Obesity represents the number one chronic health problem in the United States today. Overweight and obese individuals constitute over 50% of the United States population, making issues surrounding obesity and weight loss paramount to most clinical practices [1]. Obesity is defined by body mass index (BMI), obtained by dividing weight in kilograms by height in meters squared (kg/m²). The clinical definition of obesity is BMI > 30 kg/m², severe obesity is BMI > 35 kg/m², and morbid obesity is BMI > 40 kg/m². Inherent in these calculations is the knowledge that obesity is linked to a number of comorbid conditions, including heart disease, hypertension, dyslipidemia, diabetes, obstructive sleep apnea (OSA), gastroesophageal reflux disease (GERD), and osteoarthritis.

Bariatric surgery has evolved as an effective and relatively safe treatment for morbid obesity. Most importantly, it provides durable weight loss, which can lead to improvement and even resolution of many comorbid illnesses [2–6]. Consequently, over 100,000 patients in the United States underwent gastric bypass in 2003 (estimate by the American Society of Bariatric Surgeons). Many of these patients will seek consultation with a plastic surgeon for skin laxity after weight loss. The massive weight loss patient represents a great challenge to the body contour surgeon. With nearly every region of the body as a potential operative site and an unprecedented number of surgical procedures available, we must give attention to thoughtful perioperative management. Bariatric surgery is a life-changing event for the morbidly obese patient, and the body contouring that follows weight loss often has an equally profound effect. Plastic surgeons must strive to maintain the highest level of safety in this pursuit.

In this article the authors address issues surrounding preoperative evaluation and measures to minimize the risk of complications.

Timing of body contouring surgery relative to bariatric surgery

In general, it is best to delay body contouring until after the patient has been weight stable for a period of 2 months (often corresponding to 12–18 months after gastric bypass). This delay is advocated for three reasons. First, it allows the patient to achieve a metabolic and nutritional homeostasis. As the authors will discuss later in more detail, a period of rapid weight loss may not be the best time for good wound healing. Second, the risk of surgical complications decreases as the patient moves out of the morbidly obese category and approaches ideal body weight. Third, aesthetic outcomes tend to be better for patients who are close to their ideal body weight.

With regard to surgical risk, a number of studies point to the increased incidence of wound infections [9–12], pulmonary complications [13,14], thrombo-
embolic events [15,16], and even mortality [17] associated with surgery in obese patients. Two studies demonstrate this relationship between BMI and operative risk with body contouring procedures. Matory et al [18] performed panniculectomy on 42 obese patients, each weighing more than 220% of ideal body weight (IBW). A majority of operations were combined with intra-abdominal (eg, gynecological) procedures. The incidence of complications was 68% and primarily reflected wound and pulmonary problems. Vastine et al [19] performed a retrospective analysis of 90 abdominoplasty patients. Patients were subsequently divided into three groups based on deviation from IBW: obese (> 100 lbs over IBW), borderline obese (50–100 lbs over IBW), and non-obese (within 50 lbs of IBW). Complications were seen in 42% of patients. When patients were stratified by weight categories, obese individuals had a complication rate of 80%. In contrast, borderline and nonobese groups demonstrated complication rates of 33% and 32.5%, respectively.

It is unknown exactly how much weight loss will reduce surgical risk, but a reasonable approach is to avoid operating on patients who are morbidly obese unless there is strong indication, such as chronic panniculitis or a pannus that severely limits ambulation. In such a patient, a panniculectomy is a purely functional procedure and should be performed with no direct undermining of tissues and little regard to aesthetic contour. A more refined abdominal contouring procedure may be undertaken at a lower BMI.

After bariatric surgery, many patients will plateau at a BMI between 30 kg/m² and 35 kg/m². Motivated patients in this category who are still intent on reaching a lower goal weight should be considered for an initial panniculectomy or breast reduction as a means of improving comfort during exercise. This procedure often facilitates body image and lifestyle changes that result in further weight loss and allow subsequent procedures to be performed with a better aesthetic outcome. Nutritional counseling is a useful adjunct at this time. Patients in this category may also have a more significant loss of adipose tissue from either the upper or lower half of the body, facilitating refined contouring in the leaner anatomic regions. The best candidates for extensive body contouring surgery after weight loss reside in the BMI range of 25 kg/m² to 30 kg/m².

