Perioperative Management of Obese Patients

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KEYWORDS

- Obesity • Perioperative management • Surgery • Metabolic syndrome
- Bariatric surgery • Morbid obesity • Preoperative care • Postoperative care

KEY POINTS

- There is an increase in the prevalence of obesity within the United States, with an estimated 30% of the population considered obese; given the increase in prevalence, practicing surgeons will encounter more and more of this complex population.
- Obese patients are at increased risk for morbidity and mortality secondary to associated comorbidities and benefits from optimization of these morbidities before elective surgery.
- The perioperative management of obese patients is complex and requires the coordinated care of surgeons, anesthesiologists, nurses, and other hospital staff.
- There is still considerable controversy and variability in certain aspects of management of obese patients; this article reviews the literature ranging from expert opinion to guidelines set forth by regulatory organizations to provide up-to-date management recommendations.

INTRODUCTION

The prevalence of obesity in the United States has grown significantly within the past 2 decades, with current figures estimating that one-third of adults in the United States are obese[1,2]; a statistic that has quadrupled since the 1980s.[3] Paralleling the increased prevalence of obesity is the number of bariatric surgical procedures, which have increased from 8597 in 1993 to 220,000 in 2004.[4,5] The World Health Organization and US Centers for Disease Control and Prevention define obesity as body mass index (BMI) greater than or equal to 30.[2,6] Obese patients usually have other conditions associated with obesity, such as hypertension, type II diabetes mellitus, dyslipidemia, and cardiovascular disease.[7,8] The constellation of these comorbidities has been defined as metabolic syndrome, which has been shown in the literature to

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have increased morbidity and mortality.[9–11] Surgeons are likely to encounter this challenging population during the course of their practice and need to be adept at the often complex management of these patients.

ANESTHESIA, PARALYTICS, AND ANALGESIA

Obesity causes variation in drug pharmacokinetic profiles, which makes drug dosing complicated, because most data are from nonobese patients. The greater fat mass, extracellular volume, and lean body weight in obese patients all affect drug pharmacokinetics.[7] In addition, the volume of distribution of lipophilic drugs is substantially greater than in normal-weight individuals, whereas hydrophilic drugs do not vary as much.[12] The decision to use ideal body weight (IBW) or total body weight to calculate drug dosages is not always clear. For example, paralytics are dosed based on IBW and most analgesics are based on lean body weight.[7,12] **Table 1** shows common medications and how dosage should be based.

Given the larger dosages required with the increased distribution volume and the risk of prolonged effects after discontinuation, lipophilic drugs, such as barbiturates, benzodiazepines, and volatile inhalation agents, should be used with caution or minimally in obese patients.[3,10,12–16] Maintenance of anesthesia can safely be performed either by intravenous (IV) anesthesia or inhalation anesthesia. The ideal inhalational anesthetic has a short onset and short, reliable recovery profile. Desflurane is the inhalational agent of choice in obese patients, but sevoflurane can also be used, because it has similar results to desflurane.[3,12,17–20]

With regard to paralytics, rocuronium, vecuronium, and cisatracurium have been studied and should be dosed based on IBW. Succinylcholine should be based on total body weight, because obese patients recover more rapidly secondary to increased pseudocholinesterase activity.[7,12] Sugammadex, a reversal agent for paralytics, has been used in the obese population with good results and should be dosed based

Table 1
Common medications and suggested dosages based on weight

Medication	Dosing Weight
Propofol	Lean body weight (induction) Total body weight (maintenance)
Etomidate	Lean body weight
Succinylcholine	Total body weight
Vecuronium	IBW
Rocuronium	IBW
Cisatracurium	IBW
Fentanyl	Lean body weight
Sufentanil	Total body weight
Remifentanil	IBW Lean body weight
Morphine (PCA)	Lean body weight
Neostigmine	Total body weight
Sugammadex	IBW + 40% or total body weight
Lidocaine (local)	Total body weight

Abbreviation: PCA, patient controlled analgesia.
Data from Refs.[7,17,22,25]

on total body weight.[7,12] It is essential that full reversal of the muscle relaxant be performed once the patient is to be extubated, because inadequacy in reversal can cause residual curarization and lead to clinically significant respiratory depression and need for emergent reintubation.[7]

