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Cardiovascular Evaluation and Management of Severely Obese Patients Undergoing Surgery

A Science Advisory From the American Heart Association

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Abstract**—**Obesity is associated with comorbidities that may lead to disability and death. During the past 20 years, the number of individuals with a body mass index >30, 40, and 50 kg/m^2, respectively, has doubled, quadrupled, and quintupled in the United States. The risk of developing comorbid conditions rises with increasing body mass index. Possible cardiac symptoms such as exertional dyspnea and lower-extremity edema occur commonly and are nonspecific in obesity. The physical examination and electrocardiogram often underestimate cardiac dysfunction in obese patients. The risk of an adverse perioperative cardiac event in obese patients is related to the nature and severity of their underlying heart disease, associated comorbidities, and the type of surgery. Severe obesity has not been associated with increased mortality in patients undergoing cardiac surgery but has been associated with an increased length of hospital stay and with a greater likelihood of renal failure and prolonged assisted ventilation. Comorbidities that influence the preoperative cardiac risk assessment of severely obese patients include the presence of atherosclerotic cardiovascular disease, heart failure, systemic hypertension, pulmonary hypertension related to sleep apnea and hypoventilation, cardiac arrhythmias (primarily atrial fibrillation), and deep vein thrombosis. When preoperatively evaluating risk for surgery, the clinician should consider age, gender, cardiorespiratory fitness, electrolyte disorders, and heart failure as independent predictors for surgical morbidity and mortality. An obesity surgery mortality score for gastric bypass has also been proposed. Given the high prevalence of severely obese patients, this scientific advisory was developed to provide cardiologists, surgeons, anesthesiologists, and other healthcare professionals with recommendations for the preoperative cardiovascular evaluation, intraoperative and perioperative management, and postoperative cardiovascular care of this increasingly prevalent patient population. **(*Circulation*. 2009;120:86-95.)**

Key Words: AHA Scientific Statements ■ obesity ■ surgery

Obesity has reached epidemic proportions in the United States and in much of the industrialized world.[1] In the most widely used classification of obesity, body weight is expressed in terms of body mass index (BMI).[1] Obesity is defined as a BMI ≥30 kg/m^2 and may be further subdivided into 5 grades (Table 1). With these BMI criteria, an estimated 65% of Americans are now classified as overweight or obese, thus predisposing >100 million Americans to a host of

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Table 1. Classification of Body Weight

Underweight: BMI $<$18.5 kg/m^2
Normal or acceptable weight: BMI 18.5–24.9 kg/m^2
Overweight: BMI 25–29.9 kg/m^2
Obese: BMI $\geq$30 kg/m^2
Grade 1: BMI 30–34.9 kg/m^2
Grade 2: BMI 35.0–39.9 kg/m^2
Grade 3: BMI $\geq$40 kg/m^2 (severe, extreme, or morbid obesity)
Grade 4: BMI $\geq$50 kg/m^2
Grade 5: BMI $\geq$60 kg/m^2

Adapted from Reference 4.

Table 2. Obesity-Related Comorbidities That Are Most Likely to Influence the Preoperative Cardiac Assessment and Management of Severely Obese Patients

Atherosclerotic cardiovascular disease
Heart failure
Systemic hypertension
Pulmonary hypertension related to sleep apnea and obesity hypoventilation
Cardiac arrhythmias
Deep vein thrombosis
History of pulmonary embolism
Poor exercise capacity

chronic diseases and serious medical conditions.[2] For example, it was estimated from data from the National Health and Nutrition Examination Survey III (NHANES III) that white women 20 to 30 years of age with a BMI $\geq$45 kg/m^2 will lose 8 years of life, and their male counterparts will lose 13 years.[3] The most rapidly growing segments of the obese population are the severely obese and superobese.[4] Between 1986 and 2000, the numbers of individuals with a BMI $>$30, 40, and 50 kg/m^2 are reported to have doubled, quadrupled, and quintupled, respectively, in the United States.[5] The rising prevalence of severe obesity and superobesity coupled with the high risk for premature death in this population has markedly increased the demand for bariatric surgery as a means of achieving marked weight loss. Indeed, the number of bariatric operations performed in the United States has risen from 12 775 in 1998 and 70 256 in 2002 to an estimated $>$140 000 surgeries in 2005.[6] Various bariatric procedures are available for management of high-risk obese patients. Currently, Roux-en-Y gastric bypass procedures account for $>$80% of bariatric operations, although the proportion is changing with the advent of the laparoscopic adjustable gastric band procedure.[7] Given the increasing prevalence of severely obese patients, this scientific advisory was developed to provide evidence-based recommendations concerning preoperative cardiovascular evaluation, perioperative and intraoperative cardiopulmonary management, and postoperative care of severely obese patients undergoing surgery.

