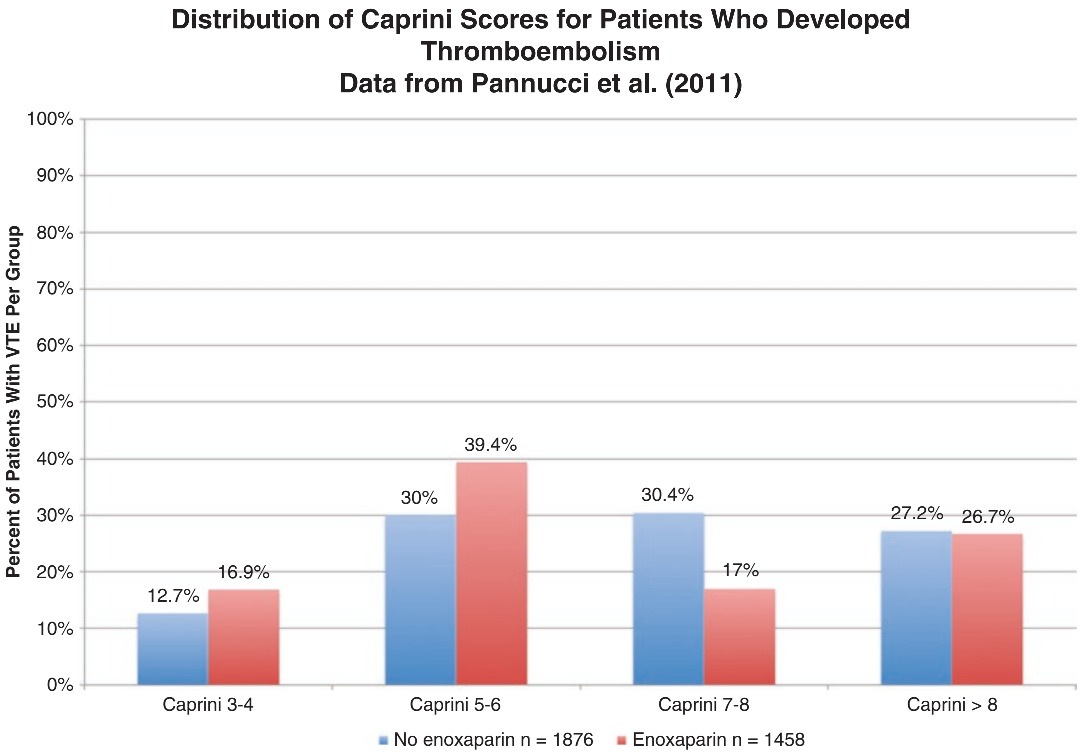

Fig. 12.5 Histogram showing the distribution of affected patients by Caprini group. Unlike the authors' graph (bottom graph, Fig. 12.2), this is a true histogram. The percentages add up to 100%. The graph accounts for the 29% difference in sample sizes. There is a very similar amount of blue and red, reflecting the equal overall incidence of this complication. There is no evidence of a treatment benefit in patients with the highest Caprini scores. [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

Caprini scores. All of these impressions are wrong, as demonstrated in Fig. 12.5.

> It is informative to compare the published graphic (the bottom illustration in Fig. 12.2) with a true histogram (Fig. 12.5). The data are the same, but the presentations are very different.

> There is no evidence of a treatment benefit in patients with the highest Caprini scores.

Unjustified Statistical Adjustments

There are problems in the authors' adjustments. The authors adjust the data analysis to fit their conclusion, rather than the reverse.

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The VTEP investigators must have been surprised to find an equal incidence of VTEs among control and anticoagulated patients, to the extent that they did not report these numbers and implemented statistical adjustments. To find a significant treatment benefit, the authors used logistic regression. Pannucci et al. [2] determined that the median Caprini score was higher for the treatment group than for the historical control group (5 versus 4). Controlling for this difference seems reasonable until one considers the difference in data collection between retrospective and prospective cohorts [44]. As Pannucci and colleagues have recognized in previous publications [15, 45], this information (totaling 40 parameters [9]) is often incomplete in a retrospective chart review, leading to underestimated Caprini scores. This fact can explain a discrepancy in scores when comparing retrospective and prospective cohorts, undermining the case for a statistical adjustment.

Pannucci et al. [2] also adjusted their data to account for a disparity in mean length of hospital stay (3.8 days for treated patients versus 3.1 days for historical controls), a questionable statistical maneuver for several reasons. First, the length of hospitalization is not a known factor increasing the risk of a VTE. In fact, Caprini [9] believes that patients after discharge may be just as sedentary as they were in hospital, remarking, "these individuals spend most of the time in a recliner, which is not early ambulation but rather early angulation." Second, from a statistical perspective, the sample sizes in the hospital stay subgroups are much too small to allow a reliable statistical analysis. Third, controlling for the Caprini score is unjustified because there is no known linear relationship between such scores and risk [11]. Finally, anticoagulation was continued for the duration of the hospitalization [2], so that patients with longer admissions would have also received longer periods of anticoagulation [26]. Pannucci has conceded that disregarding the difference in duration of anticoagulation is a weakness of the study [8]. Of course, all studies have weaknesses. However, this weakness leads to an erroneous conclusion and one that remains uncorrected by the authors. By making adjustments in the direction favored by the investigators, and disregarding a factor that opposes it, the authors just barely find significance, citing a p value of 0.042 [2], just within the bounds of a 0.05 level of significance.

Even with the authors' adjustments, the data are too evenly distributed to skew sufficiently to find a significant treatment advantage for patients with higher Caprini scores. Nevertheless, nonsignificant differences ($p = 0.230$ and $p = 0.182$) are used to support the authors' conclusions [2]. Regarding the authors' claim to a significant ($p = 0.042$) overall treatment benefit, many investigators will be skeptical of an adjustment that produces a significant overall treatment difference despite an identical 1.2% incidence of this complication for treatment and control patients (Figs. 12.4 and 12.5). Statistical modeling requires prudence so that it does not become a form of statistical photoshopping [26].

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Indeed, the VTEP investigators [2] would have done well to trust their data and conclude that there was no significant treatment effect [11, 43]. Certainly a negative outcome is not what these investigators expected, but such a conclusion would have been a valuable contribution and one that would lead to a new direction in the management of this serious problem [11].

Prevailing Wisdom

Twelve authors were listed on the VTEP study [2], including some well-known researchers. The study was funded by the Plastic Surgery Foundation [2]. Dr. Pannucci received a grant from the National Institute of Health [2], and of course the University of Michigan is a respected academic institution. Pannucci has received the James Barrett Brown and Leonard R. Rubin awards from the American Association of Plastic Surgeons for this work [46, 47]. Do these considerations impart authority to the conclusions? Sackett [48], one of the founders of evidence-based medicine, once commented: "The first sin committed by experts consists in adding their prestige and their position to their opinions, which give the latter far greater persuasive power than they deserve on scientific grounds alone." No degree of personal or institutional authority can take precedence over the facts. This point is central to scientific study and has been recognized by Galileo and later by Bernard in the nineteenth century [49]. It would seem obvious to modern researchers, but plastic surgeons need to be reminded that reliance on authorities or letting others "do the science" is as risky today as it was in Galileo's era.

> *When we meet a fact which contradicts a prevailing theory, we must accept the fact and abandon the theory, even when the theory is supported by great names and generally accepted.*
>
> –Claude Bernard 1865.

Conflicts are not always financial [50]. It is possible to become so intellectually and professionally invested in a concept that it becomes difficult or impossible to reconsider.

Some might argue that we had better accept chemoprophylaxis because it is the trend in medicine and surgery—"everyone else is doing it." Interestingly, orthopedic surgeons may be having second thoughts; the 2012 recommendations of the American College of Chest Physicians allow for the use of aspirin instead of low-molecular-weight heparin in orthopedic surgery [17]. Perhaps surprisingly, a large randomized study among hospitalized patients, reported in the *New England Journal of Medicine* [51], found no benefit in VTE risk for patients who were given enoxaparin. This finding was made all the more remarkable by the fact that the study was funded by the manufacturer of enoxaparin.

A study of 20,794 general medical inpatients, published in 2014, compared 90-day VTE incidence among 35 Michigan hospitals with varying rates of chemoprophylaxis use. The findings challenged the conventional wisdom. Patients admitted to hospitals with lower rates of chemoprophylaxis did not have more VTEs [52]. The investigators recommended avoiding pharmacologic prophylaxis and its attendant risks in patients who are at otherwise low risk of VTE.

A study of 16,120 patients undergoing colorectal surgery at one of 52 Washington State hospitals showed no change in VTE rates despite an increase in perioperative and in-hospital chemoprophylaxis from 31.6% to 86.4% and from 59.6% to 91.4%, respectively [53].

Sharrock et al. [54] reviewed 20 studies of patients undergoing total joint arthroplasty and found that pulmonary emboli occurred despite the use of anticoagulants. Ominously, all-cause mortality was increased in patients receiving potent anticoagulation, such as enoxaparin and rivaroxaban. The authors note that physicians may feel compelled to prescribe anticoagulants to avoid potential litigation.

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Unfortunately, a lack of understanding of the basic physiology coupled with a strong mandate from the Centers for Medicare and Medicaid Services (CMS) to prevent VTE has resulted in aggressive attempts at chemoprophylaxis with no reduction in risk [55].

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Clinical research is often funded by the pharmaceutical industry. Seife, in a sobering article published in 2012 in Scientific American [56], questions whether drug research is trustworthy. The Food and Drug Administration has identified numerous cases of research misconduct that (surprisingly) remain unavailable to the public [57]. The misconduct includes trials of anticoagulants for VTE prevention. Seife concludes, "I think that the approval of rivaroxaban and apixaban in particular were ill-considered" (Seife C, 20 March 2016, personal communication).

If plastic surgeons are not careful, they may be jumping on the anticoagulation bandwagon just as our colleagues are jumping off [26].

Hematomas

This controversy would be less important if anticoagulation did not add to the complication rate of surgery. However, excessive bleeding with

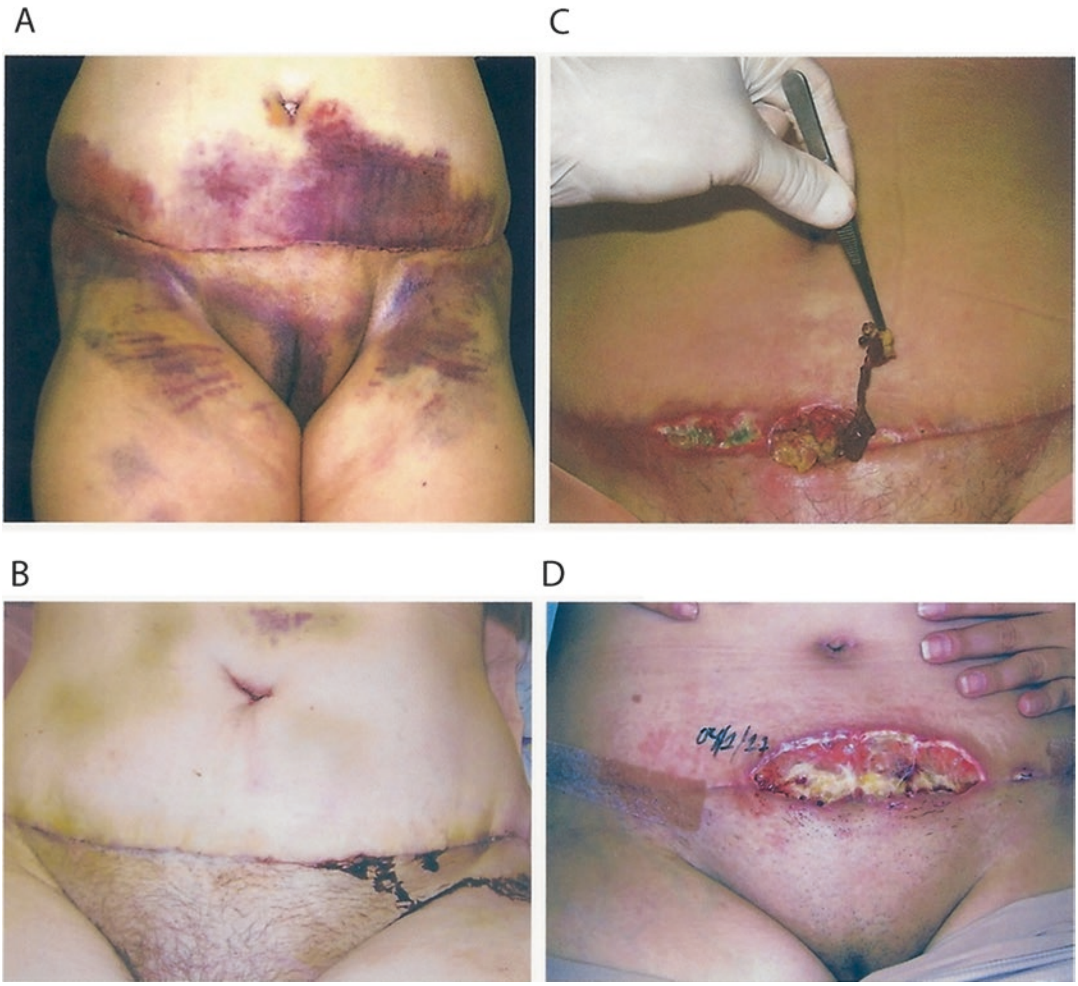

Fig. 12.6 Complications of hematomas, including skin and fat necrosis and wound dehiscence, in patients treated with rivaroxaban. (**a**) Large hematoma after abdominoplasty. (**b**) Spontaneous drainage of the hematoma through the abdominoplasty incision. (**c**) Fat necrosis associated with the hematoma. (**d**) Dehiscence and tissue necrosis associated with the hematoma [Reprinted from Dini GM, Ferreira MCC, Albuquerque LG, Ferreira LM. How safe is thromboprophylaxis in abdominoplasty? Plast Reconstr Surg. 2012;130:851e–857e. With permission from Wolters Kluwer Health, Inc.]

chemoprophylaxis has been reported [58, 59]. A randomized study from Brazil [59] had to be stopped before it could be completed because of a startling number of hematomas and wound dehiscences after abdominoplasty, all (8/8) occurring in the anticoagulated patients (Fig. 12.6). Proponents ask rhetorically, which is the lesser of two evils, a hematoma or a VTE? [60–64]. A comment from Davison and Massoumi [64] is frequently referenced [61, 63, 65]: "A hematoma is a medical stress, an inconvenience, an embarrassment, or an additional procedure, but rarely does it kill a patient."

Pannucci et al. [3] conclude that the hematoma rate is not increased by enoxaparin. At the same time, Pannucci and Wilkins ask plastic surgeons to choose between a VTE and a hematoma [61–63]. According to the drugs.com website, "common" (1–10%) adverse reactions to enoxaparin include major hemorrhage, anemia, and thrombocytopenia [66]. Figure 12.7 compares hematoma rates in recent publications [59, 67–

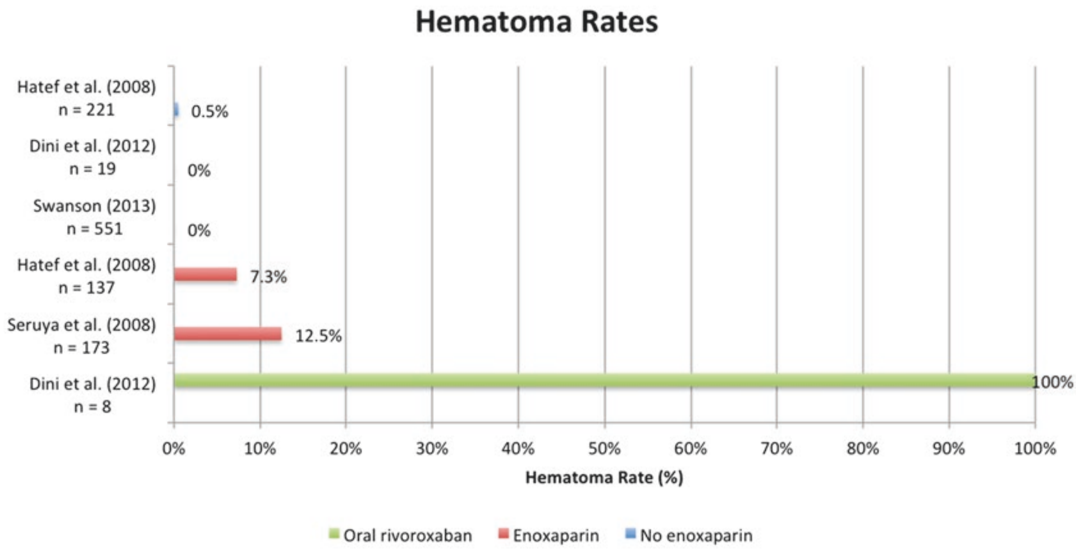

Fig. 12.7 Hematoma rates in published series of plastic surgery patients treated without anticoagulation (*blue*), with enoxaparin injections (*red*), and with oral rivaroxaban (*green*). Patients in series reporting a 0% hematoma rate did not receive anticoagulation [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

69]. Two of these studies [67, 68] report hematoma rates of 7.3% and 12.5% in anticoagulated patients, in the expected range. This frequency contrasts with rates of <1% among untreated and control patients [59, 67, 69].

As any plastic surgeon will attest, hematomas are not just an inconvenience. A seroma is an inconvenience; hematomas have serious consequences. Hematomas frequently cause skin necrosis and wound dehiscences (Fig. 12.6) [59]. Hematomas are likely to cause anemia, adding to patient morbidity, especially after combined liposuction and abdominoplasty, procedures that cause substantial blood loss [70]. Bleeding may lead to unplanned blood transfusions and hospitalizations [67]. The CosmetAssure data documented 47 emergency department visits and hospitalizations for hypotension [71] secondary to hypovolemia.