**Patients with abdominal wall hernias**

As laparoscopic bariatric techniques become more prevalent, the incidence of large abdominal wall hernias following weight loss surgery is decreasing. However, a significant number of patients have had open gastric bypass, which is associated with a high risk of hernia. Therefore, it is not uncommon for the plastic surgeon to encounter a massive weight loss patient with an incisional hernia. When approaching these patients, the authors first consider whether there has been sufficient weight loss to avoid excessive pressure on the repair exerted by a still obese intra-abdominal compartment. They often recommend further weight loss and use of an abdominal binder for comfort before performing surgery.

If the patient has reached an appropriate body weight for hernia repair, consideration is then given to the extent of the procedure. For small or moderate-sized hernias, the authors may combine the repair with major body contouring procedures (eg, lower body lift). Very large hernias may require extensive lysis of adhesions or separation of the abdominal wall components to achieve closure. When such an abdominal wall reconstruction is anticipated, the authors limit the body contouring procedures to a concurrent panniculectomy and stage any other desired surgeries. They routinely bowel prep patients with hernias and seek recommendation from the patient’s bariatric surgeon regarding the preferred method. Bariatric surgeons may be dogmatic about which gastrointestinal medications are prescribed for their patients. The referring weight loss surgeon may also want to be involved with these cases in a team approach.

**Screening and management of medical issues that may affect surgical outcomes**

Along with weight loss after gastric bypass comes a tremendous improvement, if not complete resolution, of many medical disorders associated with obesity. Even moderate weight loss has a significant impact on medical comorbidity in obese patients. In several studies, 10-kg weight loss was associated with a 30% reduction in diabetes-related mortality and had major benefits with regard to blood pressure, angina, and serum lipids [20–22]. Other authors have found that an initial loss of 10% of body weight is associated with improvements in blood pressure, plasma glucose, lipid levels, and hemostatic factors, and even reduces cancer risk [23–25]. Although any amount of weight loss can be beneficial in improving obesity-related disorders, complete resolution of these comorbidities may not occur. Therefore, the plastic surgeon must be wary of unresolved medical problems.
Psychosocial issues

The incidence of depression is very high among bariatric patients. A majority of patients seeking plastic surgery consultation at the authors’ institution report the use of antidepressants. Provided that patients have appropriate expectations and motivation for body contour procedures, this condition is not a contraindication for surgery and does not require clearance from a psychiatrist. If patients have just started the medication, they should be allowed to stabilize for several weeks before scheduling surgery. Bipolar disorder or schizophrenia, in contrast, should be approached with great caution. These conditions may lead to unreasonable expectations and noncompliance. Evaluation and clearance by a psychiatrist is the rule.

Diabetes mellitus

Immediately following gastric bypass, serum glucose and insulin levels decrease with concomitant improved glucose control. Over 14 years of follow-up, Pories et al [26] were able to show that 82% of obese patients with type II diabetes had resolution of their disease. Serum glucose should be checked preoperatively in all patients. If an oral hypoglycemic agent is being used, it should be held the morning of surgery.

Cardiac disease

Inherent in obesity is prevalence for hypertension, increased peripheral vascular resistance, and subsequent left ventricular hypertrophy. The combination of these factors is associated with an increased risk of myocardial infarction (MI), congestive heart failure, and other cardiovascular events. Weight loss associated with gastric restrictive surgery reduces blood pressure in a linear fashion, with 50% to 60% of patients becoming normotensive [27,28]. In addition to improving blood pressure, surgically induced weight loss has been documented to reduce cardiovascular risk by means of the lowering of triglycerides and low-density lipoprotein, with associated increases in high-density lipoprotein [29,30].

It is vital that questions regarding angina, exertional dyspnea, fatigue, and syncope be addressed, and that physical examination be focused on elements of underlying cardiac disease such as jugular venous distension, additional heart sounds, respiratory crackles, and peripheral edema. A key question for the plastic surgeon to ask regards exercise tolerance. The patient who walks 3 miles four times per week without symptoms is unlikely to have significant cardiac disease. Beware of the inactive patient, however, because they may have quiescent disease that will be unmasked by surgical stress. All patients above the age of 30 should be screened with an ECG, with the focus on changes indicative of ischemia or ventricular hypertrophy [31]. Any concern on the part of the plastic surgeon should prompt a referral to a cardiologist for further evaluation.