Cardiovascular Conditions Associated With Severe Obesity

General Considerations

Obesity is associated with a variety of comorbidities, some of which may lead to disability or death. The risk of developing these rises with increasing BMI. Comorbidities likely to influence the preoperative cardiac assessment and risk of severely obese patients are listed in Tables 2 and 3.[1,8–10] There are numerous respiratory abnormalities associated with obesity. Obese individuals have an increased demand for ventilation and breathing workload, respiratory muscle inefficiency, decreased functional reserve capacity and expiratory reserve volume, and closure of peripheral lung units. These often result in a ventilation-perfusion mismatch, especially when in the supine position. Obesity is a classic cause of alveolar hypoventilation. Historically, the obesity-hypoventilation syndrome has been referred to as the *Pickwickian syndrome*. Obesity hypoventilation and obstructive apnea were first observed in patients with severe obesity. In the very obese patient, symptoms are often nonspecific. In such patients, identification of cor pulmonale is extremely important; however, because of the difficulty of evaluating heart sounds in severe obesity, an increase in the intensity of P_2 suggestive of pulmonary hypertension may be overlooked at the bedside. The cardiologist who evaluates severely obese patients for cardiovascular disease and preoperative consultation should consider sleep-disordered breathing in obese patients who present with polycythemia and who admit to habitual snoring, nocturnal gasping or choking, witnessed episodes of apnea, and daytime sleepiness. It is important to remember, however, that the clinical and electrocardiographic signs of cor pulmonale appear later than those of pulmonary hypertension assessed by right-heart catheterization.

Pulmonary hypertension may result from left ventricular failure, hypoxia due to sleep apnea, recurrent pulmonary emboli, or combinations thereof.[1] Serious cardiac arrhythmias and conduction abnormalities related to obesity per se are rare.[1] Arrhythmias in the obese are most commonly related to hypoxia due to sleep apnea, but obese patients may develop otherwise idiopathic atrial fibrillation, atrial flutter, and ventricular tachycardia, and even bradyarrhythmias related to sinus node dysfunction.[1]

The Cardiomyopathy of Obesity

Changes in cardiac hemodynamics associated with obesity may alter left ventricular structure and function and ultimately cause heart failure.[1,11–13] These alterations may be

Table 3. Proposed Obesity Surgery Mortality Risk Score for Gastric Bypass

BMI $\geq$50 kg/m^2
Male gender
Hypertension as a comorbid condition
PE risk as a comorbid condition, defined as the presence of venous thromboembolism event, previous inferior vena cava filter placement, a history of right heart failure or pulmonary hypertension, and/or a history or physical findings of venous stasis, including typical ulcerations or brawny edema
Age $\geq$45 years

BMI indicates body mass index; PE, pulmonary embolus.

present in children and adults with grades 1 and 2 obesity but are most pronounced in severely obese persons.[1,11] The risk of heart failure due to severe obesity (obesity cardiomyopathy) begins to rise steeply after 10 years of severe obesity.[1,14] Most patients with obesity cardiomyopathy have diastolic heart failure, but some manifest both diastolic and systolic dysfunction.[1,14] Symptoms and signs of obesity cardiomyopathy occur most commonly in patients with a body size ≥75% of ideal body weight or with BMI ≥40 kg/m^2. Many of the clinical manifestations and alterations in cardiac structure and function are reversible with substantial weight loss due to reverse remodeling, which is in part related to favorable alterations in loading conditions.[1,13] Whether there is an intrinsic myocardial defect in obesity cardiomyopathy is uncertain.[1,11,12]