Hematomas are not conducive to a successful elective cosmetic surgery practice. With widespread implementation of chemoprophylaxis, patient deaths will inevitably result from exsanguination, iatrogenic deaths in patients who were unlikely to develop a VTE in the first place. Even one such death is unacceptable if the benefit of anticoagulation is unproven [72].

A compensatory benefit is unclear; VTEs still occur despite anticoagulation (Fig. 12.8) [64, 67, 68]. "Chemoprophylaxis" may not live up to its billing; it does not prevent venous stasis, hypercoagulability, or vessel injury—the Virchow triad of factors implicated in the formation of a thrombosis [73]

> "Chemoprophylaxis" may not live up to its billing; it does not prevent venous stasis, hypercoagulability, or vessel injury—the Virchow triad of factors implicated in the formation of a thrombosis.

Bleeding

Many investigators emphasize the need to balance the risk of VTE with bleeding [74–76], which is a complication of anticoagulation in

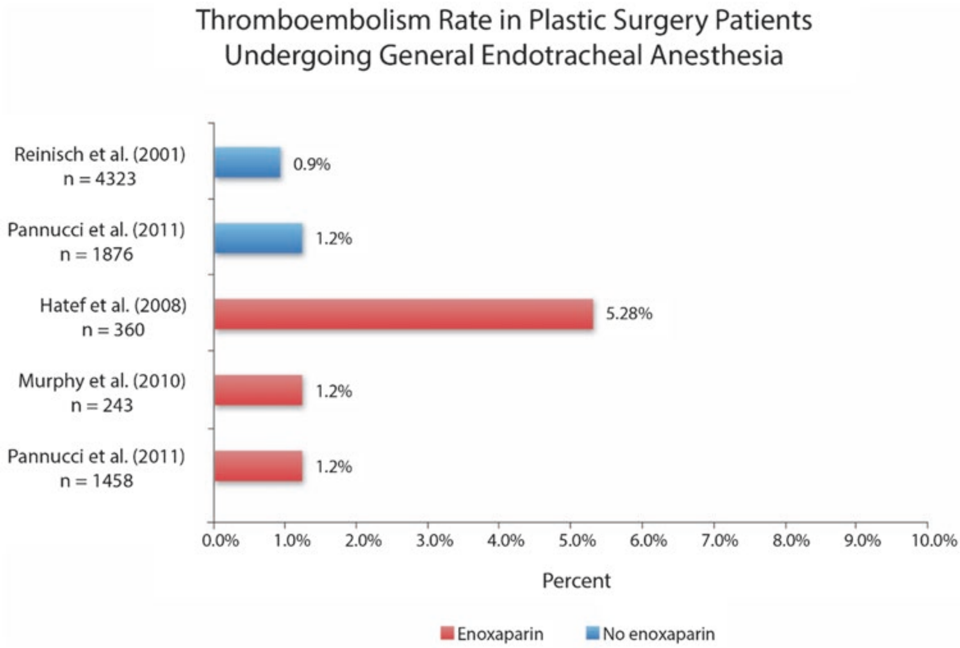

Fig. 12.8 Examples of VTE rates in plastic surgery patients undergoing general endotracheal anesthesia. Patients treated without enoxaparin are indicated in blue, and patients treated with enoxaparin are indicated in red [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

numerous case series [59, 67, 77–80] and one that is occasionally fatal [77]. Anticoagulation should not be used when the benefit does not clearly compensate for the additional risk [26, 72]. The annual risk of a VTE in adults in industrialized countries is about 0.1–0.3% [23, 81]. The risk of major bleeding from anticoagulation is about 3% annually [22, 80].

Individual Risk Stratification

Risk stratification aims to determine the risk of an individual suffering a particular condition. The VTEP study reveals that affected patients are spread across all Caprini groups (Figs. 12.3 and 12.5). The finding that there were almost equal numbers of patients affected by VTE in patients with Caprini scores <7 (20 patients) as in patients with scores ≥7 (22 patients) casts doubt on the value of risk stratification. Approximately half (52.4%) of the affected patients will be identified and receive treatment. Patients selected for treatment by risk stratification have a 3.0% VTE risk (22/735) instead of a 1.2% VTE risk, a difference of <2%. If it were a screening test, risk stratification (Caprini score ≥7) would have a sensitivity of 52.4% and a false-positive rate of 97.0%, dismal numbers indeed [26]. It makes more sense to adopt a treatment strategy that benefits all patients, making risk stratification unnecessary [26].

Surgical decisions typically rest on an assessment of the anticipated benefit versus risk. The same analysis applies to administration of a medication (Fig. 12.9). Chemoprophylaxis has no proven benefit in plastic surgery. Risk stratification is ineffective. A SAFE (spontaneous breathing, avoid gas, face up, extremities mobile) alternative to chemoprophylaxis is available that not only avoids additional risk but adds to patient safety

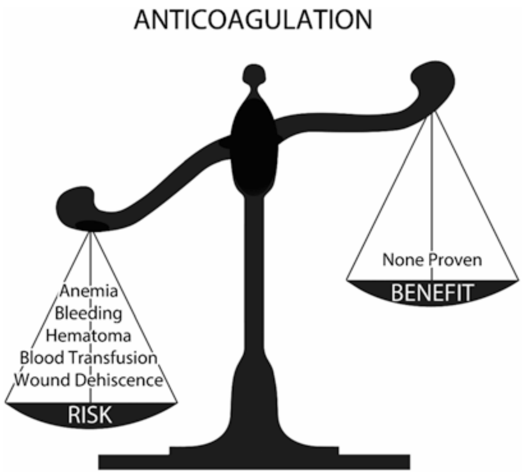

Fig. 12.9 Risk versus benefit analysis for anticoagulation. Chemoprophylaxis introduces new risks without a proven compensatory benefit [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

[26]. This anesthesia method is discussed in Chap. 5. The choice for plastic surgeons is not between a VTE and a hematoma. The real choice is between a VTE and adjusting our anesthesia and surgery habits to reduce risk to a baseline level [26].

> The choice for plastic surgeons is not between a VTE and a hematoma. The real choice is between a VTE and adjusting our anesthesia and surgery habits to reduce risk to a baseline level.

Ethical Concerns

Despite the ethical principles at stake, there is little discussion in our literature. A critical analysis should include ethical considerations [72].

The dilemma is a classic example of the double effect principle—the intervention is both good and bad. This ethical conundrum is hardly new or specific to plastic surgery. It was first considered by Thomas Aquinas [82]. The language may be archaic (e.g., "evil" effect), but the meaning is not. The ethical criteria are summarized as follows [83]:

1. That the action in itself from its very object be good or at least indifferent
2. That the good effect and not the evil effect be intended
3. That the good effect be not produced by means of the evil effect
4. That there be a proportionately grave reason for permitting the evil effect

To be morally justified, these conditions must be met. An example is the use of vaccines. A vaccine would never be approved if as many people died from the side effects as were saved by prevention of the targeted disease.

That the Action in Itself Be Good

First, the benefit must be clear. This bar has not been met conclusively for plastic surgery outpatients. Guidelines provided by the American College of Chest Physicians cannot be reliably extrapolated to plastic surgery because of the differences in patient characteristics, presence of serious diseases, and types of surgery [84]. Plastic surgery patients, particularly those undergoing elective cosmetic surgery, are different from other surgical patients. They are predominantly healthy outpatients without disease processes or cancer diagnoses.

Not only are our patients different, but their anesthetic requirements are different too (or should be) [70]. A laparoscopic cholecystectomy requires insufflation of the abdomen with carbon dioxide and positive pressure ventilation (mandating paralysis) using an endotracheal tube. This is not the case for elective plastic surgery outpatients. Even abdominoplasties (and lower body lifts) may be performed under total intravenous anesthesia with spontaneous breathing and without muscle relaxation [70]. Anesthesia management is discussed in detail in Chap. 5.

Clinical experience reveals a lack of efficacy. The case for chemoprophylaxis is undermined by: (1) nonsignificant *p* values in the Venous

Thromboembolism Prevention Study [2], (2) equal complication rates (1.2 %) in both treatment and control groups, (3) questionable statistical adjustments, and (4) unacceptable false-positive rates and sensitivity [26]. Advocates of chemoprophylaxis have not specifically addressed these concerns in the form of any journal communications. From a scientific perspective, one can accept an argument or reject it, but not ignore it [85]. Clearly, if chemoprophylaxis is ineffective in preventing VTE in plastic surgery patients, no further discussion is needed.

> From a scientific perspective, one can accept an argument or reject it, but not ignore it.

Murphy et al. [86] report three cases of VTE, all occurring in patients receiving chemoprophylaxis. Hatef et al. [67] report a 5% incidence of VTE after abdominoplasty despite the use of enoxaparin (including preoperatively) in high-risk patients. When investigators [67] report a 5% VTE rate despite using chemoprophylaxis, while also encountering more bleeding and the need for blood transfusions, it is time to consider other options.

Shaikh et al. [25] attempted to use Caprini scores and the American Society of Anesthesiologists (ASA) Physical Status Classification to identify high-risk patients. Separation of patients into "low-risk" and "high-risk" groups using Caprini scores of 1–4 versus ≥5 did not produce a statistically significant difference in risk of VTE ($p = 0.31$). Patients with "high-risk" Caprini scores of 5–8 had a 1.5% risk of VTE, no different from the overall incidence of this complication. Remarkably, none of the 36 patients with Caprini scores >10 developed a VTE. If these patients really are at "super high risk," the odds of such a finding would be remote. Jeong et al. [87] reported 19 VTEs among 574 plastic surgery patients who received chemoprophylaxis versus only 5 VTEs among 1024 patients who did not receive chemoprophylaxis. This difference, favoring the untreated patients, is highly significant ($p < 0.00001$). These findings were no doubt unexpected by the authors. None of these investigators allowed room for the possibility that their theory was wrong—Caprini scores are not helpful in identifying at-risk patients.

> *Men occasionally stumble over the truth, but most of them pick themselves up and hurry off as if nothing had happened.*
> –Winston Churchill [88].

That the Good Effect and Not the Evil Effect Be Intended

How well does prophylactic anticoagulation satisfy this criterion? Pannucci et al. [3] report a hematoma rate of 3.38% among treated patients versus 2.65% for controls and find no significant difference ($p = 0.169$). Ironically, this nonsignificant p value was in fact lower than the p values used by the same authors to determine a reduction in VTE risk [2], a testament to the investigators' bias in favor of risk stratification and against bleeding from anticoagulation. The authors' conclusion that "the absolute differences in reoperative hematoma rates when stratified by receipt of postoperative enoxaparin are small and likely irrelevant to everyday clinical practice" [3] could just as reasonably be applied to their study of VTE rates with or without enoxaparin [72].

Bleeding, hematomas, operating times, and blood transfusions are all significantly increased by enoxaparin [59, 61]. Clearly, chemoprophylaxis is not without serious risk as once believed [60]. Safety concerns are justified. Plastic surgeons' reluctance to adopt this intervention should not be deemed inadequate or mistaken for a lack of clinical understanding [72].

It is one thing for a natural adverse event to take place; it is quite another to substitute it with one that is iatrogenic. Venous thromboembolism is a known risk even without surgery. A pulmonary embolus may be viewed as an act of God, impossible to reliably predict or to completely avoid. On the other hand, bleeding from anticoagulation may be attributed to a specific intervention ordered by the surgeon to paradoxically impair a normal coagulation system in a patient who will need it [72]. Moreover, many patients are at home when bleeding from anticoagulation develops [59]. Is it safe to leave a postsurgical patient at risk for sudden bleeding in such an unmonitored setting?

This question leads to a discussion of moral hazard, loosely defined as taking risks when one does not bear responsibility for the consequences [89]. Many of the authors who promote chemoprophylaxis and publish guidelines may be professionally focused on VTEs. They may be epidemiologists. They may not be plastic surgeons practicing in the community, performing a large volume of body contouring surgery, and therefore do not have to manage the adverse consequences of routine anticoagulation.

This question leads to a discussion of moral hazard, loosely defined as taking risks when one does not bear responsibility for the consequences.

That the Good Effect Be Not Produced by Means of the Evil Effect

Anticoagulation does not fully satisfy the third criterion for ethical care in that the good effect (theoretically dissolving blood clots forming in the thigh veins) relies on an "evil" effect (indiscriminately dissolving blood clots, including in the operative field). A vaccine is different; the beneficial effect does not rely upon the negative effect.

Chemoprophylaxis does not target Virchow's triad of factors that are linked to the formation of a deep venous thrombosis [73]. Enoxaparin dissolves existing clots or clots that are forming, and the hope is that it will do so in the thigh veins, not just the operative field [72]. In this sense, it is a (nonselective) therapeutic measure, not a strictly prophylactic measure.

That There Be a Proportionately Grave Reason for Permitting the Evil Effect

Although proponents suggest that bleeding is the lesser of two evils [60, 62], the trade-off in risks is far from assuredly favorable [72]. Chemoprophylaxis invites new problems for patients that were never going to suffer a deep venous thrombosis anyway, challenging the basic rule of primum non nocere. The consequences of postoperative bleeding and hematomas should not be discounted. These are major problems that can drastically alter the surgical outcome and the patient-physician relationship. Of course, bleeding can represent more than a temporary nuisance; it can be life-threatening. Blood transfusions should rarely be necessary for cosmetic surgery patients. Our objective should be to reduce this problem [70], not to exacerbate it.

Chemoprophylaxis invites new problems for patients that were never going to suffer a deep venous thrombosis anyway, challenging the basic rule of primum non nocere.

Meta-Analyses of VTE Risk and Bleeding

With the publication of new meta-analyses and guidelines [6, 16], it is important to note that such analyses are only as reliable as the studies that are included in the analyses. Data derived from other surgical specialties are simply not applicable, regardless of whether they are based on over 17,000 patients [90]. Clinical diagnosis of a deep venous thrombosis is notoriously unreliable [33, 91, 92]. A clinical diagnosis of a VTE is confirmed by ultrasound or venography in only 20–35% of patients [92]. Objective confirmation is mandatory [92]. Analyses that do not include consecutive plastic surgery patients investigated using an objective tool cannot provide needed information regarding the true frequency, timing, and anatomic site of deep venous thromboses, which are likely to be affected by the procedure

A clinical diagnosis of a VTE is confirmed by ultrasound or venography in only 20–35% of patients. Objective confirmation is mandatory.

and type of anesthesia [26, 32, 33, 72]. An analogy would be trying to investigate arrhythmias without performing electrocardiograms [11].

Despite the multitude of confounding variables affecting individual studies, meta-analyses have been attempted [6, 16]. Pannucci et al. [6] describe their 2016 guidelines both as a "systematic review and meta-analysis of controlled trials" and a "consensus conference." Systematic reviews typically include only high level of evidence studies and are considered the highest level of evidence (Level 1) [93]. A consensus conference, on the other hand, represents collective expert opinion, the lowest level of evidence (Level 5) [93]. The authors [6] sought to build upon previous guidelines [5] that were careful not to make unsupported recommendations. Unfortunately, the authors' conclusions reached beyond the evidence [44].

Pannucci et al. [6] recommend that *all* plastic surgery patients should be risk-stratified using a 2005 Caprini score, evidently including outpatients. For patients with Caprini scores >8, the authors [6] recommend that surgeons consider chemoprophylaxis on an individual basis, relying on only two studies of hospitalized patients [2, 94]. Two studies is a very small number for a meta-analysis. Neither study was a controlled trial. The Level 3 VTEP study [2] compared an untreated historical control group with a prospective cohort of plastic surgery inpatients who received enoxaparin. The study by Bahl et al. [94], coauthored by Pannucci, was a retrospective chart review comparing VTE risk in otolaryngologic surgery patients (11% undergoing plastic surgery procedures) treated with or without heparin. Even in these two studies [2, 94], numerous confounders are at work, including diagnosis (particularly cancer), procedure, anesthesia, surgeon, anticoagulant, and the use of sequential compression devices [94]. Both studies relied on chart reviews to calculate Caprini scores. As both teams have recognized in previous publications [14, 45], this information is often incomplete in a retrospective chart review, leading to underestimated Caprini scores, as discussed previously regarding the VTEP data comparison.

Bahl et al. [94] report that patients who received chemoprophylaxis experienced a 1.2% risk of VTE versus a 1.3% risk (difference nonsignificant) for patients who did not receive heparin—almost identical to the 1.2% rates for both treated and untreated patients in the VTEP study [2]. Bahl et al. [94] also compared risk-stratified patients with Caprini scores >7, finding a higher percentage of VTE in the nontreated patients, *but the difference was not significant*. Despite its title, the VTEP study [2] also found no significant treatment benefit for risk-stratified patients. Nonsignificant differences ($p = 0.08$ for combined patients with Caprini scores >8 [6]) do not count as evidence [44]. If there is no significant difference in risk [25] and no significant treatment benefit even among patients with higher Caprini scores [2, 94], why calculate Caprini scores?

If there is no significant difference in risk and no significant treatment benefit even among patients with higher Caprini scores, why calculate Caprini scores?

Pannucci et al. [3] previously claimed that anticoagulation does not significantly increase reoperative hematoma rates. However, the 2016 meta-analysis [6] does find evidence for increased bleeding ($p = 0.02$). Bahl et al. [94] reported higher rates of bleeding in anticoagulated patients ($p < 0.001$), similar to other studies in plastic surgery patients using either enoxaparin or rivaroxaban [58, 59, 67, 95]. The risk is not eliminated by avoiding a preoperative or intraoperative dose [94, 95]. The authors cite 1999 guidelines [96] recommending preoperative anticoagulation based on first principles and on data from other surgical specialties [6]. However, ultrasonic evidence shows (surprisingly) that, in plastic surgery patients, deep venous thromboses do not typically develop during surgery [92].