Fentanyl and its analogues can be used, but remifentanil is the drug of choice because it does not accumulate in fat.[21] Given the risk of respiratory depression when using opiates, nonsteroidal antiinflammatory drugs such as ketorolac, acetaminophen, local anesthetic wound infiltration, cyclooxygenase-2 inhibitors, and regional nerve blocks have been described as analgesic adjuncts to decrease the use of IV opiates.[7,14,15,19,22] A problematic issue with regional or local nerve blocks is the potential difficulty in delineating anatomic landmarks.[7,12,13] Also mentioned is dexmedetomidine, a highly selective alpha-adrenergic agonist with sedative, amnestic, and analgesic properties without the respiratory depressive side effect.[7,13,22] Epidurals have also been described,[8–10,23] although respiratory depression, epidural hematomas, and increased risk of rhabdomyolysis can also occur with their use.[8,23,24] Adequate postoperative pain control is essential for these patients to help them gain early mobility, quicker return of gastrointestinal function, and good pulmonary function.[14] Patient controlled analgesia (PCA) using opiates can help with postoperative pain, although caution should is needed to ensure that a limited dosage without a basal rate is used to limit the risk of respiratory depression.[14,15,25] The recommended dosage of an opiate PCA should be based on lean body mass.[22,25]

PULMONARY SYSTEM

Obese patients are at increased risk of having airways that are difficult to manage, because bag mask valve ventilation and intubation can be challenging.[7] Although increased BMI does not predict difficulty with laryngoscopy or tracheal intubation, larger neck circumference (>40 cm) and higher Mallampati score (>3) were better predictors of a difficult intubation.[3,12,25,26] The probability of difficult intubation with a neck circumference of 40 cm was 5%, which increased to 35% with a 60-cm neck circumference.[15,19] Although most patients can successfully undergo tracheal intubation in a supine position, other adjuncts, such as awake intubation with a flexible fiberoptic scope, video-assisted laryngoscopy, and laryngeal mask airway (LMA), should be readily available.[7,12,14,27]

Given that the functional residual capacity (FRC) is reduced in obese patients, long periods of apnea are not tolerated and patients deoxygenate rapidly.[12,20,21,23,28,29] The use of preoxygenation using 100% fraction of inspired oxygen (FiO_2) for denitrogenation is thus recommended.[7,12–15,17,18,29,30] The use of continuous positive airway pressure (CPAP) at 10 cm H_2O is also suggested in the preintubation phase to reduce the formation of atelectasis.[7,13,15,17,27] A common intubation position for obese patients is the reverse Trendelenburg or head-up position of 25° to 40° with the use of shoulder towels. This position aids in improving oxygenation to prolong the time until desaturation, preventing aspiration, and offloading abdominal contents on the diaphragm, which increases FRC and reduces the formation of atelectasis.[14,15,19,20,25,27]

With the increase in BMI, obese patients present with a restrictive pattern with decreased forced expiratory volume, FRC, and expiratory reserve volume.[14,15,19,27] Lung volume and lung and chest wall compliance decrease as well. An increase in oxygen consumption, respiratory resistance, and work of breathing is seen in obese patients.[14,15,19,27] These changes lead to gas trapping with ventilation-perfusion mismatching, hypoxemia, and atelectasis, which becomes worse with anesthesia and paralysis. In addition, a higher prevalence of obstructive sleep apnea (OSA) is present, with rates of 30% to 93% in bariatric patients.[30] Moderate to severe OSA causes an increased in all-cause mortality and adverse outcomes. The American Association of Clinical Endocrinologists (AACE), The Obesity Society (TOS), and the American Society for Metabolic and Bariatric Surgery (ASMBS) advocate preoperative screening with polysomnography and preoperative CPAP in at-risk patients.[31] Preoperative CPAP has been shown to decrease severe hypoxemia, pulmonary vasoconstriction, hospital length of stay, and the incidence of postoperative complications.[13,15,28,30,32] Postoperative CPAP reduces the risk of pulmonary restrictive disease and acute respiratory distress syndrome.[7,15,16,19,29,30] McGlinch and colleagues[18] suggested the use of postoperative CPAP therapy until pulse oximetry is greater than 90% while sleeping and IV narcotics for pain management are no longer needed.

No strict guidelines as to ventilator strategies or modes for obese patients exist; however, recommendations within the anesthesiology literature include use of at least 10 cm H_2O of post–end expiratory pressure (PEEP) after a recruitment maneuver, tidal volumes of 6 to 12 mL/kg IBW, and use of lower FiO_2 (<0.8) to maintain physiologic oxygenation.[14,17,27] The respiratory rate should be adjusted to maintain normocapnia and offload carbon dioxide absorbed from pneumoperitoneum.[27,33] Kaw and colleagues[15] reported using high tidal volumes, PEEP, and vital capacity maneuvers to improve ventilation and oxygenation, whereas Cullen and Fergusen[7] reported no benefit in high tidal volumes in an attempt to maintain FRC.