Atherosclerotic Cardiovascular Risk

The true prevalence of cardiovascular disease in the severely obese population is unknown. The Women's Health Initiative Observational Study reported an 11.5% prevalence of myocardial infarction, angina pectoris, coronary artery bypass graft surgery, and percutaneous coronary interventions among 3234 severely obese women.[15] Numerous factors including diabetes mellitus, elevated serum triglyceride levels, reduced serum high-density lipoprotein cholesterol levels, chronic inflammation, and the prothrombotic state associated with obesity probably contribute to the cardiovascular risk in this patient population.[1]

Diagnosed or occult coronary heart disease (CHD) increases surgical risk. The prevalence of diagnosed CHD was not reported in a population-based analysis of 25 428 patients undergoing bariatric surgery, but the event rate for cardiac complications was 6.8 to 15.3 per 1000 patients.[16] Rates of cardiac arrest and annualized mortality were 1.6% and 1.5%, respectively, among patients undergoing bariatric procedures.[16,17] These rates are substantially higher than that associated with other forms of general surgery. With regard to bariatric surgery, laparoscopic adjustable gastric banding clearly has the lowest risk of all of the procedures but is associated with a lower weight loss and lower resolution of comorbidities (Table 4). Roux-en-Y gastric bypass is associated with a rapid remission of diabetes in most patients and greater weight loss but carries a somewhat higher operative risk (0.5% versus 0.1% in past studies)[7,18,19]; however, the overall operative risk has decreased markedly in recent years to 0.34% at 90 days. Biliopancreatic diversion with duodenal switch carries the greatest operative risk and possibly produces the greatest long-term weight loss, but the latter has not been confirmed with a randomized, prospective trial.[7,18,19]

Table 4. Early Mortality for Bariatric Surgery by Procedure

Obesity Procedure	Death ≤30 Days, Mean (95% CI)
Gastric banding	
Open	0.18 (0.00–0.49)
Laparoscopic	0.06 (0.01–0.11)
Gastroplasty	
Open	0.33 (0.15–0.51)
Laparoscopic	0.21 (0.00–0.48)
Gastric bypass	
Open	0.44 (0.25–0.64)
Laparoscopic	0.16 (0.09–0.23)
BPD/DS	
Open	0.76 (0.29–1.23)
Laparoscopic	1.11 (0.00–2.70)

CI indicates confidence interval; BPD/DS, biliopancreatic diversion with duodenal switch.

Adapted from Buchwald et al,[18] with permission from Elsevier.

Cardiovascular Preoperative Evaluation

General Considerations

The challenge for the clinician before surgery is to identify the patient who is at increased perioperative cardiovascular risk, judiciously perform supplemental preoperative evaluations, and manage the perioperative risk. All severely obese patients referred for surgery should undergo a comprehensive medical history, physical examination, and additional blood chemistry testing as clinically indicated.[16] The obtainment of a 12-lead electrocardiogram (ECG) is reasonable in all patients with at least 1 risk factor for CHD, poor exercise tolerance, or both. The presence of systemic hypertension, diabetes mellitus, tobacco abuse, and use of medications (including β-blocker therapy) should be documented.[20] The specific preoperative evaluation of the bariatric surgery patient should be directed toward symptoms, risk factors, and index of suspicion for secondary causes of obesity. When symptoms of obstructive sleep apnea or hypercapnia (elevated P_{CO_2}) are identified, polysomnography should be performed. Other treatable causes of hypercapnia, including obesity-hypoventilation syndrome, other restrictive lung diseases, chronic obstructive pulmonary disease, left ventricular failure, and hypothyroidism may also be considered.[7] Arterial blood gas measurements in severely obese patients with suspected hypoventilation or other pulmonary conditions may be useful. A chest radiograph (preferably posteroanterior and lateral) should be obtained on all severely obese patients under consideration for surgery. Severely obese patients experience increased respiratory difficulties postoperatively, and a baseline chest radiograph helps evaluate these problems. In addition, the chest radiograph may suggest undiagnosed heart failure, cardiac chamber enlargement, or abnormal pulmonary vascularity suggestive of pulmonary hypertension, which warrants further cardiovascular investigation. The patient with poor functional capacity presents a particular challenge, because it is important to distinguish between deconditioning with some expected dyspnea and underlying cardiac disease. Also, it appears that bariatric surgery is not uniformly a low-risk procedure, and judicious patient selection and diligent perioperative care are imperative (Tables 3 and 4).