It is time to move beyond making ineffective predictions and instead make use of highly accurate and noninvasive diagnostic imaging [92]. Without this disruptive technology, VTE research is analogous to the proverbial blind men examining an elephant [44]. Proponents of chemoprophylaxis argue that ultrasound screening does not prevent VTEs [27] (although improved anesthesia might [26]). True, but the value of this method is in identifying thromboses while they are still small, located in the calf, where they are less dangerous (2% risk of pulmonary emboli), and susceptible to early treatment [92]. This "early warning system" may detect thromboses before they propagate to the proximal deep veins in the thigh, where they are much more likely to cause pulmonary emboli (50% risk) [92].

> Without this disruptive technology, VTE research is analogous to the proverbial blind men examining an elephant.

Pannucci et al. [16] recently published another meta-analysis. This study, published in the top-ranked *Annals of Surgery*, was not limited to plastic surgery patients. Caprini scores and chemoprophylaxis are promoted to reduce VTE risk. Again, there are problems with the data and analysis [97].

Pannucci et al. [16] report a 2.45% (149/6085) overall VTE risk for patients who did not receive chemoprophylaxis but do not report the 4.37% (380/8691) risk for patients who did receive chemoprophylaxis ($p < 0.0001$). The VTE rate for patients with Caprini scores of 5 and 6 was significantly greater for anticoagulated patients (3.54% versus 1.85%, $p < 0.001$) [16]. For patients with Caprini scores of 7 and 8, the VTE risks were 5.37% for patients receiving chemoprophylaxis versus 4.02% for untreated patients, not significantly reduced for anticoagulated patients, as claimed [16]. Among patients with Caprini scores ≥5, the VTE risk was significantly greater ($p < 0.001$) for anticoagulated patients (comparisons performed using a chi-square test [98]).

Jeong et al. [87] reported 19 VTEs among 574 plastic surgery patients who received chemoprophylaxis and only 5 VTEs among 1024 patients who did not receive chemoprophylaxis ($p < 0.00001$). These numbers are much different from those included in the meta-analysis (5/238 and 3/301, respectively) [16].

Pannucci et al. [16] report that anticoagulated plastic surgery inpatients with Caprini scores of 7–8 or >8 have a significant VTE risk reduction. However, the referenced VTEP study found that these differences were not significant (p = 0.230 and 0.182, respectively), as discussed previously [2]. Moreover, the lead author's previous meta-analysis [6] found no significant difference in VTE risk ($p = 0.08$) for plastic surgery inpatients when compared by Caprini scores but a higher risk of bleeding ($p = 0.02$) in anticoagulated patients. The bleeding risk was also significantly increased (p = 0.006) in the recent meta-analysis [16]. The findings of both meta-analyses contradict the lead author's earlier claim of no significant increased bleeding risk [3].

The title of the 2017 meta-analysis [16] references risk in surgical patients, but the authors included 1176 nonsurgical patients [99, 100]. A bewildering number of confounding variables undermines the comparisons [97]. These include a cancer diagnosis, surgery, anesthesia, method of VTE diagnosis, length of follow-up, the use of sequential compression devices, whether upper-extremity thromboses and superficial thromboses are included, and method of evaluating the 40 parameters that make up a Caprini score. Retrospectively evaluating Caprini scores based on chart reviews or insurance billing information is unreliable [14]. For example, Obi et al. [99] recorded only one patient with a history of varicose veins among 4844 patients admitted to an intensive care unit. According to the American Venous Forum, about 23% of the American adult population suffers from varicose veins [101]. Publication bias is obvious. One study grouped patients according to "appropriate" and "inappropriate" prophylaxis and called failure to administer chemoprophylaxis "malpractice" [102].

The false-positive rate for individual risk stratification is consistently 97%, and almost half of affected patients are missed using Caprini scores ≥7 as a cutoff [11]. This method can hardly be considered "precision medicine" or capable of predicting VTE risk, as claimed [16]. In evaluating the American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF) data for 354,969 abdominoplasties, Keyes et al. [103] find Caprini scores unhelpful because 135 (67.5%) of the 200 VTEs occurred in patients with Caprini scores <5.

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A Randomized Study?

Proponents of chemoprophylaxis request controlled studies demonstrating the benefits of total intravenous anesthesia [62]. Admittedly, none is available. Such a study would be: (1) impractical because of the large number of patients needed (especially with complication rates of <1%) and reluctance of surgeons to vary their surgical and anesthetic methods (using different surgeons would involve too many confounding variables) and (2) possibly unethical because of the other known safety advantages of total intravenous anesthesia. For example, it may be difficult today to justify the use of a muscle relaxant triggering a case of malignant hyperthermia if a safe alternative is available [72].

Equipoise is unlikely, particularly when the risk may be existential. Such a study would be inadvisable considering the low incidence of this complication [72]. Moreover, ethical considerations may not permit such a study because of the profound empirical treatment difference (Figs. 12.8 and 12.10 use the same horizontal scale).

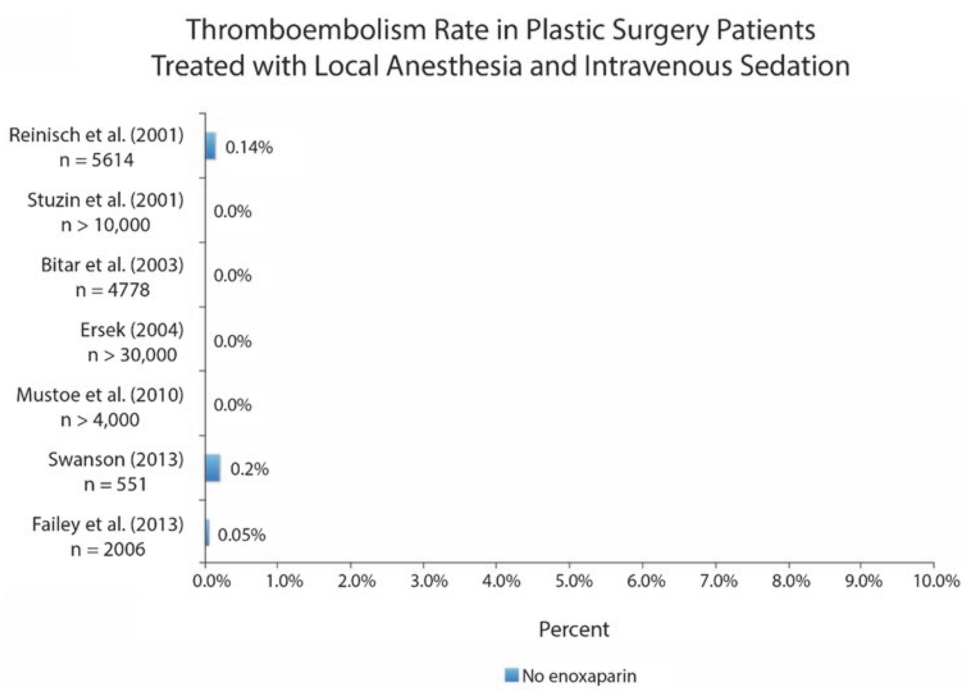

Fig. 12.10 Examples of VTE rates in plastic surgery patients treated with local anesthesia and intravenous sedation. Patients were not treated with anticoagulation. This empirical evidence supports the use of total intravenous anesthesia to reduce the incidence of VTE. The same horizontal scale is used in Fig. 12.8 [Reprinted from Swanson E. The case against chemoprophylaxis for venous thromboembolism prevention and the rationale for SAFE anesthesia. Plast Reconstr Surg Glob Open 2014;2:e160. With permission from Wolters Kluwer Health, Inc.]

Oral Anticoagulants

New oral factor Xa inhibitors such as rivaroxaban (Xarelto, Janssen Pharmaceuticals, Titusville, NJ) and apixaban (Eliquis, Bristol-Myers Squibb, New York City) are appealing to surgeons and patients because they are orally administered [104, 105]. However, oral anticoagulants have not been shown to be effective in reducing VTE risk in plastic surgery patients [106]. Dini et al. [59] report numerous hemorrhages in abdominoplasty patients treated with rivaroxaban. Patronella [95] discontinued using rivaroxaban because of a 2.8% hematoma rate, which he considers unacceptable. Hunstad et al. [105] report a lower incidence of this complication in their own study—three hematomas requiring evacuation among 132 patients (2.3%), excluding two hematomas that were evacuated before the patients received rivaroxaban. By contrast, in my own study [69] of 167 consecutive abdominoplasties treated with SAFE (spontaneous breathing, avoid gas, face up, extremities mobile [26]) anesthesia and no chemoprophylaxis, there were no hematomas. Both series [69, 105] identified one known VTE (0.76% and 0.60%, respectively). Although its use is approved in patients undergoing knee or hip replacement (different patients, surgery, and natural history of thromboses [92, 107]), rivaroxaban is not approved by the US Food and Drug Administration for deep venous thrombosis prophylaxis in plastic surgery [108]. Unlike alternatives such as heparin, warfarin, and enoxaparin, no antidote is presently available [108].

Today, dozens of law firms ("Xarelto lawyers" [109]) solicit patients who experience bleeding after taking rivaroxaban, alleging that patients are not informed of the risk of uncontrolled hemorrhage. If plastic surgery patients are informed that (1) there is no proven benefit in reducing VTE risk, (2) bleeding risk is increased, and (3) there is no antidote, how many patients would agree to take oral anticoagulants, particularly if they are offered a risk-free alternative? When given the choice, >90% of patients prefer ultrasound surveillance to routine anticoagulation [92].

Extra Doses of Enoxaparin?

Pannucci et al. [110] believe that inadequate enoxaparin dosing causes "breakthrough" cases of venous thromboembolism. This study won the Leonard R. Rubin award at the 2016 meeting of the American Association of Plastic Surgeons [47]. Unfortunately, the study design is flawed [111]. One cannot compare 90-day VTE risk by anti-factor Xa levels while simultaneously giving extra enoxaparin to patients with low levels. Higher doses for these individuals would theoretically remedy the low anti-factor Xa blood levels. Two studies would be needed, one to compare VTE risk by anti-factor Xa level and another to evaluate whether extra doses reduce risk. Otherwise one could just as reasonably conclude that higher enoxaparin doses, not lower anti-factor Xa levels, increase the VTE risk. Regardless, the findings do not support the efficacy of additional dosing; all five VTEs (5/49, 10.2%) occurred in the group that received higher doses of enoxaparin [110].

Importantly, three of the five VTEs were upper-extremity thromboses in patients with central catheters [110]. These secondary thromboses have a different etiology (foreign body and intimal trauma) related to the catheter [112], as opposed to venous stasis and valvular hypoxia [55]. The VTE literature typically evaluates primary VTEs that originate in the lower extremities [15, 113]. One has to be careful not to adjust the eligibility criteria to create a level of significance ($p < 0.05$) that would not otherwise exist.

Excluding the upper-extremity thromboses, the 2.1% (2/94) frequency of VTE is similar to the 1.2% incidence (same for control and anticoagulated patients) among 3334 plastic surgery inpatients previously reported in the VTEP study [2]. The small sample size ($n = 94$) precludes any meaningful comparisons. Confounding variables include diagnosis (particularly cancer), procedure, anesthesia method, body mass index, central catheters, immobilization, length of hospitalization, and duration of enoxaparin administration (range, 1–40 days) [110].

Testing for anti-factor Xa levels requires additional expense and inconvenience [110] but provides no diagnostic information regarding VTEs [111]. The authors [110] dismiss ultrasound screening, referencing the 2012 American College of Chest Physicians guidelines [15]. This low-grade (2C) recommendation was made for general and abdominal-pelvic surgery patients [15]. The authors' reluctance to take advantage of this highly accurate [92] technology is puzzling. It is preferable to detect a small distal thrombosis of minimal or no clinical significance than to miss a deep venous thrombosis that may otherwise propagate undetected and cause a fatal pulmonary embolism.

As previously discussed, clinical signs of VTE are unreliable (20–35% of clinical diagnoses are confirmed by ultrasound or venogram [92]). Reliance on limb swelling is dangerous because, as the authors [110] note, 10% of symptomatic pulmonary embolisms present with sudden death [113].

> It is preferable to detect a small distal thrombosis of minimal or no clinical significance than to miss a deep venous thrombosis that may otherwise propagate undetected and cause a fatal pulmonary embolism.

The authors [110] claim that inadequate enoxaparin dosing "predicts" VTE risk, despite the fact that 90% (44/49) of patients with low peak anti-factor Xa levels did not develop VTEs or 96% (47/49) if upper-extremity thromboses are excluded. Three study patients (3.2%) experienced bleeding, and one required a laparotomy [110]. The sample size is too small to support the authors' claim that extra doses of enoxaparin do not increase the risk of bleeding [111].

Enoxaparin is approved by the US Food and Drug Administration for preventing VTEs in joint replacement and general surgery patients [114], not plastic surgery patients. The recommended dose for VTE prophylaxis in abdominal surgery is 40 mg subcutaneously once daily [115]. Higher doses may represent an investigational use [116], exceeding the scope of off-label use. Aggressive chemoprophylaxis can be harmful and provide no VTE risk reduction [55]. Pannucci et al. [117] have recently doubled the enoxaparin dose from 40 mg daily to 80 mg daily, well above the recommended dose for VTE prophylaxis. Clinically relevant bleeding increased in these patients from 3.2% to 6.8% and blood tests showed that 28% of patients had excessive anti-factor Xa levels (i.e., overdoses).

Bloodletting Analogy

Surgeons would do well to consider the history of surgery or, as the saying goes, be condemned to repeat it [85]. The most common surgical procedure performed for over 2000 years, up until the mid-nineteenth century, was bloodletting. This medieval practice persisted while our scientific colleagues were plotting the orbit of the planets, filling in the periodic table, and discovering electromagnetism. Were surgeons unaware of the scientific method? Hardly. The scientific method had been known since the time of Galileo, two centuries earlier. The famed mathematician and philosopher, René Descartes, observed, "Doubt is the origin of wisdom" [118]. Where were the doubters then and where are they now [85]?

Both bloodletting and chemoprophylaxis cause bleeding that may be harmful (Fig. 12.11). One would think that surgeons today would be much more enlightened than their nineteenth-century counterparts. Surprisingly, until recently [92, 107], there have been no published studies in plastic surgery using an accurate diagnostic method to determine the frequency of deep venous thromboses, their timing, and where they are likely to develop. "Risk stratification" sounds sophisticated, but it is no substitute for this basic knowledge. Surgeons routinely prescribing enoxaparin invert the time-honored sequence of making the diagnosis before prescribing a treatment. My international colleagues inform me that some countries, such as Columbia and Portugal, already mandate the use of anticoagulation [119]. The horse has truly left the barn in such places [85].

Fig. 12.11 Comparison of bloodletting and chemoprophylaxis [Reprinted from Swanson E. Chemoprophylaxis for venous thromboembolism prevention: has the horse already left the barn? Plast Reconstr Surg. 2015;136:575e–577e. With permission from Wolters Kluwer Health, Inc.]

Characteristic of treatment	Bloodletting	Chemoprophylaxis
Causes bleeding	✓	✓
Efficacy questionable	✓	✓
Natural history of condition poorly understood	✓	✓
Institutional authority	✓	✓
Patients told it would help them	✓	✓
Harmful effects minimized	✓	✓
No diagnostic study beforehand	✓	✓
No alternative treatment recommendations	✓	✓
Scientific method overlooked	✓	✓
Introduces iatrogenic complications	✓	✓
Proponents consider it the standard of care	✓	✓

Medicolegal Consequences

There is an emerging opinion that anticoagulation in plastic surgery is part of the standard of care. It is not difficult to imagine a plastic surgeon having to defend *not using* chemoprophylaxis in a patient who develops thromboembolism or, on the other hand, defending *using* anticoagulation in a patient who suffers the consequences of excessive bleeding [72]. The medicolegal climate is difficult enough without adding this intervention (and a perceived failure to intervene) to our liability risk.

The American Society of Plastic Surgeons website highlights VTE prevention. A featured article asks, “Are you current with VTE prevention techniques?” and tells the cautionary tale of a plastic surgeon whose patient died of a fatal pulmonary embolism after undergoing a mommy makeover [120]. The surgeon’s competitors rallied against him. The surgeon’s medical license was suspended, in part, for failing to perform a risk assessment and perioperative care “to prevent DVT/PE occurrence” [120]. Tragically, the surgeon lost his hospital privileges and his practice, his wife filed for divorce, and he attempted suicide. The catastrophe of a patient death was compounded by the tragedy of the professional and very nearly physical destruction of the surgeon. Such an outcome underscores the importance of critical evaluation of our present methods to reduce risk. This issue is essential not only to patient safety but to medical malpractice defense [11].

As discussed above, it is impossible to reliably predict which patients will be affected by VTE. Venous thromboembolisms cannot be considered “never events” [86], in that it is unreasonable to expect a surgeon to never encounter one.

After all, pulmonary emboli can occur even without surgery. The best we can do is endeavor to lower the probability to a baseline risk [26]. Blaming the surgeon for such an unpredictable event compounds the tragedy of a patient death caused by a pulmonary embolism.

Blaming the surgeon for such an unpredictable event compounds the tragedy of a patient death caused by a pulmonary embolism.

Unfortunately, some plastic surgeons are willing to state, and testify, that chemoprophylaxis represents the standard of care for patients deemed to be at higher risk and are making themselves available as expert witnesses, even advertising their services online [63].