Extubation should be performed once return of protective airway reflexes and muscle strength recovery has been assessed, the patient is fully awake and able to follow commands,[7,12,13] and in the reverse Trendelenburg position.[17,27,29] Once extubated, continuous pulse oximetry is used to detect subclinical periods of desaturation. Supplemental oxygen should be provided after major surgery, with some clinicians recommending treatment times of at least 24 to 48 hours.[7,15,16,18,22,30] Nasal CPAP has also been recommended postoperatively, in addition to supplemental oxygen.[12,13,17,20,27,30]

CARDIOVASCULAR SYSTEM

Obesity is an independent risk factor for coronary artery disease and therefore all obese patients should undergo a cardiac evaluation before an elective surgery, because they are at higher risk for essential hypertension, left ventricular hypertrophy, pulmonary hypertension, and congestive heart failure.[9,20,33,34] Work-up includes chest radiograph, 12-lead echocardiogram, and polysomnography in those patients with OSA or hypercapnia, because arrhythmias are commonly caused by hypoxia from OSA.[20,33] The AACE/TOS/ASMBS guidelines recommend echocardiography, spirometry, and arterial blood gases only if the patient has additional risk factors. Their guidelines recommend that "patients at risk for heart disease should undergo evaluation for perioperative beta-adrenergic blockade."[31] Apovian and colleagues[35] recommend "perioperative beta blockers in patients with stable or suspected coronary artery disease, unless contraindicated." However, some side effects of beta-blockade, such as impaired glucose tolerance, increased insulin resistance, and other metabolic abnormalities, can be harmful in severely obese patients or patients with metabolic syndrome.[7] Other medications, such as antihypertensives, should be continued preoperatively up to the operation.[3,12]

Routine intraoperative hemodynamic monitoring should be initiated using telemetry and blood pressure monitoring.[19] Given the increased size of extremities in some obese patients, ankle and wrist pressures are acceptable, if it is not possible to obtain routine arm noninvasive pressures. Blood pressure cuffs should be long enough to encircle at least 75% of the arm and the wide enough to encircle 40% of the arm.[3,9,33] Invasive arterial or pulmonary catheter monitoring may be needed in the superobese (>60 BMI), patients with severe cardiopulmonary disease, those with access difficulties, and patients with unreliable noninvasive cuff readings.[3,7,9,10,14,17–19] Intraoperative transesophageal echocardiography has been used, but no data exist to support everyday use.[20,33] The American College of Cardiology (ACC) and American Heart Association (AHA) task force 2007 guidelines recommend postoperative cardiac monitoring in patients with single or multiple risk factors for coronary artery disease who are undergoing noncardiac surgery,[36] as does the AACE/TOS/ASMBS guideline recommendation for at least the first 24 hours.[31]

GASTROINTESTINAL SYSTEM/NUTRITION

Although most elective cases do not require extensive work-up of gastrointestinal reflux disease (GERD), cholelithiasis, *Helicobacter pylori*, or fatty liver and nonalcoholic steatohepatitis, the AACE/TOS/ASMBS guidelines recommend work-up in symptomatic patients when preparing for weight loss surgery.[31] GERD should be treated preoperatively with proton pump inhibitors or histamine receptor blockers.[14,19]

Obese patients commonly (15%–25%) have type 2 diabetes.[28] Hyperglycemia can delay wound healing, increase infection rate, and cause significant postoperative morbidity. The AACE/TOS/ASMBS guidelines indorse preoperative glycemic control targets of hemoglobin A1c of 6.5% to 7% or less, fasting blood glucose level of less than or equal to 110 mg/dL, and a 2-hour postprandial blood glucose level of less than or equal to 140 mg/dL.[31] Less stringent targets can be applied to patients with extensive comorbid conditions, long-standing and hard-to-control diabetes despite intensive medical therapy, and those with advance microvascular and macrovascular disease per the AACE/TOS/ASMBS guidelines.[31] Before surgery, oral hypoglycemics should be withheld and blood glucose should be controlled with a sliding scale.[3,12] Intensive insulin therapy (target of 110 mg/dL) is recommended in the perioperative period because of a reduction in in-hospital death, length of stay, and improvement in clinical outcomes.[37]