Sleep apnea and pulmonary disease

Obstructive sleep apnea (OSA) and obesity hypoventilation syndrome (OHS) are intimately related to obesity, present in over 50% of obese individuals. OSA is defined by the occurrence of more than five apneic episodes per hour, in association with excessive daytime somnolence. Severity of the disorder is measured by the apnea index, or the number of apneic episodes per hour, with severe cases having 400 to 500 events per night [32]. Risks and complications of OSA include MI, sudden death from arrhythmia, and stroke during apneic episodes, in addition to the risks of daytime somnolence. Short- and long-term follow-up after gastric bypass demonstrated improved apnea indices in 93% of patients [33]. If a patient has active OSA and uses continuous positive airway pressure, arrangements should be made with the inpatient respiratory therapy team to apply this device postoperatively. In addition, postoperative analgesia, particularly with narcotics and sedatives, may exacerbate mild or borderline apnea symptoms. Consideration should be given to intensive care unit (ICU) monitoring for apneic episodes and associated arrhythmias during the first 24 hours following extubation [33]. It is recommended that the plastic surgeon coordinate the care of OSA patients with a pulmonologist.

OHS is a chronic condition characterized by hypoxia and hypercarbia, with diagnosis by means of documentation of arterial blood gases demonstrating a PaO2 of < 55 mm Hg or a PaCO2 of > 47 mm Hg. Associated with this condition is a high prevalence of pulmonary hypertension and right-sided heart failure. Resolution of pulmonary hypertension and significant improvement in blood gas parameters have been documented after gastric bypass surgery in patients with OHS [34]. For patients with a diagnosis of OHS and the concomitant finding of pulmonary hypertension, Sugerman et al [34] have advocated preoperative invasive hemodynamic monitoring and optimization of cardiopulmonary function, in addition...
to a more prudent protocol of ventilator weaning. Therefore, patients with a history of OHS should be carefully evaluated by their pulmonologist to determine the operative risk associated with elective body contour surgery.

Obese patients have been shown to have alterations in their pulmonary mechanics. Specific changes include a reduction in functional residual capacity, expiratory reserve volume, and arterial oxygen tension \((\text{PaO}_2)\), with an increase in the alveolar-arterial oxygen gradient \([35]\). All patients should receive an aggressive pulmonary toilet regimen, including incentive spirometry, and encouragement for early ambulation.

**Gastroesophageal reflux disease**

Reflux disease, with its constellation of symptoms and concomitant risk of cancer and pulmonary aspiration, has been extensively studied in the obese population. Although rates of GERD in obesity vary, a recent multivariate analysis demonstrated a direct relationship between increasing BMI and reflux symptoms \([36]\). Several factors are thought to cause this relationship, including the incidence of associated hiatal hernias, an increase in intra-abdominal pressure, an increased sensitivity in obese patients to esophageal acid exposure, and vagal abnormalities associated with obesity which may cause a higher output of bile and pancreatic enzymes within the refluxate \([37]\). Several studies have shown the efficacy of gastric bypass in alleviation of GERD: the procedure can significantly reduce symptoms (including aspiration) and medication use \([38–40]\). Results have shown equivalency with standard reflux procedures, including Nissen fundoplication \([40]\). Patients noted to have active GERD should be stabilized on appropriate medication by their bariatric surgeon or gastroenterologist before body contouring surgery. In addition, patients should be counseled about the potential risk of worsening symptoms if abdominal fascial plication is performed.

**Medications of interest**

In an effort to promote further weight loss, many post–bariatric-surgery patients use herbal medications. These should be inquired about and stopped 2 weeks before surgery to avoid any additional anesthetic risks. Nonsteroidal anti-inflammatory drug use is also common among this patient population, paralleling the incidence of arthritis and musculoskeletal disorders.