Plastic surgeons who do not use anticoagulation in their practice are not insisting that proponents do the same or face serious professional consequences; the opposite is not true [26]. The issue is not simply a debate of the merits but a question of standard of practice. Today, many hospitals and surgery centers have protocols for chemoprophylaxis, which may be the default option. The surgeon signs a form if he or she does not wish to comply. By not going along with this intervention, the surgeon may be (unfairly) perceived as deviating from the standard of practice and regarded negatively by nurses and colleagues. Plastic surgeons may be inclined to order anticoagulation simply for legal reasons (a problem endemic in medicine today), especially in view of the lack of literature supporting a decision not to order anticoagulation [26].

The author seeks to remedy this imbalance by presenting the case against chemoprophylaxis on behalf of the majority of plastic surgeons who are not uninformed but unpersuaded of the benefit and safety of this intervention. The literature now contains plenty of references to support VTE risk reduction by other means [11, 26, 44, 55, 72, 84, 85, 91, 92, 97, 106, 111]. These publications can be used to defend surgeon practices and avoid implementing a faulty plan purely for medicolegal protection.

The literature now contains plenty of references to support VTE risk reduction by other means. These publications can be used to defend surgeon practices and avoid implementing a faulty plan purely for medicolegal protection.

In a lecture given at the 2008 meeting of the American Society of Plastic Surgeons, Venturi [121] reported that deaths from venous thromboembolism are a major source of liability. Unlike most medical malpractice cases, the verdicts and settlements tend to favor the plaintiffs. The awards often exceed $1 million [121]. One plastic surgeon who developed an early risk assessment model testified in a malpractice case that noncompliance represents a deviation from the standard of care, and if the surgeon defendant had used a scoring system and administered anticoagulation, the risk of a VTE could be reduced 80% [122]. Such opinions drive up the cost of malpractice premiums and cause tremendous personal and professional grief. It is too late after a trial or settlement to reconsider one's sworn testimony. Apart from any intellectual, professional, or financial considerations, there can be no stronger conflict of interest than having given sworn testimony on the issue.

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Our Own Worst Enemy?

There is a downside to drawing lines in the sand (Fig. 12.12). Plaintiff attorneys are likely to be very interested in such articles. Ironically, experts may feel most passionate about recommendations for which there is the least solid evidence [123]. Plastic surgeons who offer their opinion as testimony do a

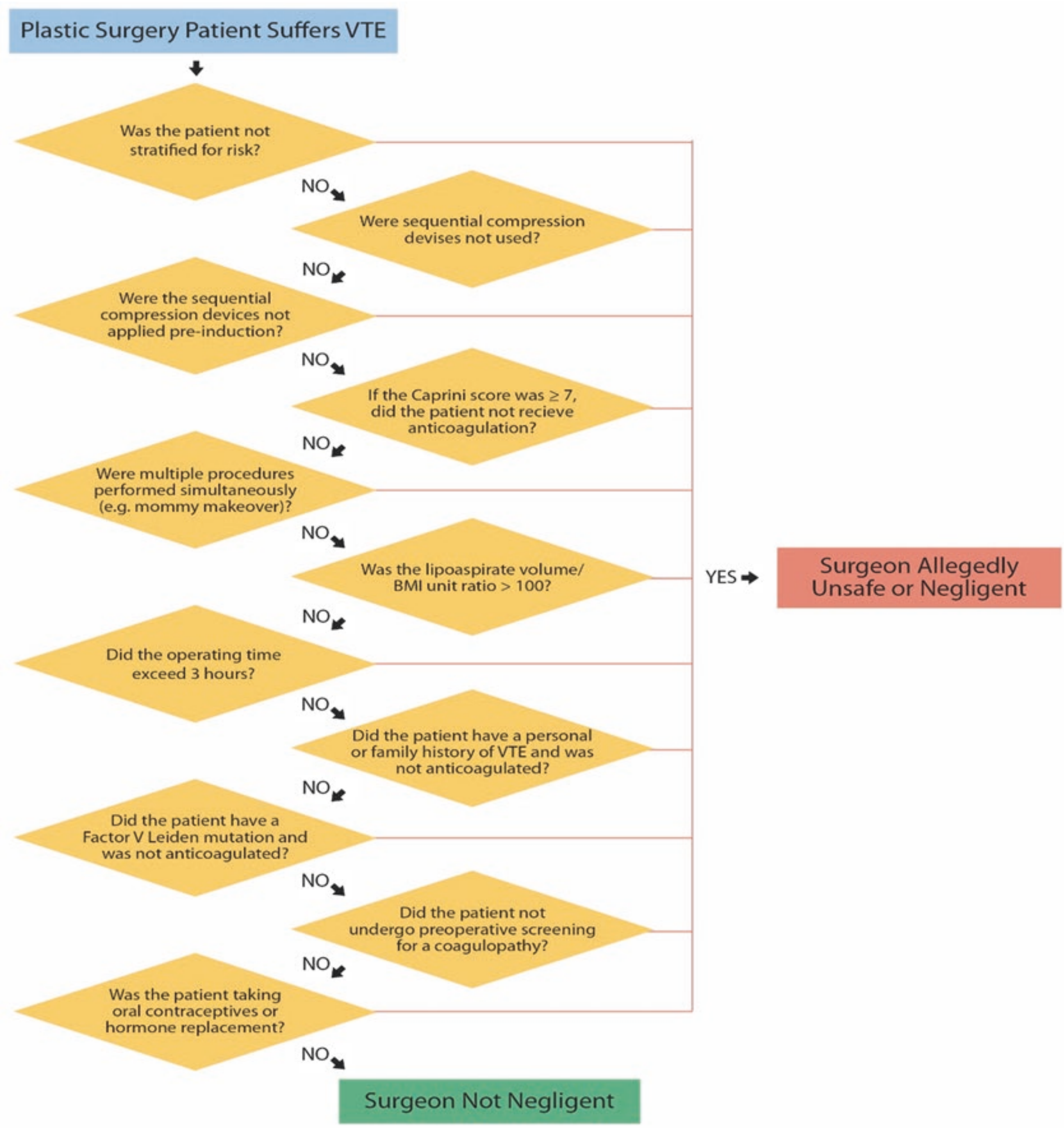

Fig. 12.12 Today, the plastic surgeon may be confronted by a number of challenges to his or her care of a patient who suffers from VTE. If the plastic surgeon does not successfully clear each hurdle, the surgeon may be deemed responsible for a bad outcome. The pathophysiology of venous thromboembolism remains poorly understood in plastic surgery. Consequently, there is little scientific justification for holding a plastic surgeon negligent for not conforming with these numerous presumed safety criteria. *BMI* body mass index [Reprinted from Swanson E. Our own worst enemy. Plast Reconstr Surg. 2016;137:911e–914e. With permission from Wolters Kluwer Health, Inc.]

disservice to their colleagues, sometimes destroying them. Such testimony also prejudices the families of affected patients, who may unfairly blame their surgeon—thinking, for example, that if their surgeon had only done a risk assessment, their tragedy might have been averted [120]. When insurance companies settle such cases, we all lose. With these serious consequences in mind, investigators need to be careful when specifying safety benchmarks, and experts must be cautious when testifying as to the standard of care. Otherwise, we risk becoming our own worst enemy [123].

> Investigators need to be careful when specifying safety benchmarks, and experts must be cautious when testifying as to the standard of care.

Of course, we are told that treatment is to be individualized [10, 124], but such a recommendation may be difficult to reconcile with an algorithm or scoring system that is meant to group patients together in categories with a view to assigning a treatment [5–7, 124]. Many VTEs occur in patients with moderate risk scores [2, 86, 125]. When asked whether one would prefer to treat a VTE or a hematoma [60, 62], the well-informed plastic surgeon will respond, "neither" [72].

> When asked whether one would prefer to treat a VTE or a hematoma, the well-informed plastic surgeon will respond, "neither."

After publishing my concerns about the ethics of chemoprophylaxis and the reliability of the study conclusions [72], I had expected to see a strongly worded Letter to the Editor from these investigators defending their statistics and conclusions. I had also expected a vigorous defense at a debate at the American Society of Plastic Surgeons meeting in 2013 [126]. However, there was none, other than Wilkins' general response that one cannot always trust the raw data [126].

In 2016, I had the opportunity to debate this topic with Guyatt [127], who coined the term "evidence-based medicine" [128] and was the lead author for the 2012 ACCP guidelines [129]. At the debate, Guyatt pointed out that his areas of expertise do not include statistics or deep venous thrombosis. He did not defend my criticisms of the lack of correlation between Caprini scores and relative risk. He did not defend Caprini's financial conflicts. Guyatt said that he was "tossed" as lead investigator. After the debate, my impression that the emperor wore no clothes was not diminished.

Pathophysiology

Fortunately, hemodynamic data are available to compare anesthesia methods in plastic surgery patients, and this issue is discussed in Chap 5. A general anesthetic with muscle paralysis can lower the mean arterial blood pressure. In a study of five large-volume liposuction patients, the change was dramatic, a loss of 30% over 1–2 h after induction, without a return to baseline during surgery or postoperatively [130]. By comparison, a total intravenous anesthetic in liposuction and abdominoplasty patients without paralysis did not cause a drop in blood pressure [70]. Sustained hypotension (>2 h) with muscle paralysis causes valvular hypoxia [131]. This difference may be the "smoking gun" evidence linking the anesthesia method to VTE risk. The clinical findings were equally dramatic, a VTE rate of 5% for abdominoplasty using traditional general endotracheal anesthesia with paralysis [67] versus 0.6% after total intravenous anesthesia [69]. Moreover, in 200 consecutive plastic surgery outpatients, no deep venous thromboses were detected on Doppler ultrasound scans performed the day after surgery [92]. Maintaining a normal blood pressure and preservation of the calf muscle pump seem to be effective in reducing the risk of deep venous thrombosis [55].

> This difference may be the "smoking gun" evidence linking anesthesia method to VTE risk.

The evidence speaks against a recommendation of chemoprophylaxis among plastic surgery patients based on a risk scoring system. There are substantial risks in using prophylactic anticoagulation. Plastic surgeons should not feel compelled to recommend anticoagulation based solely on a Caprini score. Other preventative measures are logical, consistent with our understanding of the pathophysiology of thromboembolism, ethical, and, most importantly, invite no new risk. *Safely* reducing the number of patients who suffer venous thromboembolism is clearly in our patients' interest and in ours.

Safe Prevention of Thromboembolism

The conscientious plastic surgeon may ask, if we do not give chemoprophylaxis, what can we do to minimize risk? Fortunately, there are much safer ways to reduce the risk of this complication [26, 85] and ones that are aimed at the root of the problem—venous stasis.

Notably, many investigators using total intravenous anesthesia, including myself, report very low VTE rates [32, 69, 125, 132]; some surgeons report no cases at all in very large (i.e., 4000 to over 30,000 cases) series of patients that include abdominoplasties and face lifts [28–31] (Fig. 12.10). A 2008 German study [133] assessing serious complications after liposuction found that all eight liposuction fatalities occurred in patients administered general anesthesia and none occurred in patients treated with intravenous sedation and local anesthesia. A survey conducted by Reinisch et al. [32] found a significant reduction in risk of thromboembolism among facelift patients treated with intravenous sedation and local anesthetic compared with patients who received traditional general endotracheal anesthesia.

There may be a physical basis for these findings. Avoidance of muscle relaxation may reduce blood pooling in the lower extremities [30, 31, 58]. This is a physiologic argument that has not been clinically proven. However, such large patient series with exceptionally low rates of thromboembolism [28–32, 125, 132] constitute empirical evidence pointing to additional risk from traditional general endotracheal anesthesia.

Sequential Compression Devices: Are They Really Effective?

The use of sequential compression devices (also called intermittent pneumatic compression) is often considered an essential part of VTE prevention [6, 68, 134]. A widely cited 2005 meta-analysis [135] evaluated 15 randomized studies comparing sequential compression devices with no treatment and concluded that their use reduces the risk of deep venous thrombosis 60% (relative risk: 0.40). Oddly, there was no reduction in the risk of pulmonary embolism. In fact, the relative risk of pulmonary embolism was slightly (although not significantly) *higher* in the control patients (relative risk: 1.12). The authors offer no explanation as to why the risk of pulmonary embolus was not reduced significantly despite a decreased risk of deep venous thromboses, from which they develop. After all, pulmonary embolism is the life-threatening complication that we wish to prevent.

In fact, the relative risk of pulmonary embolism was slightly (although not significantly) *higher* in the control patients (relative risk: 1.12).

Urbankova et al. [135] recognize several limitations of their meta-analysis. The authors [135] used two statistical tests, Begg's funnel plot and Egger's test, to evaluate the possibility of publication bias. Both tests revealed significant publication bias, undermining the case for efficacy of compression devices. Publication (or "citation" [136]) bias is well-known in medicine. Unfortunately, studies that find a therapeutic effect are more likely to be submitted for publication than studies with a negative finding (even though studies that fail to support a treatment are just as useful) [137]. There is no more relevant example of this preference for positive results than the VTEP study [2].

In 14 of the 15 studies included in the meta-analysis by Urbankova et al. [135], radioactive iodinated fibrinogen uptake was used to make the primary diagnosis, either on its own or in combination with impedance plethysmography. These obsolete tests suffer from a low sensitivity for detecting thromboses [135]. Both tests have been replaced by Doppler ultrasound [92]. The lack of diagnostic sensitivity is a confounder that might also account for a perceived treatment benefit if some thromboses went undetected [137]. Moreover, it was not possible to control for the length of immobilization or to detect all cases of VTE that occurred after discharge [135]. It is risky to extrapolate findings from one group of patients to another. General and orthopedic patients are known to have high rates of venous thromboembolism [92]. Patients undergoing total knee replacement experience much more trauma to the lower extremity than patients undergoing liposuction, and a tourniquet compresses the deep veins in the thigh [137].

Geerts, the lead author of the 2004 and 2008 American College of Chest Physicians Guidelines on Prevention of Venous Thromboembolism, finds insufficient validity; his hospital does not even own a pair [Geerts WH, 15 October 2015, personal communication].

Doppler ultrasound surveillance reveals that deep venous thromboses do not tend to occur intraoperatively in plastic surgery patients [92]. This is an important difference from studies conducted in orthopedic patients, which find a high percentage of thromboses developing within 24 h of surgery [92].

Patients are told, "these devices squeeze your calves and prevent blood clots," which is certainly intuitive. In an experimental study assaying antecubital blood samples in volunteers wearing sequential compression devices, Comerota et al. [138] report a decrease in plasminogen activator inhibitor-1 levels and an increase in tissue plasminogen activator. However, evidence-based medicine demands more than intuition, first principles, or even experimental data [139]. Clinical data are needed. In truth, there is no evidence that sequential compression devices affect the frequency of deep venous thromboses in plastic surgery patients.

> In truth, there is no evidence that sequential compression devices affect the frequency of deep venous thromboses in plastic surgery patients.

Is there a reason *not* to use sequential compression devices? Indeed, there are two negatives and both are insidious [137]. One problem is that by wrapping these devices around the calves, the surgeon may think that this intervention is effective on its own and will be disinclined to incorporate other modalities that may be equally safe but more effective, such as SAFE (spontaneous breathing, avoid gas, face up, extremities mobile) anesthesia and ultrasound surveillance [92]. Another negative is the medicolegal implications. Today, these devices are often considered part of the standard of care. The plastic surgeon may be unfairly blamed for a fatal pulmonary embolism that may have occurred regardless of whether these devices were used in surgery. One always needs to be careful in testifying as to the standard of care when the factual support is at least open to question. A strong conviction is no substitute for critical thinking [137]. To their credit, Murphy et al. [5] made no recommendation regarding sequential compression devices in their 2012 American Society of Plastic Surgeons Venous Thromboembolism Task Force Report. Evidence as to their efficacy remains inconclusive [137].

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13 Ultrasound for VTE Surveillance and Other Plastic Surgery Applications

Abstract

In view of the shortcomings of individual risk stratification and chemoprophylaxis, the author adopted ultrasound surveillance as a method to screen for deep venous thromboses in plastic surgery outpatients, starting in 2013. The findings were published for the first 100 and 200 patients, and the results for 1000 patients are being tabulated now.

The findings were surprising. In the first 200 patients, no deep venous thromboses were detected on Doppler ultrasound scans conducted the day after surgery. This finding supports total intravenous anesthesia with intraoperative preservation of the calf muscle pump. Deep venous thromboses do not seem to be developing during surgery in plastic surgery outpatients.

One distal thrombosis was detected in a 55-year-old patient 8 days after abdominoplasty and other procedures. The patient was treated with oral anticoagulants as an outpatient. Subsequent scans revealed resolution in 1 month.

Ultrasound scans are highly accurate, noninvasive, and well-tolerated by patients. Unlike the routine administration of anticoagulation, there is no added risk. The diagnosis is made before treatment rather than the reverse. Early detection of thromboses allows the surgeon to initiate treatment before the thrombosis propagates and becomes dangerous. Importantly, it avoids unnecessary bleeding and hematomas.

Numerous other applications of ultrasound technology have become apparent. Abdominal penetration can be a catastrophic complication of liposuction. This device can be used to screen liposuction and abdominoplasty patients for abdominal defects. Other uses include seroma management, evaluation of breast implants, detection of fat necrosis, and evaluation of soft tissue masses.

Ultrasound is a disruptive technology and there is natural resistance to change. As more surgeons (not just plastic surgeons) adopt this vital diagnostic tool, we are likely to learn much more about this serious and enigmatic complication.