Considerations Specific to Obesity

Possible cardiac symptoms such as dyspnea with exertion and lower-extremity edema occur commonly but are nonspecific in obese patients.[21] Because of increased ventilatory demands, exertional dyspnea is commonly attributable to noncardiac causes. Furthermore, the physical examination and electrocardiogram often underestimate the presence and degree of cardiac pathology and dysfunction in obese patients.[1] Body size alone may camouflage jugular venous distention, and heart sounds are often distant. Pedal edema is common in massive obesity and may be a consequence of elevated right ventricular filling pressures or increased intra-abdominal pressure, despite an increased cardiac output.[1,22] Electrocardiographic signs of right ventricular hypertrophy including right-axis deviation and right bundle-branch block suggest pulmonary hypertension, an important surgical risk factor. In contrast, a left bundle-branch block configuration is unusual in uncomplicated obesity and raises the possibility of occult CHD.

Mortality in the medical intensive care unit is significantly higher in severely obese patients than in lean patients.[23,24] The risk of an adverse perioperative cardiac event is related to the degree of underlying CHD, associated comorbidities, and the type of surgery performed. Except for bariatric surgery, few data are available regarding the morbidity and mortality associated with severe obesity and specific surgical procedures. Cardiac surgeons often perceive obesity as a risk factor for perioperative adverse outcomes after coronary artery bypass surgery. Indeed, the Parsonnet risk-stratification scoring system attributes a score of 1 point for patients with morbid obesity, which is defined as >1.5 times ideal weight.[25] Nevertheless, severe obesity is not associated with increased mortality but with an increased length of hospital stay and a greater likelihood of renal failure and prolonged assisted ventilation.[26,27] Total knee arthroplasty has not been associated with increased perioperative deaths or fatal pulmonary emboli in severely obese patients,[28] although 1 fatal pulmonary embolus was documented in a morbidly obese patient after nailing for femoral fracture.[29] In a population-based historical study with data from the Rochester Epidemiology Project, overweight and obese patients did demonstrate an increased rate of cardiac complications among patients undergoing urgent hip fracture repair.[30] The American College of Cardiology/American Heart Association divides surgical risk into low-risk surgery (<1% combined morbidity/mortality; eg, ambulatory surgery), intermediate-risk surgery (1% to 5% combined cardiac morbidity/mortality; eg, intra-abdominal or intrathoracic surgery), and vascular surgery.[20] These categorizations were used in the decision algorithm for further testing, but it is unknown whether obesity influences these categorizations.

Most of the data on evaluating surgical risk in severely obese patients are derived from bariatric surgical results. The best choice for any bariatric procedure (type of procedure and type of approach) depends on the available local/regional expertise (surgeon and institution), patient preferences, BMI, metabolic variables, perioperative risk stratification, and comorbidities. The clinician should consider age, male sex, cardiorespiratory fitness, electrolyte disorders, and congestive heart failure as independent risk factors for surgical mortality.[16,31] An exponential increase in mortality after the age of 65 years has been reported.[16] BMI ≥50 kg/m^2 and cigarette smoking have also been associated with a higher surgical complication rate.[17] The only contraindications to bariatric surgery are persistent alcohol and drug dependence, uncontrolled severe psychiatric illness such as depression or schizophrenia, and cardiopulmonary disease that would make the risk prohibitive.[7] Pulmonary embolism is the leading cause of mortality in experienced bariatric surgery centers. The incidence of pulmonary embolism in patients who have undergone bariatric surgical procedures has been reported as 0.1% to 2%.[7]

Alternatively, an Obesity Surgery Mortality Risk Score (OS-MRS) has been validated in 4 bariatric programs in 4431 patients in the United States using 5 risk variables (comorbidities; Table 3).[32,33] Class A (low risk) consisted of patients with 0 or 1 comorbidity. Class B (intermediate risk) consisted of patients with 2 to 3 comorbidities, and class C (high risk) consisted of patients with 4 to 5 comorbidities. Diabetes mellitus was not identified as a factor that increased mortality risk. All risk factors used to calculate the score are valued at 1 point. Overall mortality was 0.7%, and mortality rates at individual centers ranged from 0.4% to 2%. The highest-risk group (class C) comprised a very small proportion of available patients for analysis (3%). Mortality was 0.2% for class A, 1.2% for class B, and 2.4% for class C patients.[33] Three quarters of all deaths occurred within 30 days of surgery. The most common cause of death was pulmonary embolism (30%), followed by cardiac causes (27%) and gastrointestinal leak (21%). Sudden death without a definitive diagnosis occurred in 15% of those patients who died.[33]