**Deep vein thrombosis prophylaxis**

Obesity is an independent risk factor for deep vein thrombosis and pulmonary embolism (DVT/PE) \([16,41–44]\), and this risk must be taken into account when operating on patients with a high BMI. Risk of DVT also increases with age, showing a linear increase after age 40. The type of surgery and magnitude of the procedure are additional important factors: most post–bariatric-surgery body contouring procedures should be considered equivalent to major general surgery operations. Prior DVT or PE is an especially notable risk, and patients with this history should be screened by a hematologist before undergoing elective body contouring surgery. The potential for thromboembolic complications in the post–bariatric-surgery patient is underscored by a 9% incidence of PE reported by Aly \([45]\) in a series of 32 patients. However, the true incidence of PE in this study is unclear, because two of the three patients diagnosed with PE were treated presumptively without radiographic confirmation.

The choice of a prophylactic regimen is a balance between efficacy and risk of bleeding complications. Body contouring procedures often involve large potential spaces from tissue undermining and liposuction, making bleeding complications more dangerous. Intermittent pneumatic compression (IPC) devices are an effective measure with essentially no complications. The biggest drawback to IPC devices is that they are only effective when placed on the patient and activated. Comprehensive evidence-based guidelines published from the sixth American College of Chest Physicians Consensus Conference on Antithrombotic Therapy \([46]\) state that either heparin therapy or IPC devices are acceptable as solo therapy for general surgery patients at moderate or high risk for DVT. For major procedures, patients are at moderate risk if aged less than 40 with no other significant factors, and at high risk if older than 40 or having other significant factors. Patients are felt to be at very high risk for DVT when undergoing major procedures if they are older than 40 with other significant factors (eg, morbid obesity, prior DVT, hypercoagulable state, cancer). Very high-risk patients are best treated with a combination of IPC and heparin therapy. Aspirin has generally been found ineffective in preventing DVT in general surgery patients and is not recommended as an appropriate strategy \([46]\).

At the authors’ institution, as at many others, morbidly obese patients undergoing the initial gastric bypass operation are treated with a high dose of low molecular weight heparin and IPC devices. The choice between low molecular weight heparin
Malabsorptive procedures involve bypassing a segment of small bowel using a variable segment of small bowel is bypassed using a Roux limb. Thus weight loss is achieved by limiting intake into a small gastric pouch, delaying exposure of ingested food to gastric, biliary, and pancreatic secretions, and bypassing absorptive small bowel surface. Variation in the length of the Roux limb allows the bariatric surgeon to tailor malabsorption to a specific patient’s needs, but also complicates analysis of results from different centers. The procedure is particularly efficacious in habitual sweet-eaters because of the potential for dumping syndrome, in which faster transit of low molecular weight sugars through the gastrointestinal tract leads to postprandial diaphoresis, hypotension, flushing, cramping, and nausea. Dumping provides the negative reinforcement necessary to discourage patients from eating inciting foods [57].

Up to 30% of patients experience persistent vomiting during the initial months following GB and RYGB surgery. In many cases, this is due to correctable behavioral problems such as overeating, inadequate mastication, and rapid eating [58–60]. Red meat and other concentrated animal proteins, which are more difficult to chew, are not tolerated by many patients following GB and RYGB. As noted later in this article, this limitation can contribute to long-term nutrient deficiencies [61,62]. Stomal obstruction due to edema may exacerbate nausea and vomiting. This problem will generally resolve with time, although strictures may develop that require endoscopic or
fluorescopic dilation. Intractable vomiting has resulted in acute thiamine deficiency in GB and RYGB patients, manifesting as acute neurologic deficits such as diplopia, ataxia, vertical and horizontal nystagmus, facial palsy, acute polynuropathy, and paralysis [63,64]. Treatment of thiamine deficiency is accomplished by parenteral administration of 100 mg thiamine daily for 7 to 14 days, followed by 10 mg/day orally [65].