E. Swanson, *Evidence-Based Body Contouring Surgery and VTE Prevention*,
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Introduction

Deep venous thrombosis is a serious surgical complication that can lead to fatal pulmonary emboli [1]. To reduce the frequency of this postoperative condition, prophylactic anticoagulation (i.e., chemoprophylaxis) has been recommended for patients deemed to be at high risk [2–4]. The author has challenged the efficacy and safety of this treatment [5–12]. A detailed discussion is provided in Chap. 12.

Despite efforts to accurately predict which patients will develop a deep vein thrombosis postoperatively [1], the goal remains elusive [3]. An intervention that benefits all surgery patients without causing harmful side effects is needed. In 2013, the author initiated routine Doppler ultrasound screening in all plastic surgery outpatients in the form of a registered clinical trial [13]. Preliminary findings were presented at the 2014 Meeting of the American Society for Aesthetic Surgery [14] and in two publications evaluating the first 100 and 200 patients, respectively [15, 16]. An evaluation of 1000 consecutive plastic surgery outpatients is nearing completion at the time of this writing.

Clinical diagnosis of venous thromboembolism (VTE) is known to be unreliable [17–24]. A clinical diagnosis is confirmed by objective testing using ultrasound or venography in only 20–35% of patients [18, 19, 21, 24], making objective confirmation obligatory [18].

Noninvasive ultrasound technology has replaced venography as the standard for screening [23]. When compression ultrasound is complemented by Doppler color flow evaluation ("duplex" sonography), the sensitivity for thrombosis detection is about 96%, with a high negative predictive value (99%) [25].

Only one large study, the Venous Thromboembolism Prevention (VTEP) study, compares the incidence of VTE in plastic surgery inpatients treated with or without postoperative enoxaparin [3]. The incidence of this complication was 1.2% in both groups [6]. The VTEP study did not include screening examinations and did not provide information on the timing of deep venous thromboses [3].

Anticoagulation carries a risk of bleeding and hematomas [6]. In an effort to improve safety and reduce risk, the author advocates a SAFE (spontaneous breathing, avoid gas, face up, extremities mobile) anesthesia method, foregoing individual risk stratification and chemoprophylaxis [6]. The details of this type of anesthesia are discussed in detail in Chap. 5.

Limitations of Existing Knowledge Base

The risk of VTE is related to the type of surgery performed [1]. Much of the present knowledge base derives from studies of orthopedic patients [22, 26, 27] in whom the risk of deep venous thrombosis is as high as 60% in patients undergoing hip replacement [22]. Dahl et al. [22] suggest that local vascular injury and both local and systemic activation of coagulation and suppression of fibrinolysis are responsible for the increased risk after hip replacement. Temporary interruption of blood flow is likely to induce venous stasis [28]. Maynard et al. [26] report deep vein thrombosis in 47% of patients undergoing total knee arthroplasty, as detected by venography performed on the day of surgery or on the first postoperative day.

VTE After Plastic Surgery

Unlike orthopedic surgery, little is known regarding the natural history of deep venous thrombosis occurring after plastic surgery [16]. Lemaine et al. [29] used duplex sonography to evaluate 118 breast reconstruction inpatients (average operating time, 10.5 h) who were treated postoperatively with low-molecular-weight heparin.

Their patients were scanned before discharge from hospital, which took place on average 4.7 days after surgery [29]. Four patients (3.4%) were identified with asymptomatic distal deep venous thromboses [29]. In the study by Lemaine et al. [29], the ultrasound scans were negative in the nine patients clinically suspected of having a deep venous thrombosis, underscoring the unreliability of clinical examination. No patient developed a known symptomatic VTE after discharge [29]. The findings of the author's study [16] and the experience of Lemaine et al. [17] suggest that deep venous thromboses developing within the first week after surgery in plastic surgery patients tend to be limited to the calf veins.

Origin of Deep Venous Thromboses

Virchow's original triad [30] implicates changes in blood flow, the state of the endothelium, and the composition of the blood. Severe hypoxia from prolonged venous stasis has been documented in the venous valvular sinuses of dogs in the absence of calf muscle-driven pulsatile blood flow [31]. Pathologic studies suggest that thrombosis initiation also occurs in the valve sinus in humans [32, 33]. Impaired blood flow in the pocket of a valve and low oxygen tension are believed to precipitate activation of a coagulation cascade involving tissue factor, P-selectin, platelets, microparticles, monocytes, and granulocytes [28, 33, 34]. Small thrombi forming within the valve pocket grow slowly over days or weeks [33, 34]. It is generally believed that most deep venous thromboses start within the calf [17, 19, 23, 35]. After forming in the calf, the thrombosis may extend proximally, where it is more likely to cause a pulmonary embolism [1, 23, 26, 35, 36]. Proximal extension precedes embolization [36].

> After forming in the calf, the thrombosis may extend proximally, where it is more likely to cause a pulmonary embolism. Proximal extension precedes embolization.

The natural history of a deep venous thrombosis isolated to the calf is difficult to study because many patients receive anticoagulation [37]. Patients with isolated calf thrombi are frequently asymptomatic [1, 38]. Distal thromboses represent approximately 11% of deep venous thromboses diagnosed in the community [39], but isolated distal thromboses are the prevalent finding in asymptomatic patients [37]. The rate of pulmonary embolism occurring in association with thromboses limited to the calf is about 2% [39, 40], and fatal emboli are rare [36, 38]. Palareti et al. [40] report that >90% of untreated distal thromboses monitored by serial compression ultrasound go on to complete resolution. By contrast, it is estimated that about 50% of patients with untreated proximal deep venous thrombosis will develop symptomatic pulmonary embolism within 3 months [1, 35].

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A 2012 literature review [38] reports an 8% rate of thrombus propagation to the popliteal vein in patients treated with surveillance only. Two forms of treatment are recognized, either anticoagulation or imaging surveillance with selective anticoagulation [38, 41]. The 2012 American College of Chest Physicians guidelines [41] allow for surveillance using ultrasound with no anticoagulation in a patient with a postsurgical distal venous thrombosis, mild symptoms, and no other risk factors. There is no widely accepted protocol for surveillance ultrasound testing [41]. A 2014 multicenter study [42] reports no propagation of distal deep venous thromboses and no adverse events in 110 patients treated with nadroparin and compression therapy and monitored with serial duplex scanning. A meta-analysis [43] reveals a significantly lower incidence of thrombus propagation and pulmonary embolism in patients with a distal venous thrombosis who received anticoagulation.

Ultrasound Screening of Plastic Surgery Patients

Objective data are needed regarding the natural history of deep venous thrombosis in plastic surgery patients, so as to better inform patient management [6]. The author's study [16] was undertaken to gain an understanding of the frequency and timing of deep venous thromboses in plastic surgery outpatients. A large study of consecutive plastic surgery outpatients had not been previously reported. Institutional review board approval was obtained from Chesapeake Institutional Review Board Services, Inc. accredited by the Association for the Accreditation of Human Research Protection Programs. The study hypothesis was that deep venous thromboses likely develop during surgery and that subclinical thromboses may go undetected and untreated [16]. Surprisingly, this hypothesis was not confirmed by the study findings.

> The study hypothesis was that deep venous thromboses likely develop during surgery and that subclinical thromboses may go undetected and untreated. Surprisingly, this hypothesis was not confirmed by the study findings.

At the author's clinic, Doppler ultrasound screening is offered to all plastic surgery patients undergoing surgery under total intravenous anesthesia. Patient consent is obtained and patients are enrolled in the study. There is no charge or reimbursement for taking part in this clinical trial [13]. To date, all patients (almost 1000) have consented to take part in the study, making the inclusion rate 100%. Scans are scheduled before surgery, the day after surgery, and approximately 1 week (range, 6–10 days) after surgery.

The Terason t3200 Ultrasound System Vascular series (Terason Ultrasound, Burlington, Mass.) is used to image the deep veins of both lower extremities, including the calf veins, at each visit. The imaged vessels include the common femoral, great saphenous, superficial femoral, deep femoral, popliteal, posterior tibial, and peroneal veins (Figs. 13.1, 13.2, 13.3, 13.4, 13.5,

Fig. 13.1 This 35-year-old woman is undergoing a Doppler ultrasound examination in the office 1 day after an augmentation/mastopexy [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

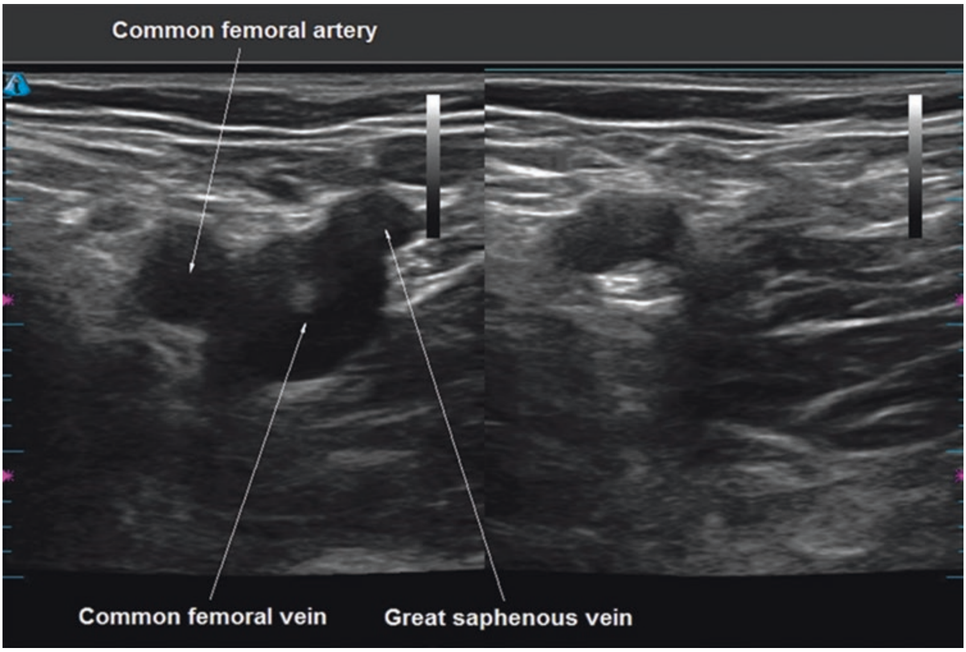
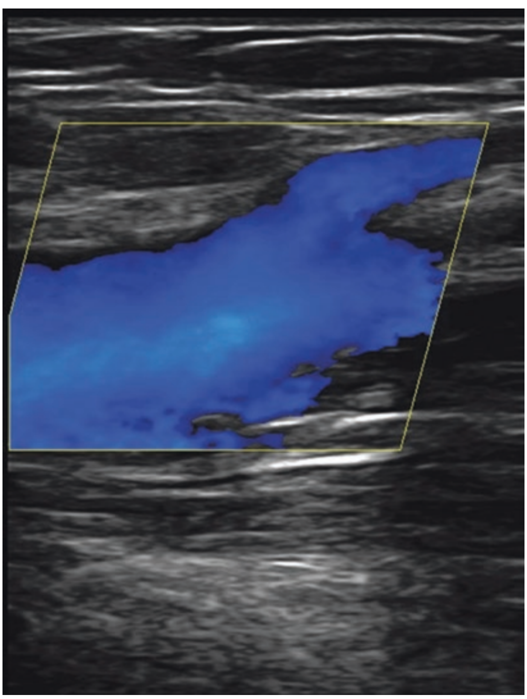


Fig. 13.2 This 27-year-old woman underwent transverse ultrasonography of the right common femoral vein 6 days after breast augmentation. The images show the veins before (*left*) and after compression (*right*) of the common femoral and great saphenous veins. A normal vein compresses completely, as shown. The common femoral artery remains patent [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]



13.6, 13.7, 13.8, and 13.9). Compression ultrasound (B-mode imaging), duplex ultrasound (B-mode imaging and Doppler waveform analysis), and color Doppler imaging are performed.

A pilot study of the first 100 patients demonstrated the feasibility of this method [15]. A control group of 25 volunteers who did not have surgery also underwent scans at the same time intervals and completed surveys [15]. No evidence of thrombosis was found on sonograms obtained from either group.

Fig. 13.3 Longitudinal color Doppler image of the same patient featured in Fig. 13.2 showing the right common femoral vein (*blue*) at its junction with the great saphenous vein [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

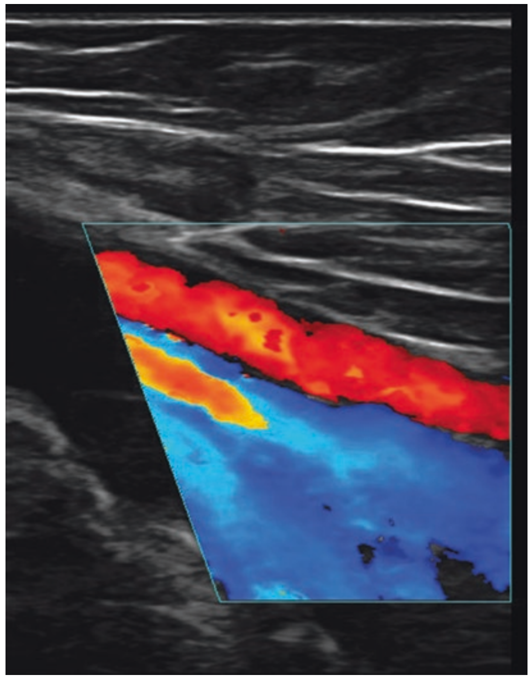


Fig. 13.4 Longitudinal color Doppler image of the same patient depicted in Fig. 13.2 showing the right superficial and deep femoral veins (*blue*) as they join to form the common femoral vein. Note the femoral artery (*red*) above [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

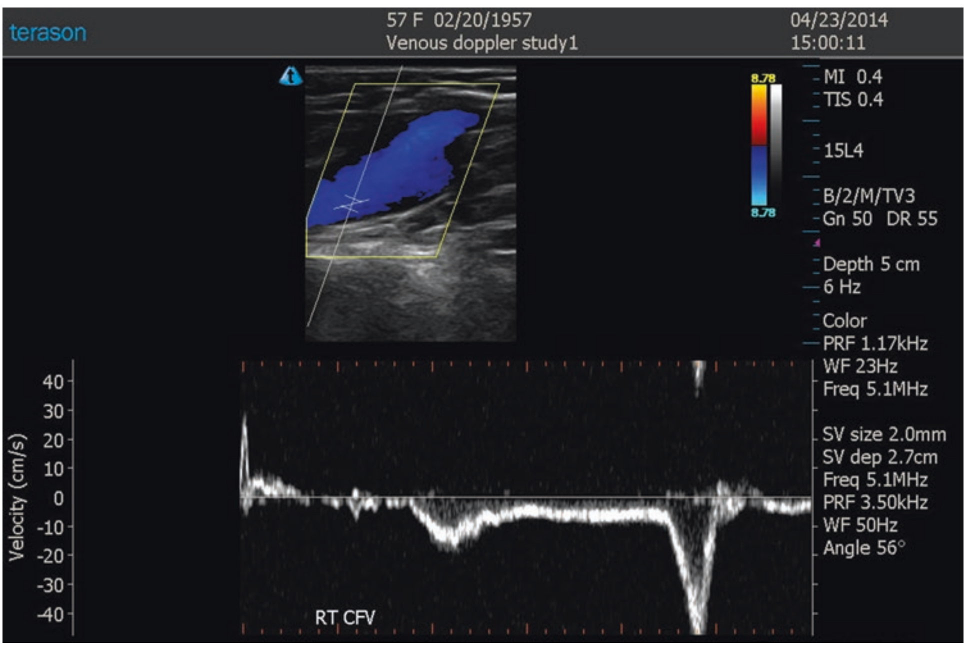


Fig. 13.5 This 57-year-old woman underwent color Doppler imaging (*above*) and Doppler waveform analysis (*below*) of the right common femoral vein 1 week after liposuction of the arms and axillae and brachioplasties. The distal thigh is compressed, causing a spike proximally at the level of the transducer in the right common femoral vein (shown as a "Z", *above*), which indicates blood flow. Fluctuations (phasicity) in the waveform are produced by respirations and indicate patency of the vein [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