Indications for Further Testing

There are 6 known risk factors for perioperative cardiovascular morbidity in the general population according to the Revised Cardiac Risk Index.[34] These include (1) high-risk surgery, such as emergency surgical procedures or major thoracic, abdominal, or vascular surgery; (2) history of CHD; (3) history of congestive heart failure; (4) history of cerebrovascular disease; (5) preoperative treatment with insulin; and (6) preoperative serum creatinine levels >2.0 mg/dL.[20] Obese patients with no CHD risk factors who are referred for elective surgery may not require further testing. On the other hand, patients with ≥3 CHD risk factors or diagnosed CHD may require additional noninvasive testing if the results will change management. If significant coronary artery disease is found, surgery could be delayed to allow the institution and titration of appropriate medical therapy, such as statin or β-blocker therapy, or even coronary revascularization in appropriate patients with severe 3-vessel or left main disease.[20,35] Although there is no consensus, patients with known or presumed coronary artery disease and high perioperative risk should be managed in an intensive care unit setting for the first 24 to 48 hours postoperatively (grade D).[7] In 2 recent studies reporting the use of β-blockade in noncardiac surgery,[36,37] BMI was not reported, and therefore, the risk/benefit assessment is unknown in this population. Notably, waist circumference is of limited value in predicting metabolic and cardiovascular risk in severely obese subjects.[38,39] The results of the evaluation and any diagnostic testing should dictate further preoperative management and the need for evaluation by a cardiologist. Those candidates currently treated with a β-blocker or a statin should continued to receive these drugs perioperatively.[20] Compensated heart failure may be aggravated by the fluid shifts associated with anesthesia and abdominal surgery. Intra-abdominal pressure exceeding 20 mm Hg during laparoscopy can impede venous return from the lower extremities and decrease cardiac output.[40] Clinical assessment of concomitant valvular disease may also be important in severely obese patients because of prior exposure to appetite-suppressant drugs.[41] Antibiotic therapy to prevent infective endocarditis should be used in accordance with recent guidelines.[42]

Patients with atrial fibrillation or nonbioprosthetic valves will routinely receive anticoagulation therapy preoperatively and need close monitoring in the perioperative period. Heparin or low-molecular-weight heparin can be used as a bridge before surgery, although the former requires preoperative hospital admission for its administration. Although there is consensus that subcutaneous unfractionated or low-molecular-weight heparin should be administered both preoperatively and postoperatively, few data exist concerning the appropriate dosing of these agents in severely obese and superobese patients. The literature supports low-molecular-weight heparin dosing based on total body weight in obese patients (90 to 150 kg), but only a small number of patients weighing >150 kg were included in these trials.[43] It was reported that subtherapeutic anti-factor Xa levels are more common with once-daily dosing than with dosing every 12 hours in obese patients; therefore, it may be more prudent to recommend low-molecular-weight heparin twice daily in this population.[43] Peak anti-factor Xa levels should be obtained 4 hours after administration if low-molecular-weight heparin utilization is contemplated in patients who previously had undergone chronic anticoagulation therapy.