Proper nutrition is paramount to decrease morbidity and mortality postoperatively. Surgical stress can cause protein malnutrition, ureagenesis, and accelerated protein breakdown secondary to increased insulin levels from stress blocking lipid use in obese patients.[7,38]

The AACE/TOS/ASMBS guidelines and Apovian and colleagues[35] suggest preoperative nutritional screening, because deficiencies of nutrients such as iron, thiamine, vitamin B_{12}, and vitamin D are common.[31]

The American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines weakly recommend a high-protein, hypocaloric diet.[39] They define hypocaloric feeds as 50% to 70% of estimated energy needs or less than 14 kcal/kg actual body weight, and define high protein as 1.2 g/kg actual body weight or 2 to 2.5 g/kg IBW, with adjustment of goal protein intake determined by nitrogen balance studies. They strongly recommend all patients be screened for nutrition risk within 48 hours of admission and for critically ill, obese patients to have a nutrition assessment and support plan in placed within 48 hours of intensive care unit admission.[39] To determine energy requirement, indirect calorimetry should be used.[7] If unavailable, the ASPEN guidelines recommend the Penn State University 2010 predictive equation to determine energy requirements, with the modified Penn State equation being used in patients more than 60 years old.[39] Although the 2013 AHA/ACC/TOS guidelines also suggest a hypocaloric, high-protein diet, they also offer options for nutrition, such as the AHA Step 1 diet, a macronutrient targeted diet, and a Mediterranean-style diet.[40]

RENAL SYSTEM/FLUIDS

The comorbidities (cardiovascular disease, hypertension, diabetes) associated with obesity lead to an increase in chronic kidney disease (CKD).[41–44] Obesity-related glomerulopathy is the process resulting in proteinuria and renal dysfunction associated with structural changes, such as glomerulomegaly and focal segmental glomerular sclerosis.[41,43–46] Other hypothesized mechanisms by which obesity affects kidney function are inflammatory cytokines, oxidative stress, intraoperative and postoperative hemodynamics, and pharmacologic nephrotoxicity.[43,44,47] However, the exact pathophysiology of these mechanisms is unknown at this time.

The literature has shown an association with obesity and acute kidney injury (AKI) postoperatively and in the intensive care unit.[42,45–48] Glance and colleagues[11] reported a 2-fold to 3-fold increased risk of postoperative AKI in obese patients using the American College of Surgeons (ACS) National Surgical Quality Improvement Program database. Risk factors for postoperative AKI in bariatric patients include age greater than 50 years; BMI greater than 35; hyperlipidemia; hypertension; preoperative CKD; diabetes; male gender; long operative times; intraoperative hypotension; and preoperative use of statins, angiotensin-converting enzyme inhibitors (ACE-Is), and angiotensin II receptor blockers (ARBs).[24,42,45,46,48,49] AKI related to long operative time is usually secondary to rhabdomyolysis, with an overall incidence of 7% in bariatric patients.[50] Recommendations regarding the optimization or reduction of AKI postoperatively include avoiding preoperative exposure to nephrotoxic agents (eg, antibiotics, ARBs, ACE-Is), adequate fluid administration, avoiding intraoperative and postoperative hypotension, avoiding long operative times, and use of invasive hemodynamic monitoring to aid in intraoperative hemodynamic monitoring.

Fluid management in obese surgical patients can be difficult, because body fluid compartments are different compared with nonobese patients.[12,51,52] A urine output of approximately 1 mL/kg/h based on lean body mass is a good predictor of adequate fluid replacement in obese patients, with 4 to 5 L of crystalloid as an average for a 2-hour operation.[12] Recommendations regarding fluid management in obese patients are limited, because there are no large randomized controlled trials on morbidity and mortality in liberal versus restrictive fluid management in this population. Ingrande and Brodsky[51] advise that fluid be goal directed, using maximal stroke volume via transesophageal Doppler monitoring.