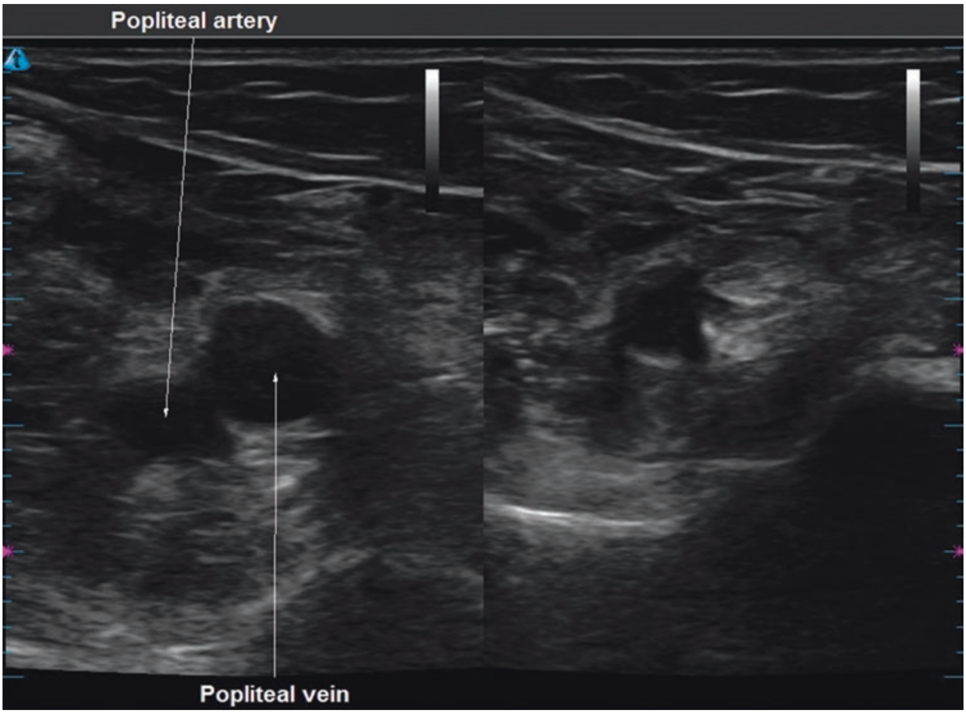
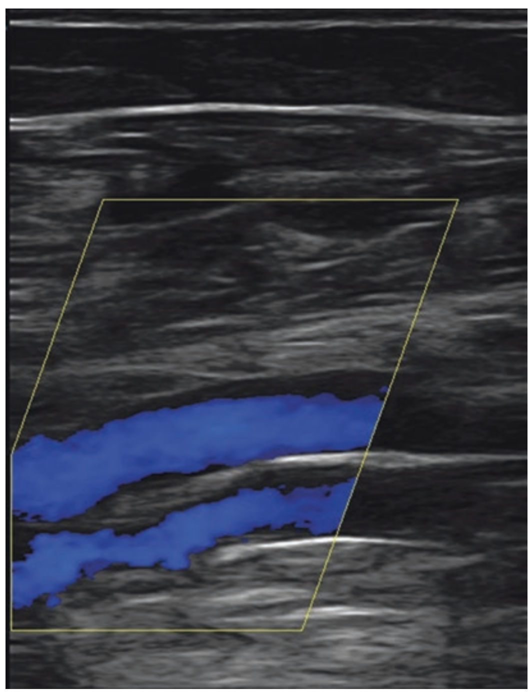


Fig. 13.6 Transverse ultrasound images of the right popliteal vein of the same patient depicted in Fig. 13.5 before (*left*) and after (*right*) compression. The popliteal artery remains patent [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

Fig. 13.7 Longitudinal color Doppler image obtained in the same patient shown in Figure 13.5 showing the paired right peroneal veins (*blue*) [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]



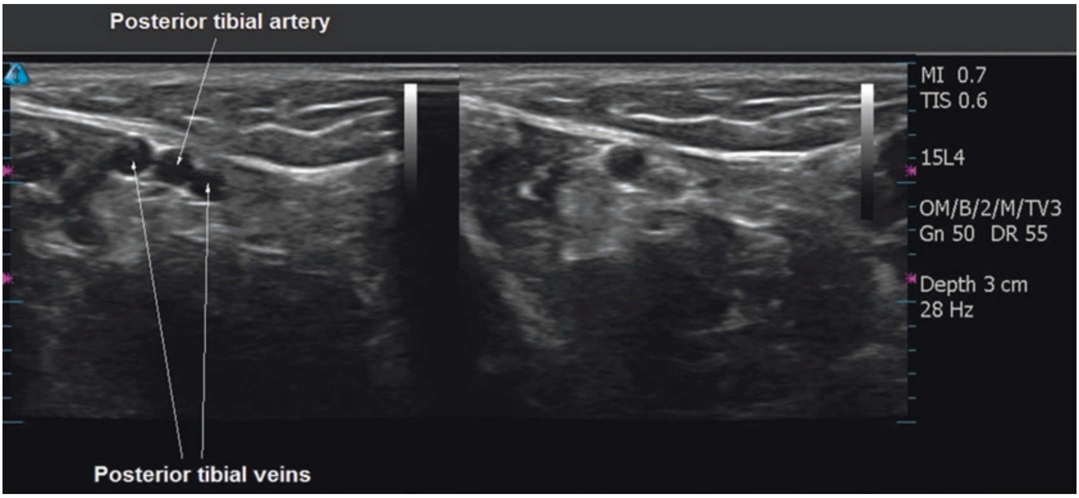
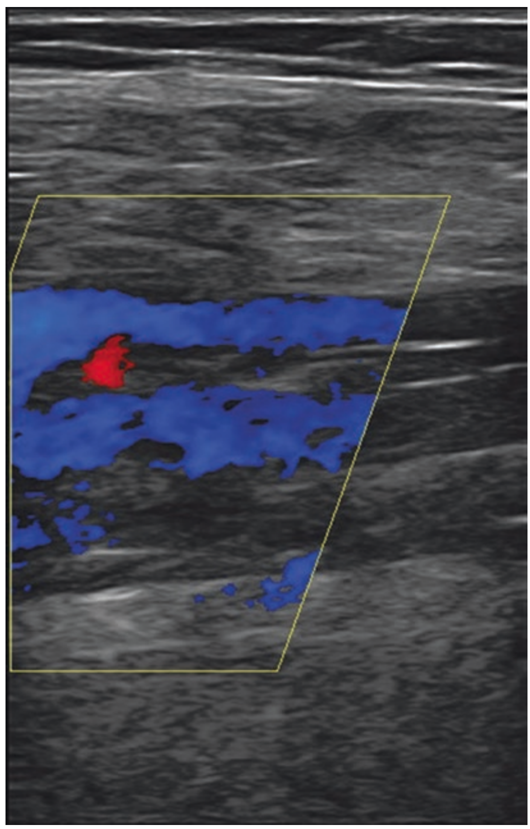


Fig. 13.8 This 41-year-old man underwent transverse ultrasonography of the paired posterior tibial veins 2 weeks before liposuction of the trunk, subcutaneous mastectomies for gynecomastia, and a submental lipectomy. Images depict the patient before (*left*) and after (*right*) compression [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

Fig. 13.9 This 45-year-old woman underwent longitudinal color Doppler imaging of the paired right posterior tibial veins (*blue*) 2 weeks before abdominoplasty and liposuction of the lower body, arms, and axillae. The posterior tibial artery is located between the veins (*red*) [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]



Figures 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 13.8, and 13.9 show sonographic results in four outpatients. Full compression confirmed that no thrombus was present within the lumen (Figs. 13.2, 13.6, and 13.8). Figures 13.3 and 13.4 depict color Doppler images showing no signs of obstruction. Figure 13.5 includes a Doppler waveform analysis with augmentation (i.e., squeezing of the distal thigh), causing an increase in amplitude in the right common femoral vein at the more proximal level of the transducer. This technique is not recommended if the results of compression or color Doppler flow are suggestive of a thrombus [15]. Figures 13.6, 13.7, 13.8, and 13.9 depict the popliteal and calf veins of three patients [15].

Survey Results

The first 200 patients were surveyed regarding their experience with ultrasound screening tests [16], completing 183 surveys (response rate: 91.5%). About two-thirds of patients (65.6%) were already familiar with the risk of blood clots after surgery. Only eight patients (4.4%) reported discomfort. Ninety percent of the 165 patients would choose to undergo perioperative ultrasound screening examination in the future. When asked which method patients would prefer, ultrasound screening versus taking a blood thinner, 92.9% chose ultrasound surveillance.

> Ninety percent of the 165 patients would choose to undergo perioperative ultrasound screening examination in the future. When asked which method patients would prefer, ultrasound screening versus taking a blood thinner, 92.9% chose ultrasound surveillance.

Doppler Ultrasound Is the Definitive Method

Today, venous ultrasound evaluation, including compression (Figs. 13.2, 13.6, 13.8, 13.11, 13.13, and 13.15) and color flow Doppler imaging (Figs. 13.3, 13.4, 13.5, 13.7, 13.9, 13.12, 13.14, and 13.16), represents the standard for the diagnosis of deep venous thrombosis [15, 23, 37, 44]. Two different approaches are recommended: (1) serial compression ultrasonography of the proximal veins, based on the belief that thrombosis of the distal veins (i.e., distal to the popliteal vein) is not dangerous unless it extends proximally, or (2) complete compression ultrasonography of the deep veins of the lower extremity, including the calves [37]. Color flow Doppler imaging improves the accuracy of ultrasonography of the calves [45].

D-dimer assays and impedance plethysmography are not sufficiently sensitive for detecting distal thromboses [44, 45]. Whenever possible (marked calf swelling can interfere with calf evaluation) [45], the proximal and distal veins should be examined [44]. Color Doppler imaging enables visualization of the calf veins, provides optimal thrombosis detection [46], and is preferable to D-dimer assays, which are less sensitive for isolated thrombi in these veins [44].

> Sonographic detection of a thrombus is sufficient to start treatment; if there is no sign of a thrombus, anticoagulation may be withheld.

When a patient has clinical findings consistent with a deep venous thrombosis (i.e., pain and swelling in a lower extremity), the presence of a thrombosis can be assessed in the office by ultrasonography, avoiding the increased inconvenience, time, and cost of a hospital visit. If a thrombosis is detected, the patient can be referred for treatment. The author refers to a consulting hematologist. Sonographic detection of a thrombus is sufficient to start treatment; if there is no sign of a thrombus, anticoagulation may be withheld [15, 23, 44]. Only in unusual circumstances is a venogram required (e.g., when a patient cannot be adequately imaged with Doppler ultrasound) [15, 23, 44].

In treating largely healthy outpatients who are not morbidly obese, the author has yet to encounter a patient who cannot be imaged adequately by ultrasound; no patient has required a venogram. Venograms pose additional risks, such as allergic reaction to the contrast dye and postvenographic phlebitis, and are more expensive [45].

> Moving the extremities during surgery with supine and side-to-side positioning mimics the normal movement of patients when sleeping, avoiding prolonged immobility, which is a known risk factor for VTE.

Because of its superior sensitivity for thrombosis detection and its safety and practicality in terms of cost and patient compliance, no attempt was made to compare ultrasound imaging with other methods [15].

A power analysis and sample size calculation were not performed because the study was not intended to evaluate a treatment effect [26]. This is an important point because Morales et al. [47], a group that evidently does not include a statistician, have faulted the study for being statistically underpowered.

Some investigators consider compression testing of the proximal veins sufficient [18, 19, 48], saving time and expense. These concerns may be misplaced. A complete ultrasound screening examination of both lower extremities, including the calf veins (Figs. 13.7 and 13.8), takes about 20 min for an experienced sonographer [16].

Preventing Venous Stasis

SAFE anesthesia aims to reduce the risk of venous stasis [6]. Venous stasis is the final common pathway that is believed to be responsible for causing deep venous thrombosis [6]. The reduced risk of total intravenous anesthesia (i.e., spontaneous breathing and no gas) as opposed to traditional general endotracheal anesthesia is supported by strong empirical evidence [6]. Avoiding prone positioning eliminates pelvic pressure from a bolster that might impair venous return [49]. Undue pressure on the face, the need for mechanical ventilation, and more difficult airway access are also avoided [6]. Moving the extremities during surgery with supine and side-to-side positioning mimics the normal movement of patients when sleeping, avoiding prolonged immobility, which is a known risk factor for VTE [6].

Prospective Study of 200 Patients

Two hundred patients underwent a total of 205 operations [16]. Total intravenous anesthesia [50] was administered to all patients. “SAFE” principles were observed, consisting of (1) spontaneous breathing, (2) avoid gas, (3) face up, and (4) extremities mobile [6].

All patients underwent surgery in a licensed ambulatory surgery center as outpatients and were ambulatory before leaving the recovery room. No patient was admitted to hospital or was immobilized postoperatively. Patients undergoing liposuction and abdominoplasty were positioned supine and then turned from side to side during the superwet infusion [50]. The sequence was repeated for liposuction, ensuring mobility of the lower extremities.

There were no deaths, hospitalizations, or patients with symptoms or signs of pulmonary emboli. Only one screening examination revealed a deep venous thrombosis, in a 55-year-old woman who underwent an abdominoplasty, liposuction, and augmentation/mastopexy (Figs. 13.10, 13.11, 13.12, 13.13, 13.14, 13.15, 13.16, and 13.17). The affected patient had no personal history of VTE and no history of a clotting disorder. Her ultrasound scans before surgery and the day after surgery were negative. A thrombosis was detected in her left calf veins (Figs. 13.11 and 13.12). The popliteal vein was not involved (Figs. 13.13 and 13.14). At the time of her scan, she reported a discomfort in her left calf that she noticed just the day before, 7 days after surgery. She was not admitted. A consulting hematologist

Fig. 13.10 This 55-year-old woman underwent an abdominoplasty, liposuction of lower body, and augmentation/mastopexy. Thromboses of the left calf veins were detected by ultrasound screening 8 days after surgery. She had moderate swelling and bruising of the lower extremities, as expected after liposuction. She is seen undergoing a follow-up ultrasound examination 2 weeks after surgery

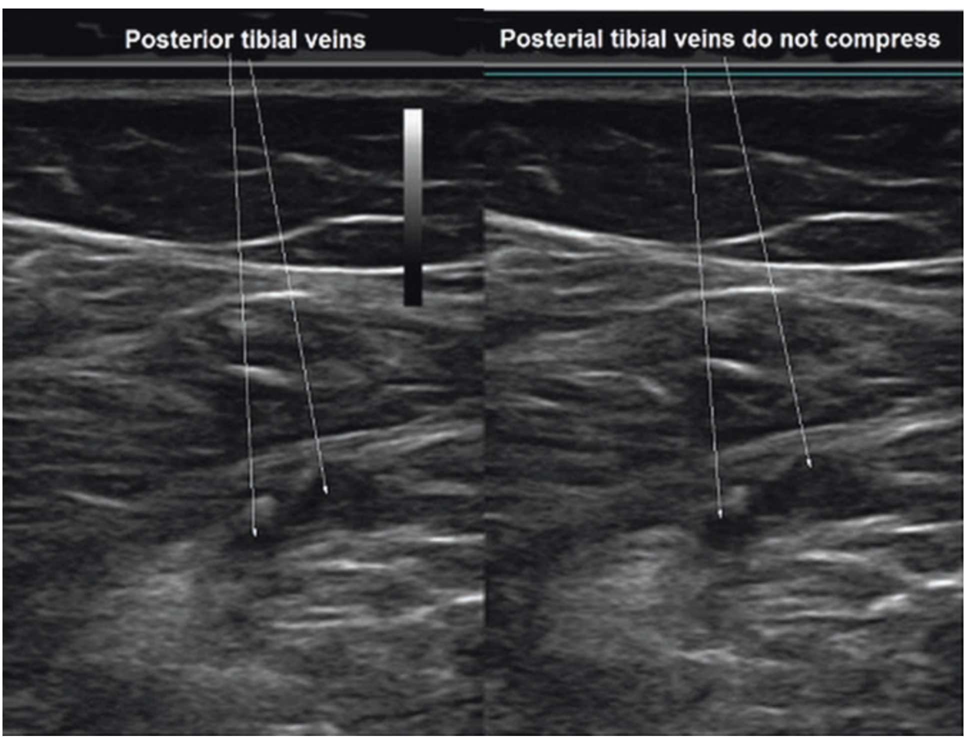
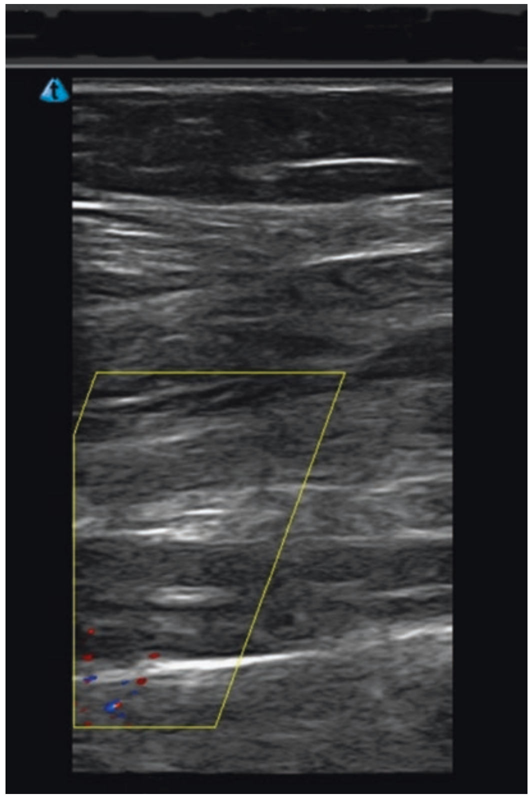


Fig. 13.11 Transverse ultrasound image of the left lower extremity shows the paired left posterior tibial veins and the posterior tibial artery before (*left*) and after compression (*right*). The inability to compress the veins indicates the presence of a thrombosis

Fig. 13.12 Longitudinal color flow Doppler ultrasound image reveals no flow in the left posterior tibial veins