Role of Stress Testing

Exercise testing remains the cornerstone of noninvasive cardiac evaluation, because it can provoke ischemic signs and symptoms in patients with occult hemodynamically significant disease. There are no specific recommendations for the medical preoperative evaluation of severely obese patients undergoing surgery, but the current American Heart Association/American College of Cardiology guidelines state that assessment of functional capacity, when possible, is the first step in the evaluation of all patients for noncardiac surgery.[20] Severely obese patients have cardiorespiratory fitness levels comparable to those of slightly older patients with heart failure, and exercise performance in severely obese patients is inversely related to BMI.[44] Exercise testing also helps predict postoperative complications in severely obese patients undergoing bariatric surgery. The composite complication rate of death, unstable angina, myocardial infarction, deep venous thrombosis, pulmonary embolism, renal failure, and stroke occurred in 16.6% of severely obese patients whose peak oxygen consumption was $<15.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ but in only 2.8% of those whose cardiorespiratory fitness was $\geq 15.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$.[31] Hospital lengths of stay and 30-day readmission rates were also highest in the lowest tertile of peak oxygen consumption.[31] As described previously, the guidelines also utilize a surgical risk categorization (<1%, 1% to 5%, or vascular surgery) to help determine the need for further evaluation.[20] In the assessment of perioperative cardiac risk in severely obese patients, transesophageal dobutamine stress echocardiography to detect the ischemic burden may be useful in patients with ≥1 CHD risk factor, those with poor echocardiographic windows, and those who are unable to exercise.[45] Radionuclide ventriculography may be used to assess right and left ventricular function. The role of other imaging modalities (nuclear imaging, magnetic resonance imaging, computed tomography) in the preoperative evaluation of severely obese patients has not been established. Importantly, several studies have been unable to document the benefits of coronary revascularization before noncardiac surgery, and therefore, noninvasive stress testing and coronary angiography should not be performed unless the results will change management, that is, use of a drug regimen such as β-blockers or revascularization.[20] However, obesity cardiomyopathy, diabetic cardiomyopathy, or chronic long-standing significant myocardial ischemia (hibernating myocardium) may lead to heart failure in severely obese patients and should be identified before surgery. Functional exercise testing is the preferred evaluation modality, but some obese patients cannot exercise because of their weight or orthopedic issues, and some facilities do not have treadmills that are capable of supporting the severely obese. Such situations warrant pharmacological testing or the combination of exercise and pharmacological stress. Thus, functional capacity, cardiac risk factor analysis, and the presence or absence of potential cardiovascular symptoms will determine whether formal testing beyond electrocardiography is required.

The Figure provides an algorithm for the assessment of morbidly obese individuals undergoing noncardiac surgery. In patients at very low risk for heart and lung disease, routine chest radiography and electrocardiography add little information. The specific preoperative evaluation of the bariatric surgery patient should be directed toward symptoms, risk factors, and index of suspicion for secondary causes of obesity.[7]

Intraoperative and Postoperative Management

A systematic review of best practices for anesthesia and postoperative pain management in weight loss surgery is available.[46] For intraoperative care, critical issues in severely obese patients include intubation of the trachea, periods of hypoxia/hypercapnia, and extubation. An increased incidence of pulmonary hypertension and right-sided heart failure is often seen in patients with the obesity-hypoventilation syndrome. In severe cases, intraoperative monitoring with a pulmonary artery catheter or transesophageal echocardiography may be prudent, although there are no data to support its use in severely obese patients.[20]

Induction and Intubation

Severely obese patients undergoing surgery are known to have reduced pulmonary functional residual capacity, a mark-

Comprehensive medical history, physical examination, blood chemistry as clinically indicated

STEP 1 Very low risk patient → yes → proceed with planned surgery

↓

No

↓

STEP 2 One risk factor for CAD → 12-lead ECG

or presence of stable CVD

if signs of RVH: consider pulmonary hypertension

if signs of LBBB: consider occult CAD

Chest X-ray → if hypoventilation or other pulmonary conditions

↓

consider arterial blood gas

↓

STEP 3 Good functional capacity → yes → proceed with planned surgery

↓

No, unknown or unable to exercise

↓

STEP 4 Imaging technique to assess cardiac function

↓

STEP 5 Decreased left ventricular systolic function → consider obesity cardiomyopathy or hibernating myocardium

↓

consider angiography

Figure. Cardiac and pulmonary algorithm assessment for elective noncardiac surgery in severely obese patients. CAD indicates coronary artery disease; ECG, electrocardiogram; CVD, cardiovascular disease; RVH, right ventricular hypertrophy; and LBBB, left bundle-branch block. Reprinted from reference 4, with permission from Springer.