Protein-calorie malnutrition is uncommon after RYGB [66]. Subclinical protein deficiency is indicated by thinning and brittleness of the hair and fingernails. Patients are routinely instructed to modify their diet by eating several small meals of protein-rich food throughout the day. Since protein taste and texture aversions are common and present with patterns unique to individual patients, care must be taken to ensure adequate protein intake. Many patients are able to tolerate eggs and nonfat dairy products. Some patients may require commercially available protein-dense supplements to meet their needs. Non-compliance with dietary guidelines may result in severe malnutrition [56], and such noncompliant patients may present to the plastic surgeon before a long overdue follow-up visit with the bariatric surgeon. In general, one should be cautious when assessing a bariatric patient who is still in the throes of rapid weight loss. It is difficult to tell if intake will be adequate to foster good wound healing after elective body contouring surgery.

Even patients who are weight stable may still have a tenuous protein and calorie intake. Major elective surgery will require an increased calorie and protein consumption of approximately 25% [67]. Most bariatric patients who have stabilized in their weight loss should be able to meet these needs. However, burns, trauma, infection, and large open wounds can substantially increase these nutritional requirements to the point where they cannot be met through oral intake (Ann Schwentker, J. Peter Rubin, unpublished data, 2003). In addition to increased metabolism resulting from these pathologic processes, a substantial amount of protein can be lost from a large wound. Exudate from an open wound may contain up to 44 mg/mL protein [68,69] and result in losses that the bariatric patient cannot match. Aggressive nutritional supplementation, including endoscopic placement of an enteral feeding tube or TPN, may be necessary for the bariatric patient subjected to severe metabolic stress.

Long-term specific micronutrient deficiencies are common after RYGB and should be considered when planning subsequent surgical procedures. Calcium deficiency has been reported to result in increased serum alkaline phosphatase, reduced serum calcium, and decreased 25-dihydroxy-vitamin D for as long as 10 years following RYGB [70]. Not only can lactose intolerance decrease intake of calcium, but vitamin D-mediated calcium absorption occurs primarily in the bypassed duodenum and proximal jejunum [71]. Oral supplementation with 1200 mg to 1400 mg/day of calcium citrate is recommended following BPD or RYGB. This supplement raises the serum calcium level by means of low-level diffusion across the mucous membrane [56]. Hypocalcemia can pose a risk during general anesthesia.

Cobalamin (vitamin B12) deficiency has been reported in more than 30% of patients following RYGB [61,72–74]. Cobalamin deficiency results in megaloblastic anemia and peripheral neuropathy. Cobalamin is present primarily in meat, eggs, and milk. Meat or lactose intolerance, which is common following RYGB, may increase susceptibility. B12 is normally liberated by acid hydrolysis in the stomach. It is then bound to R binders, glycoproteins contained in saliva and gastric, biliary, and intestinal secretions. Pancreatic proteases degrade the R binders and release B12 to bind with intrinsic factor (IF), secreted in the gastric antrum. The IF-B12 complex then undergoes receptor-mediated uptake in the distal ileum [56]. Cobalamin deficiency following RYGB occurs through interference at several of these steps. Decreased acid hydrolysis and decreased absorption of both protein-bound and free cobalamin have been reported [75]. Absence of intrinsic factor in gastric juice has been noted in up to 80% of RYGB patients [76]. Oral supplementation of more than 80 times the USRDA for B12, or monthly injection, is necessary to maintain normal serum levels of B12 [74,77].

Iron deficiency is also very common, particularly among menstruating women, and affects between 33% and 50% of patients after RYGB [61,72–74]. Again, intolerance to meat products may decrease iron intake. Nonheme iron requires reduction from the ferric to the ferrous state by acid before absorption [78,79]. RYGB results in decreased acid secretion and bypass of both gastric juice and proximal small bowel mucosa, the primary site for iron absorption. Oral supplementation is usually sufficient to prevent iron deficiency [56], but may not protect menstruating women from anemia [80].

Folate deficiency is rare, but may also occur following RYGB, since folate is predominantly absorbed in the proximal third of the small intestine. Folate deficiency may result in megaloblastic anemia and glossitis [81]. Folate supplementation is especially important in young women of reproductive age to decrease the incidence of neural tube defects.
Fertility may increase following massive weight loss, and pregnancy is not uncommon, even in previously infertile women [82–84].

A rational approach to nutritional screening before body contouring surgery starts with the collection of historical data about eating habits and current nutritional supplements. Any patient with persistent nausea and vomiting should first be referred to his or her bariatric surgeon. Such a patient may require evaluation for anastamotic stricture or other anatomic problems. If the patient is intolerant of meat or dairy products, inquiries should be made about alternative sources of protein intake. All patients considering elective body contouring should be on a regimen of multivitamins, iron, and calcium before surgery.