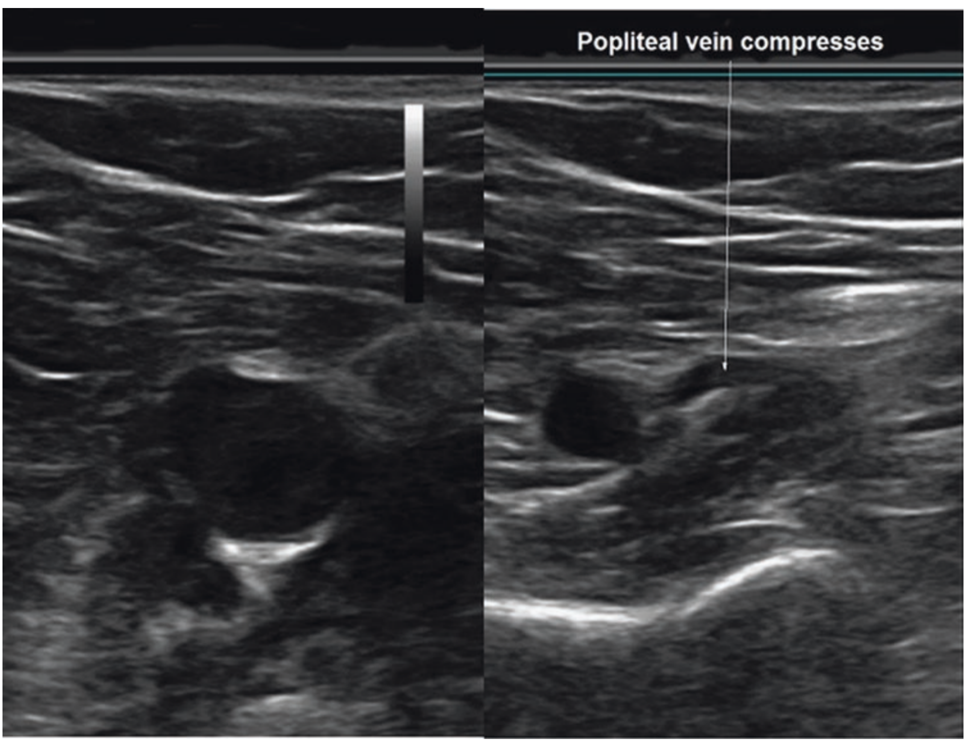


Fig. 13.13 Transverse ultrasound image of the left lower extremity shows the popliteal vein before (*left*) and after compression (*right*). Full compression of the vein indicates no obstructive thrombosis within the lumen, confirming that there is no proximal extension of the thrombosis

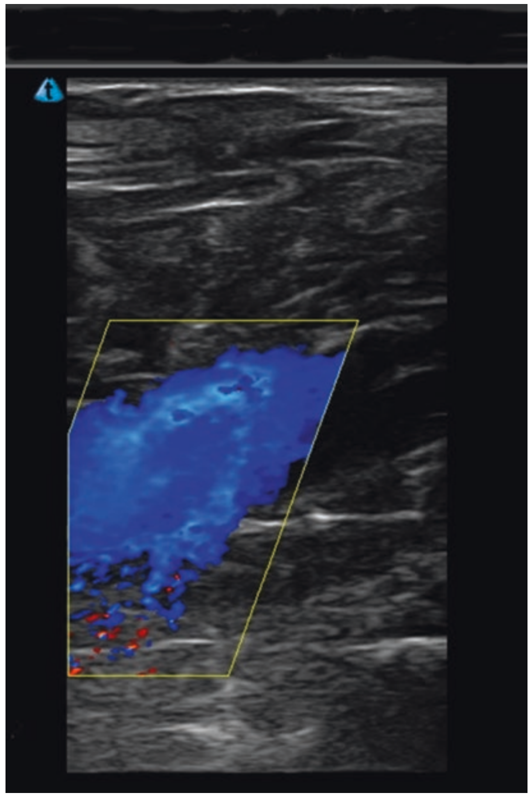


Fig. 13.14 Longitudinal color flow Doppler ultrasound image reveals unobstructed venous flow (*blue*) within the left popliteal vein

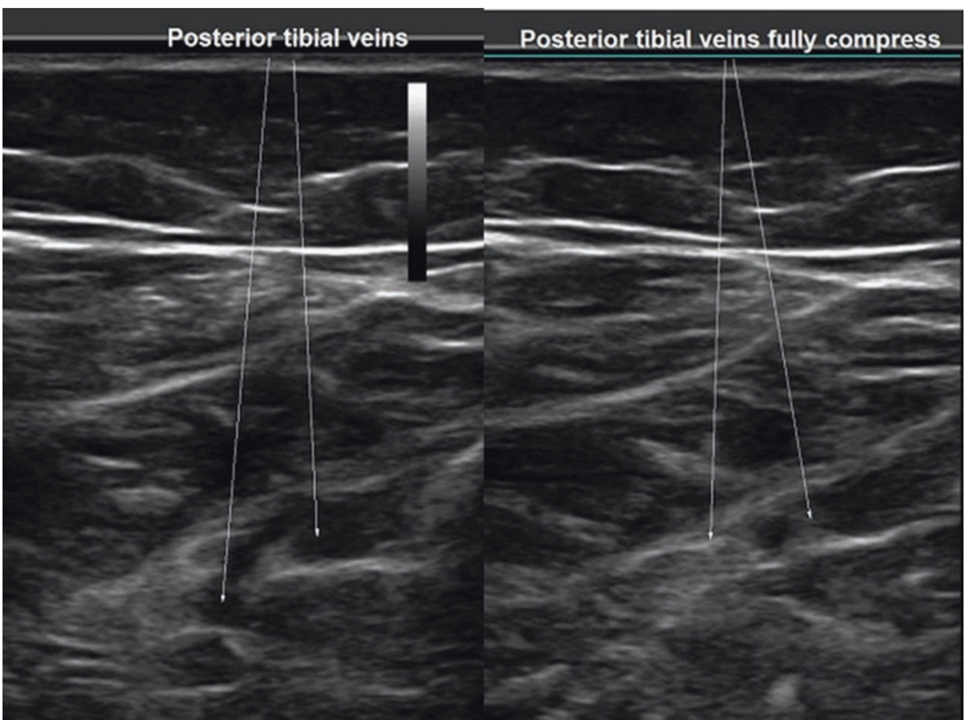


Fig. 13.15 Transverse ultrasound images of the left lower extremity 5 weeks after surgery (1 month after diagnosis and initiation of anticoagulation) before (*left*) and after compression (*right*) show that the posterior tibial vessels now compress fully, indicating resolution of the thrombosis

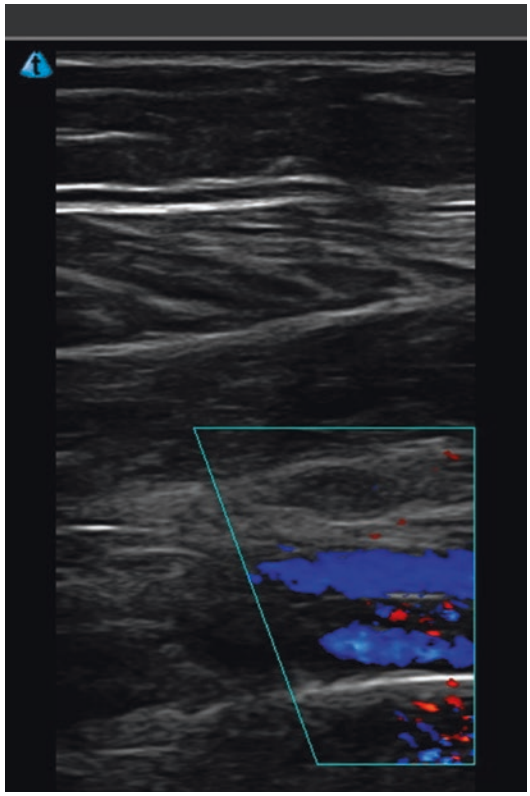


Fig. 13.16 Longitudinal color flow Doppler ultrasound image 5 weeks after surgery shows restoration of venous flow with no obstruction in the peroneal veins

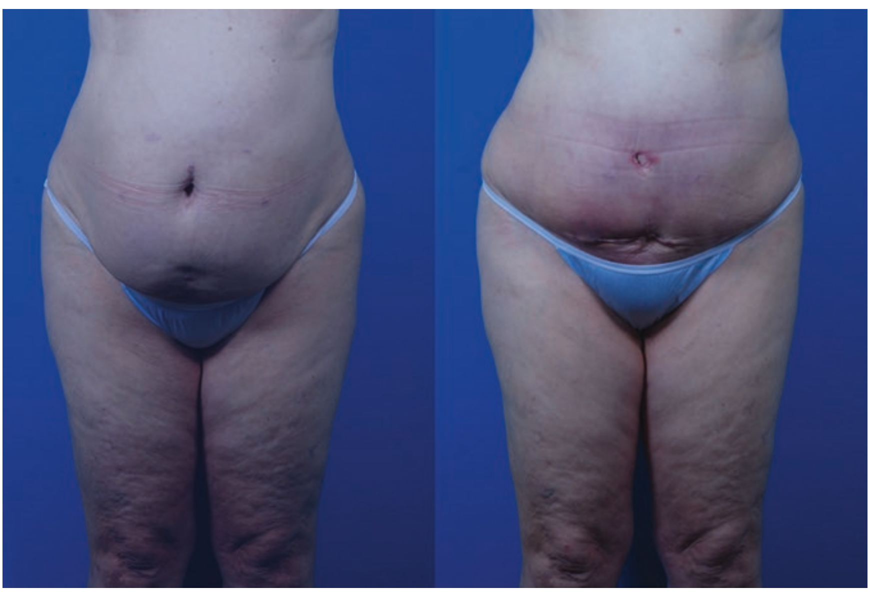


Fig. 13.17 Frontal photographs before (*left*) and 5 weeks after abdominoplasty and liposuction (*right*). The patient is asymptomatic

prescribed enoxaparin 80 mg subcutaneously b.i.d. for 3 days and (concurrently) rivaroxaban 15 mg p.o. b.i.d. for 2 weeks, followed by rivaroxaban 20 mg p.o. daily for 3 months. This was the only patient in the series of 200 consecutive patients to receive anticoagulation. She was followed with weekly ultrasound scans (Fig. 13.10). Five weeks after surgery, there was no sonographic evidence of a thrombosis (Figs. 13.15 and 13.16). Circumferences measured 45 cm for the right calf and 46 cm for the left calf. She had the usual degree of swelling (Fig. 13.17).

The Value of Ultrasound Detection Before Clinical Signs of Deep Venous Thrombosis

Failure to detect a subclinical deep venous thrombosis may allow it to propagate undetected. Such a patient is shown in Fig. 13.18. This patient developed clinical findings suggesting a deep venous thrombosis 9 days after surgery in 2004. Ultrasound surveillance may have detected this thrombosis earlier. Fortunately the patient did not experience a pulmonary embolism. Her ultrasound scans are shown in Figs. 13.19, 13.20, and 13.21. This prestudy patient's photographs are provided in the absence of a similar patient available in the series of patients screened with ultrasound surveillance.

Fig. 13.18 This 39-year-old woman is seen 2 weeks after an abdominoplasty and liposuction of the lower body. She developed swelling of the left lower extremity 9 days after surgery. This patient was treated in 2004, well before the study period. Her ultrasound scans are provided in Figs. 13.19, 13.20, and 13.21. The scans confirm the clinical diagnosis, revealing a deep venous thrombosis extending from the left popliteal vein to the common femoral vein. She did not develop a pulmonary embolism. She was anticoagulated with heparin, followed by warfarin, and made a full recovery. Her only risk factor was a 3-h operation. Her Caprini score was 3. Her before-and-after photographs are provided in Chap. 6

Duration of Anticoagulation

Patients who develop a deep venous thrombosis after surgery (a transient risk factor) are less likely to experience recurrences than patients with idiopathic thromboembolism or persistent risk factors such as malignancy or prolonged immobilization [51–55]. For these lower-risk patients, some investigators recommend 4 weeks of anticoagulation rather than the traditional 3 months [51–53].

Timing of Scans

A 1-week time frame was chosen for several reasons. First, it makes possible a high level of patient compliance in that patients are likely to keep 1-week follow-up appointments. Second, at

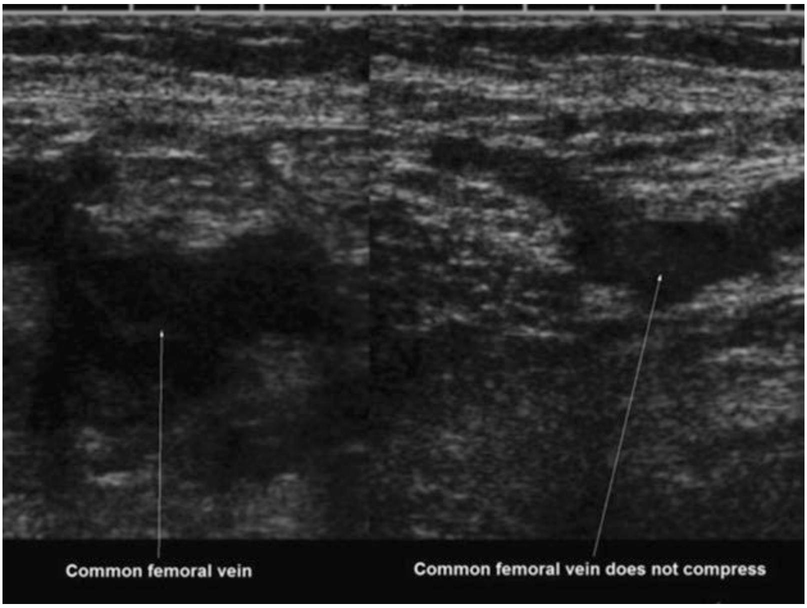


Fig. 13.19 The transverse ultrasound scan shows the left common femoral vein before (*left*) and after compression (*right*) in the 39-year-old woman depicted in Fig. 13.18. Incomplete compression (*right*) indicates the presence of a thrombosis within the lumen [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

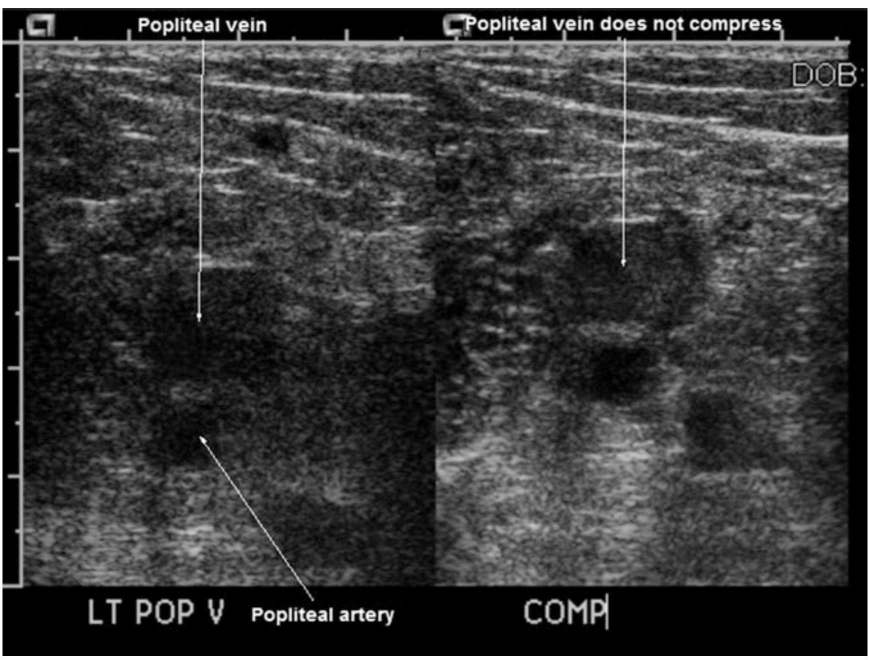


Fig. 13.20 The left popliteal vein is shown before (*left*) and after compression (*right*) in the 39-year-old woman shown in Fig. 13.18. The popliteal vein cannot be compressed, consistent with an intraluminal thrombosis. Note the presence of internal echoes within the lumen (*right*) [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

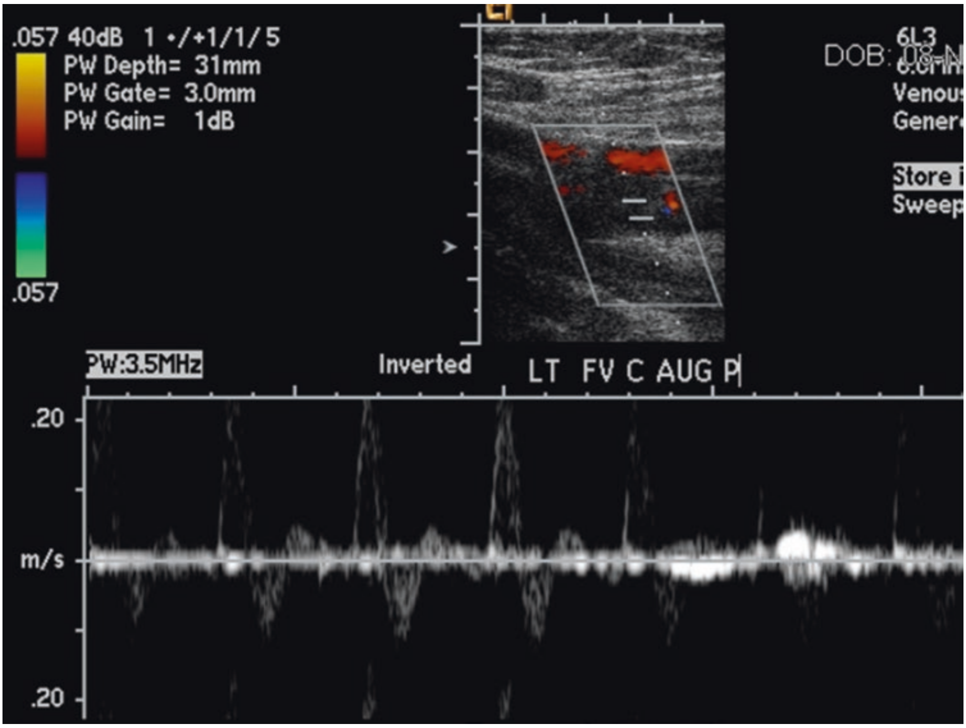


Fig. 13.21 Color Doppler imaging (*above*) shows the left femoral vein where it is joined by the deep femoral vein in the same 39-year-old patient shown in Figs. 13.18, 13.19, and 13.20. The waveform analysis (*below*) indicates no blood flow in the left femoral vein despite increased gain. The background spikes are caused by the adjacent femoral artery [Reprinted from Swanson E. Doppler ultrasound imaging of plastic surgery patients for deep venous thrombosis detection: a prospective controlled study. Aesthet Surg J. 2015;35:204–214. With permission from Oxford University Press]

this point, these outpatients had been ambulatory for approximately 1 week already, so that a thrombosis developing later related to immobility is unlikely, at least in theory [15]. This time frame also corresponds to the 1-week period of enoxaparin injections frequently prescribed for chemoprophylaxis [56, 57]. Seruya et al. [56] recommended performing Doppler ultrasound evaluations 5–7 days after surgery.