edly decreased expiratory reserve volume, and a high incidence of obstructive sleep apnea. Mask ventilation may be difficult, and desaturation can occur more rapidly than in leaner patients because of a reduced capacity to tolerate periods of apnea. In severely obese patients, the 30° reverse Trendelenburg position, with the use of a ramp to elevate the head, neck, and shoulders, or configuration of the operating room table provides the safest apnea period for tracheal intubation compared with the supine horizontal or 30° backup Fowler position.[47–49] Atelectasis formation is largely prevented by positive end-expiratory pressure applied during the anesthetic induction and is associated with more favorable oxygenation.[50] Evidence regarding the difficulty of intubation through direct laryngoscopy is conflicting. In a series of 18 500 surgical patients, risk factors for difficult tracheal intubation included male sex, age 40 to 59 years, and obesity.[51] In another study of 100 patients, neither absolute obesity nor BMI was associated with intubation difficulties.[52] Large neck circumference and high Mallampati score (grading of visualization of the oropharynx) were the only predictors of potential intubation problems in the study by Brodsky et al,[52] and importantly, all but 1 of the patients in that study were intubated successfully by direct laryngoscopy. Another study found that the extended Mallampati score, whereby the patient's craniocervical junction is extended rather than neutral, is a better predictor of a difficult intubation.[53] On the other hand, for some patients, fiber optic bronchoscopy may be the preferred intubation technique, but awake intubation with fiber optic bronchoscopy may be challenging in the severely obese patient.

Choice of Anesthesia

Few randomized trials are available to suggest that 1 general anesthetic is superior to another. In severely obese patients undergoing laparoscopic gastroplasty, postoperative immediate and intermediate recoveries are more rapid and consistent after desflurane than after propofol or isoflurane anesthesia.[54] Furthermore, severely obese adults who undergo major abdominal surgery awaken significantly faster after desflurane than after sevoflurane anesthesia, and patients anesthetized with desflurane have higher oxygen saturation on entry into the intensive care unit[55]; however, neither group had any perioperative morbidity. In contrast, others reported no difference between desflurane and sevoflurane in patients undergoing laparoscopic bypass surgery.[56]

Postoperative Care

There are few studies that address the management of severely obese patients immediately after surgery. The primary issue in postoperative care in a majority of patients is the interplay of underlying sleep apnea with both the recovery from the anesthetic agents and the need for postoperative pain management. Many patients with obstructive sleep apnea use nasal continuous positive airway pressure ventilation at home to maintain arterial oxygenation. Use of nasal continuous positive airway pressure postoperatively in these patients is critical to maintain oxygenation.

Pain management for severely obese individuals undergoing surgery can include patient-controlled intravenous analgesia or patient-controlled thoracic epidural analgesia. The latter is associated with a reduced rate of pulmonary complications and superior pain control in open abdominal surgery. The choice of postoperative analgesia technique is dependent in part on whether the surgical approach is laparoscopic or open. Schumann and colleagues[57] randomized patients undergoing gastric bypass surgery to incisional local anesthetic infiltration plus postoperative patient-controlled analgesia, epidural anesthesia and analgesia, or postoperative patient-controlled analgesia. All received perioperative nonsteroidal antiinflammatory drugs. The investigators concluded that infiltration analgesia as part of a multimodal regimen offers a simple, safe, and inexpensive alternative to epidural pain control. On the other hand, there is general concern about the use of continuous background opioid infusions in the severely obese patient, and a recent review recommended against it.[58]

Considerations Regarding Diet, Physical Activity, and Weight-Loss Pharmacology

The identification of potential barriers to long-term weight loss is an important step in formulating an effective treatment intervention, especially after surgery in severely obese individuals. The key to long-term weight loss/maintenance is calorie reduction, coupled with an adjunctive exercise program and increased lifestyle activity. Physician intervention takes little time and can play a critical role in patient implementation. There is an opportunity to assess the patient's dietary habit and regimen. The assistance of a registered dietician may be of great value. Although there are reports supporting the benefits of aggressive weight loss through such modalities as a very-low-calorie diet, appetite suppressants, or increased activity before bariatric surgery,[59] there are no data and no supportive randomized, prospective trials showing that preoperative weight loss leads to lower surgical complications. Nevertheless, regular physical activity is an effective intervention for long-term weight maintenance.[60] Walking is generally considered a convenient and mild form of training, accessible to everyone. Walking also has a low risk of injuries, which is especially important in obesity because of the extra burden excess weight places on the musculoskeletal system. However, for most obese patients, walking represents a moderate- to vigorous-intensity activity, and these patients often cannot adhere to a conventional exercise prescription because it is associated with excessive fatigue.[61] For example, normal-weight subjects use ≈35% of aerobic capacity ($\dot{V}O_{2max}$) when walking at a self-selected, comfortable pace,[61] whereas obese individuals can expend as much as 56% $\dot{V}O_{2max}$ (some using between 64% and 98% $\dot{V}O_{2max}$) to meet the demands of walking.[62] In addition, outdoor walking can be especially challenging with uneven, graded, or slippery surfaces. Moreover, severe obesity may impair walking mechanics and efficiency, especially when obesity is of the gynecoid form. Gluteal fat may increase friction on clothing and skin, making it unpleasant to walk. This common problem is often neglected in clinical practice. Pharmacotherapeutic approaches in the management of severe obesity have been reported but require additional study[63,64] and should be used with caution in the long term.[41]