Blood work should be performed to assess serum electrolytes, including calcium, magnesium, and phosphorus. A complete blood count should be drawn, along with iron and total iron binding capacity (TIBC). Serum albumin, prealbumin, cobalamin, and folate levels should also be checked (Box 1). Bariatric surgeons work closely with nutritional support teams. It is worthwhile for the plastic surgeon who cares for bariatric patients after weight loss to become acquainted with these clinicians as well. When there is concern about protein or nutrient deficiencies in a patient who seeks body contouring surgery, he or she should be referred to the bariatric nutritional team for further evaluation and treatment. After body contouring surgery, patients should be closely monitored for wound healing problems. If a patient develops a major wound dehiscence, or suffers an infection that results in a large open wound, consideration should be given to performing a nitrogen balance study. This study involves comparison of protein intake with protein losses over a 24-hour period. If negative nitrogen balance is revealed, nutritional support should be implemented, in the form of either an enteral feeding tube placed beyond the gastrointestinal anastamosis or total parenteral nutrition. Without this identification and treatment, the patient’s overall nutritional status will continue to worsen, making him or her increasingly vulnerable to further complications.

**Fluid management**

All patients undergoing extensive body contouring procedures should be monitored with a urinary catheter in the postoperative period. Adequate hydration will not only help prevent systemic complications but will also improve tissue flap perfusion. If blood loss is expected, patients should be given the option of autologous blood donation or directed donation by a family member. The authors have found colloid solutions to be a useful adjunct for increasing tissue perfusion during major procedures.

**Avoiding wound complications**

Specific factors that may predict an increased incidence of wound problems after post–weight-loss contouring include tobacco use, diabetes, active steroid use, and BMI greater than 40 kg/m². Active smokers are encouraged to stop at least 1 month before surgery. If this is not possible, then the extent of the procedure performed, especially the amount of tissue undermining, is limited. Similar caution is exercised with diabetic patients and those treated with steroids. As mentioned earlier, the best approach to body contouring procedures in patients who are still morbidly obese is to have very narrow operative indications and only perform a focused simple lpectomy without undermining.

Adequate use of drains is very important for reducing seroma formation in body contouring procedures after weight loss. Despite liberal use of drains, seroma formation remains a frequent problem. Preventative measures such as progressive tension sutures and tissue glues have been advocated by some body contouring specialists, but no controlled studies have been conducted in this patient population. The authors treat small seromas with serial aspiration and drain larger ones with a new closed suction drain placed in the office (Seroma-Cath, Shippert Medical, Englewood, Colorado).

Direct tissue undermining is limited in most procedures to prevent flap necrosis. However, the authors believe that the abdominal wall subcutaneous

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**Box 1. Preoperative blood work for the post–bariatric-surgery patient**

- Complete blood count
- Prothrombin time and partial prothrombin time
- Serum electrolytes, including calcium, magnesium, and phosphorus
- Albumin and prealbumin
- Iron and TIBC
- B12 and folate
- Serum glucose
- Serum HCG in premenopausal female patients
tissue in the weight loss patient is extremely well perfused and more tolerant of undermining than in the standard abdominoplasty patient. The effect of massive weight gain and loss on the subcutaneous adipose layer is analogous to a delay, with the vascular network expanding to meet the metabolic demands of the increased tissue mass and then remaining in place after body mass decreases. Great caution is still exercised with tobacco smokers, who are at greater risk for wound healing complications.

Prophylactic antibiotics are started before the skin incision and continued postoperatively while drains are in place. If wound dehiscence or infection occurs, basic principles of wound management dictate therapy. For large wounds, vacuum-assisted closure sponges are very helpful in promoting wound contraction and granulation. As discussed earlier, the post–bariatric-surgery patient with a large open wound should be considered for a nitrogen balance study to assess nutritional status.

References


[30] Gleysteen JJ, Barboriak JJ. Improvement in heart dis-


[63] Feit H, Glasberg M, Iretan C, et al. Peripheral neuropa-