In a study using venograms to screen consecutive patients for the presence of a deep venous thrombosis, 86% of eventually positive limbs were already positive within 1 day after surgery [26]. However, this study evaluated patients receiving total knee replacements, who are exposed to local conditions that increase risk [22, 26], such as vessel injury and hypercoagulability.

The absence of positive findings on scans performed on the day after surgery (0/203 scans) [16] suggests that (1) the development of venous thromboses in plastic surgery patients differs from orthopedic patients undergoing joint replacement, who are more likely to develop thrombi intraoperatively, and (2) clinical adjustments to reduce the risk of venous stasis [6] may be effective.

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Number Needed to Screen

The number needed to screen [58] is the number of people that need to be screened for a given duration to prevent one death or adverse event. If a calf vein thrombosis causes a pulmonary embolism in 2% of patients [39, 40], and screening followed by selective anticoagulation is effective (and the evidence suggests it is) [42], and the prevalence of a distal thrombosis is 0.5% (as found in the author's study [16]), the number of patients needed to screen to avoid 1 case of pulmonary embolism is 10,000. However, if the rate of VTE is 5% among higher-risk patients [49], the number needed to screen to avoid 1 case of pulmonary embolism drops to 1000 and may drop lower if more dangerous proximal thromboses are more prevalent among these patients (this information is presently unavailable) [16].

"Chemoprophylaxis"

There is no evidence that anticoagulant medication prevents venous thromboses from developing in plastic surgery patients [6]. Anticoagulation does not affect the factors comprising Virchow's triad [30]. Venous thromboembolism still occurs in anticoagulated patients [3, 6, 22, 26, 38, 43, 49]. Its value is in preventing further thrombus deposition [34] and in facilitating spontaneous lysis [1] that may already be underway [40].

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Is There a Role for Testing for Clotting Disorders?

There are six moderately strong genetic risk factors for VTE [28]. Three are rare (combined prevalence <1%) [59, 60] heterozygous deficiencies of the natural anticoagulants, antithrombin, protein C, and protein S [28]. Venous thrombotic risk may be increased up to tenfold in these deficiency states [59, 60]. The other three genetic factors are factor V Leiden (three- to fivefold increase), prothrombin G20201A (two- to threefold increase), and blood group non-O (twofold increase) [28, 59, 60]. Approximately 5% of people of mixed European descent carry factor V Leiden [28, 34, 59–62]. Patients with factor V Leiden or prothrombin G20201A do not have a significantly increased risk of a recurrent VTE [1, 54]. The majority of carriers never develop a thrombosis [59, 61]. A multicenter study [61] evaluating Factor V Leiden and prothrombin G20210A mutations as risk factors for patients undergoing total hip and knee replacement surgery concludes that preoperative genotyping is of questionable value. Joseph et al. [62] recommend against routine preoperative blood screening for a potential hypercoagulable state. Any additional risk is likely to be small in comparison with the risk of surgery itself [60, 62].

A history of a previous VTE is not a significant risk factor for patients undergoing lower limb arthroplasty [62]. Individuals with a family history of thrombosis affecting a first-degree relative have a two- to threefold increased risk of VTE [60]. A high plasma level of factor VIII may increase risk fivefold, but a genetic basis has not been identified [60]. High levels of prothrombin, factor IX, and factor XI impart only a twofold increase in thrombotic risk [60]. Measurement of clotting factor levels is not routinely included in a thrombophilia evaluation [60]. Moreover, the assays are not standardized, and threshold values for identifying high-risk patients vary considerably [60]. There is no evidence that identification of thrombophilia in asymptomatic patients reduces the risk of VTE [60].

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By comparison, aging (the strongest risk factor for VTE) [33, 60, 62] raises the risk of venous thrombosis exponentially from an annual incidence of 0.01% in people under 45 years old to 0.9% by 80 years of age, a difference of 90-fold [33, 63]. Changes in compliance of the vein wall and thickening of the valve leaflets may disrupt the normal flow of blood during the valvular cycle [33]. Several large series [64–67] of plastic surgery outpatients that are statistically likely to contain numerous individuals with inherited thrombophilias report no cases of a known postoperative VTE.

Financial Commitment and Goodwill Factor

The cost of the system used by the author is about $30,000, including a 5-year warranty, or $6000 per year. The cost of employing part-time sonographers over the course of a year is about $20,000, which is similar to the cost of a single hospitalization for treatment of deep venous thrombosis [68]. The author employs a full-time sonographer at a cost of about $40,000 annually. The cost per patient for three perioperative scans is about $200, included in the surgical fee. This expense may be compared to the price of enoxaparin, at about $250 for a 1-week course. Writing a prescription is easier than scanning patients, obviously. However, Doppler ultrasound scans are not as onerous as one might think and are well-accepted by patients [15, 16].

Such an effective "early warning system" compares favorably to the cost of other plastic surgery devices in the marketplace, many of which may be of questionable value [15, 16]. Any plastic surgeon who has encountered a patient death from a pulmonary embolism understands the enormity of this complication, not just financially but emotionally, and is unlikely to find the cost prohibitive. Hematomas are distressing to patients and surgeons, and any method that mitigates this risk is welcome, quite aside from the extra cost of managing this complication.

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There is a goodwill factor and possibly a secondary marketing advantage for surgeons who offer ultrasound examinations because patients typically are grateful to know their surgeon emphasizes safety [15] and is willing to provide an important additional safety measure at no extra cost. Open discussions with patients regarding the risk of VTE and methods of risk reduction are helpful. Additional time in the office is welcomed by many patients who benefit from more contact and more bonding with the staff and additional opportunities to ask questions and be reassured. Consulting physicians are often impressed with this heightened level of concern. Such safety measures are likely to reduce our shared medicolegal liability.

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Treating a Distal Venous Thrombosis

Some investigators question whether knowledge of a thrombosis is even desirable, arguing that a distal thrombosis does not require treatment. It is true that most distal thromboses are likely to spontaneously resolve [40]. However, they may also propagate. A prudent course of management, and one supported by the ACCP guidelines [41], is weekly ultrasound scans to document resolution [9]. A hematologist may be consulted regarding management, and the consultant decides whether or not to recommend anticoagulation, the specific medication, and the duration [9].

Doppler Ultrasound Surveillance Versus Risk Stratification and Chemoprophylaxis

Ultrasound screening avoids needless anticoagulation and identifies patients with early subclinical thromboses. The diagnosis comes first and treatment second rather than the reverse. The alternative is to simply wait for a thrombosis to become clinically evident (Fig. 13.18) and only then intervene. One need not wait for a large proximal thrombosis to propagate unseen and undetected. As proponents of chemoprophylaxis point out, the presenting clinical sign of VTE may be sudden death [69]. Figure 13.22 compares ultrasound surveillance and individual risk stratification and chemoprophylaxis with rivaroxaban.

Today, it is impossible to think of practicing cardiology without electrocardiograms.

Fig. 13.22 Comparison of ultrasound surveillance versus individual risk stratification and rivaroxaban [Reprinted from Swanson E. Caprini scores, risk stratification, and rivaroxaban in plastic surgery: time to reconsider our strategy. Plast Reconstr Surg Glob Open 2016;4:e733. With permission from Wolters Kluwer Health, Inc.]

	Ultrasound surveillance	Individual risk stratification and rivaroxaban
High sensitivity	✓	
Few false positives	✓	
High patient compliance	✓	✓
Low cost	✓	✓
No increased risk of bleeding	✓	
No need for antidote	✓	
No problem with FDA approval	✓	
No concern for drug interactions	✓	
Allows early, reliable detection of thrombosis	✓	
Diagnosis before treatment	✓	
Adds to understanding of natural history	✓	
Convenient for patient and surgeon		✓
No need for ultrasound equipment or the services of a trained sonographer		✓

FDA, United States Food and Drug Administration.

Similarly, any serious study of deep venous thromboses must include ultrasound scans. Doppler ultrasound imaging may prove to be as valuable as preoperative electrocardiograms that many plastic surgeons already order routinely. Ultrasound examinations are quick, accurate, and noninvasive. Negative scans are highly reassuring to the patient and surgeon [9, 16].

The findings support ultrasound surveillance and selective anticoagulation in affected patients, consistent with the time-honored medical practice of performing tests, making a diagnosis, and then recommending treatment based on the findings.

Today, it is impossible to think of practicing cardiology without electrocardiograms. Similarly, any serious study of deep venous thromboses must include ultrasound scans.

Other Clinical Uses of Ultrasound in the Office

Other useful clinical applications of diagnostic ultrasound include diagnosing and treating seromas (Figs. 13.23 and 13.24) and preoperative abdominal imaging to identify abdominal wall defects in liposuction and abdominoplasty patients (Fig. 13.25) [70]. It can be used postoperatively to evaluate the repair of the rectus abdominus diastasis (Fig. 13.26).

Ultrasound screening may also help to prevent another rare but devastating complication—visceral perforation [71]. This evaluation is particularly important in patients with previous abdominal surgery and scarring. All patients undergoing liposuction and abdominoplasty are screened using ultrasound, at the same time that their lower extremities are checked for thromboses at their preoperative visit.

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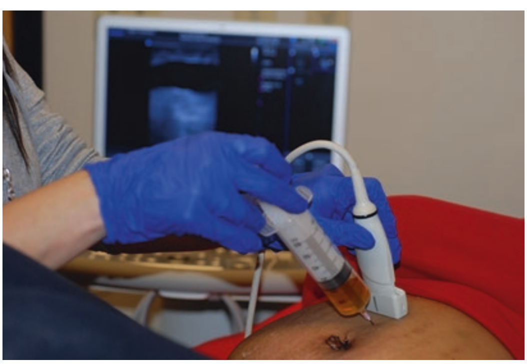

Fig. 13.23 This 36-year-old woman noticed increased swelling of the upper abdomen 3 weeks after an abdominoplasty. A volume of 20 cc of serous fluid was aspirated with ultrasound guidance

Fig. 13.24 Postoperative ultrasound scan in a 57-year-old woman who was concerned about lower abdominal swelling after abdominoplasty. The scan showed no fluid accumulation

Fig. 13.25 Patient undergoing a preoperative ultrasound scan before abdominoplasty to check for any abdominal wall defects

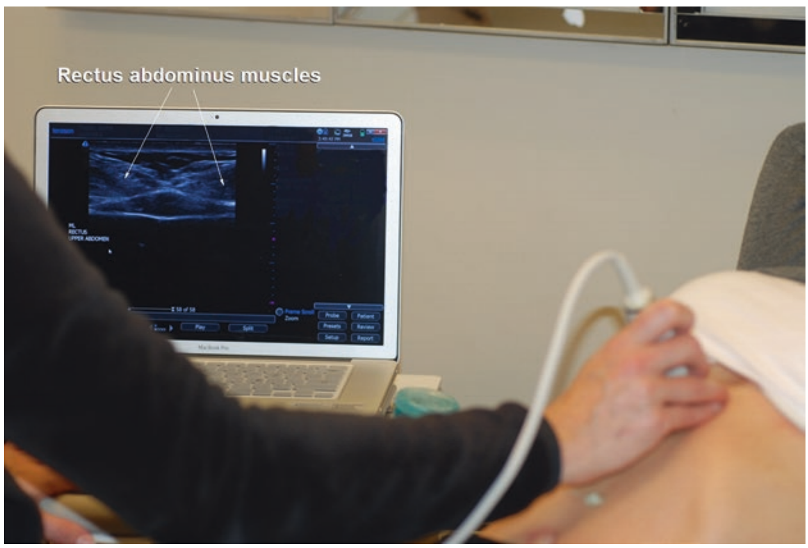

Fig. 13.26 The rectus abdominus diastasis repair is evaluated in this 57-year-old woman 2.5 months after abdominoplasty

Ultrasound scans are helpful in distinguishing between swelling and an evolving hematoma after breast surgery (Fig. 13.27) and in evaluating breast implants for folds and ruptures (Fig. 13.28). This tool is also useful for imaging large soft tissue masses to be sure there is no deep extension (Figs. 13.29 and 13.30). This device may be used to evaluate possible areas of fat necrosis after fat injection of the breasts or buttocks, to ensure subcutaneous fat placement, and to measure changes in fat thickness (discussed in Chap. 9).

Three recent unusual applications included locating a ventriculoperitoneal shunt in the neck of a prospective facelift patient, the course of a tube for a pain pump in a possible liposuction patient, and to help visualize arm veins in a patient with a difficult intravenous access.

Fig. 13.27 This 68-year-old woman underwent replacement of breast implants and mastopexies. Approximately 12 h after surgery (early the following morning), she noticed increasing pain and swelling of the right breast. On arrival, the patient was clearly uncomfortable, reporting increased pain (10 on a scale of 1–10 compared to 1 on a scale of 1–10 for the contralateral breast) of the right breast and right arm pain. Despite her symptoms, she had only marginally more swelling of the right breast and minimal bruising. The physical examination was therefore equivocal for the presence of an early right breast hematoma. An ultrasound examination clearly showed the saline-filled breast implant, the muscle layer, and subcutaneous tissue. There was no evidence of a fluid collection outside of the implant

Fig. 13.28 Scan of a 36-year-old woman after augmentation/mastopexy shows a fold in the upper pole of the implant

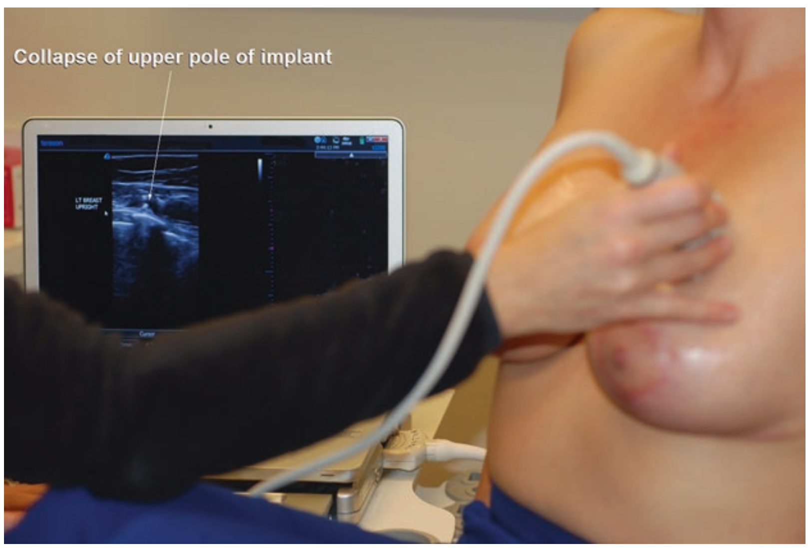

Fig. 13.29 This 50-year-old woman has a large subcutaneous mass of the right lower back. The likely diagnosis is a lipoma. Her ultrasound image is shown in Fig. 13.30

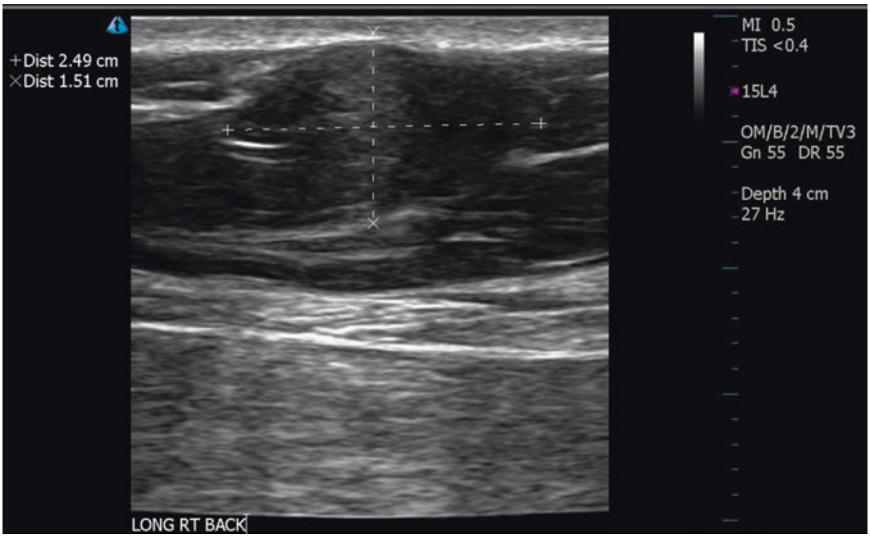

Fig. 13.30 Ultrasound imaging shows a fatty consistency of the mass and defines its borders. There is no deep fascial extension

Future Research

In addition to improving patient safety, ultrasound scans help us to learn more about VTE. Hopefully, other investigators will adopt this noninvasive measure in their practices so as to gather more experience and data. There is no reason this method cannot be used in plastic surgery inpatients and in patients undergoing other types of surgery, such as orthopedic or general surgery.

Important questions remain [9]. Should all plastic surgery outpatients be screened perioperatively using Doppler ultrasound? Are preoperative scans necessary? Do certain procedures and operating times pose greater risk? When should patients be scanned? More information will be available soon as the results are evaluated for 1000 consecutive patients. The contributions of other investigators are welcome. The more patients are scanned, the more we learn about the nature of this enigmatic complication.

> Hopefully, other investigators will adopt this noninvasive measure in their practices so as to gather more experience and data.

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