Successful preoperative evaluation requires teamwork and communication among the patient, surgeon, primary care physician, anesthesiologist, and consultants. In general, severely obese patients have limited physiological reserves. Preoperative surgery consultation may be challenging in severely obese patients because of the inability to precisely assess surgical risk. Generally, sicker patients and those with major obesity-related complications, as well as reduced levels of cardiorespiratory fitness, present an increased risk for surgery. However, complications occur infrequently when surgery is performed by experienced surgeons in well-equipped centers with appropriate personnel. In severely obese patients, who are often young and apparently healthy, the prevalence of occult CHD requires the identification of conventional risk factors, although extensive preoperative cardiovascular testing is rarely indicated. A preoperative cardiac evaluation provides an opportunity for identification and treatment of short- and long-term cardiovascular risk in this patient subset. The OS-MRS may not be the definitive risk-stratification system ultimately used, but its simplicity for use by clinicians in their everyday practice of bariatric surgery may be of value. There is much more work to be done to clarify the potential clinical value of the proposed OS-MRS. Of note, only gastric bypass procedures have been studied, and mortality is the only outcome variable that has been analyzed. Although it is reasonable to assume that the higher rate of mortality found with higher levels of the OS-MRS correlates with a higher incidence of complications, this has not been examined. The role of comorbid conditions in increasing surgical risk is intuitively appealing but has been difficult to establish. There are patients with renal failure, prior myocardial infarction, coronary stent placement, or coronary artery bypass surgery who probably represent higher risks. These risk factors were not evaluated in the original reports.[32,33] Given that morbidly obese subjects usually have an increased heart rate and that there is some controversy surrounding the use of β-blockers in noncardiac surgery, research should be performed in higher-risk morbidly obese patients regarding the use of β-blockers in patients undergoing noncardiac surgery. Also, prospective trials evaluating the benefit of preoperative weight loss should be performed.

The current obesity epidemic coupled with greater acceptance of the field of bariatric surgery has increased the number of weight-loss operations. Bariatric surgery provides an effective option for the long-term treatment of severely obese patients who have failed nonsurgical attempts to lose weight. In the near future, cardiologists may be involved more frequently in the preoperative evaluation of these patients; however, more research is needed to better characterize the prevalence of cardiovascular disease in severely obese individuals and to identify the patient at risk.

Conclusions

The challenge for the clinician before surgery is to identify the severely obese patient who is at higher perioperative cardiovascular risk. Cardiac symptoms such as exertional dyspnea and lower-extremity edema are nonspecific in obesity, and the severely obese patient with poor functional capacity should receive careful clinical evaluation. Physical examination often underestimates cardiac dysfunction in severely obese patients. Most patients with obesity cardiomyopathy have diastolic dysfunction, but some patients exhibit both left ventricular diastolic and systolic dysfunction. There are numerous respiratory abnormalities associated with obesity. The obtainment of a 12-lead ECG and a chest radiograph is reasonable in all severely obese patients under consideration for surgery. Severely obese patients with ≥3 CHD risk factors or diagnosed CHD may require additional noninvasive testing if the clinician believes that the results will change management. Functional capacity, cardiac risk factor assessment, and the presence or absence of potential cardiovascular symptoms will determine whether formal evaluation beyond a comprehensive medical history, physical examination, ECG, and chest radiograph is necessary.

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*Modest.

†Significant.

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