SURGICAL SITE INFECTIONS

Surgical site infections are increased in the obese population and the cause is likely multifactorial, including such factors as diabetic and obesity-related immune dysfunction, decreased perioperative tissue oxygenation and perfusion, and inadequate antimicrobial dosing.[7,9,14,18,19,53–57] In the 2013 Clinical Practice Guidelines for Antimicrobial Prophylaxis in Surgery developed by the American Society of Health-System Pharmacists, the Infectious Diseases Society of America (IDSA), the Surgical Infection Society, and the Society for Health care Epidemiology of America, the optimal timing of initial antibiotic dosing was recommended to be 60 minutes before incision, with 120 minutes for fluoroquinolones or vancomycin. In addition, 3 g of cefazolin were recommended in patients weighing more than 120 kg and 2 g if using cefoxitin or cefotaxime in obese patients. The systematic review by Fischer and colleagues[58] reported that cefazolin is appropriate for prophylaxis, although a specific dose was not reported. Furthermore, conclusive recommendations for weight-based dosing in obese patients are not currently possible, because there are insufficient data showing better efficacy than standard dosage regimens.[53] Given the increased body mass and volume of distribution, studies evaluating the pharmacokinetics in the obese population, such as the piperacillin/tazobactam pharmacokinetics study, are needed.[59] Al-Benna[14] recommended that any skin infection, such as *Candida albicans*, should be treated preoperatively.

MUSCULOSKELETAL DISORDERS

Obesity is a well-known risk factor for several types of musculoskeletal disorder, such as arthritis and gout,[60] that can affect mobility. Nevertheless, early postoperative mobilization is vital to decreasing pulmonary, skin, and thrombotic complications[7,9,12,17–19,34] and should occur as soon as possible, even if only to a chair.[19] To achieve early mobilization, multiple modalities and services are needed, including adjustment to hospital facilities. The ACS and the ASMBS joined their bariatric surgery accreditation programs to form a unified national standard, the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program, which released detailed standards and pathways for accreditation of metabolic and bariatric surgery centers in 2014, describing the physical and human resources needed to manage obese patients in an ACS-designated bariatric surgery center. Resources dealing specifically with mobility and musculoskeletal health, such as equipment and staff needed for transfer and patient movement, are detailed within this standard.[61] Further recommendations included adequate radiological facilities, medical imaging equipment, blood pressure cuffs, specialized wheelchairs, beds, enlarged doorways, expanded gowns, rooms, and bathrooms.[10,14,18,19,61] The recommendation has been made that toilet and shower seats be floor mounted rather than wall mounted to avoid injurious falls if the facility breaks away from the wall.[10,18,19,62]

Operative tables capable of holding more than 250 to 350 kg are needed.[9,10,14,17,34] Proper restraints should be used to avoid patients slipping off the table during position changes.[9,10,14] O'Leary and colleagues[19] suggest the use of an extra-large table strap placed at the hips and a footrest and placement of the feet in the dorsiflexed position if using reverse Trendelenburg. A bean bag may help in securing the patient.[10,14,19] Care in positioning and padding to avoid nerve injuries and rhabdomyolysis is important because of an increased prevalence of these problems in obese patients.[9,10,14,17,34] Common nerves injured by positioning and traction are the brachial plexus, sciatic, lateral femoral cutaneous, and ulnar nerve, with increased BMI and male gender being risk factors for these injuries.[9,18,34] If postoperative neuropathies are found, neurologic consultation and nerve conduction studies may be warranted if severe, but most resolve over time.[9]

In 2008, Medicare stopped reimbursement for management of stage III and IV pressure ulcers if they developed within the hospital stay.[63] Preoperative evaluation for pressure ulcers on obese patients is needed to provide adequate documentation and treatment at the time of admission. After surgery, skin care should be assessed at frequent intervals, and patients unable to mobilize themselves should be turned every 2 hours, even if on a special mattress such as an air or rotating mattress.[10,62] Inspection of skin should include lifting, cleaning, and drying skin folds, and attention should be paid to skin areas that are touching structures, such as the bed side, lines, drains, and tracheostomy or endotracheal tubing.[62]

DEEP VENOUS THROMBOSIS/THROMBOEMBOLISM

Likely secondary from decreased mobility, increased pressure on the venous system, and increased venous stasis, obesity is a risk factor for deep venous thrombosis (DVT) and pulmonary embolism (PE).[7,8,14,64,65] Other risk factors include obesity hypoventilation syndrome, pulmonary hypertension, immobility, hormonal therapy, expected long operative times or an open approach, and male gender.[66] Even with perioperative prophylaxis, the estimated incidences of DVT and PE in obese patients range from 0.2% to 2.4%,[12,14] therefore a combined protocol of pneumatic-compression lower extremity devices and anticoagulant chemoprophylaxis is needed to reduce the risk of DVT and PE.[12,18,28,31,66]

However, there are currently no universal dosing protocols, standard type of chemoprophylaxis used, or dosage duration. The American College of Chest Physicians has suggested higher dosages of low-molecular-weight heparin (LMWH) for obese patients.[67] The American Society for Metabolic and Bariatric Surgery recommends LMWH rather than unfractionated heparin (UFH) and refers to the Bariatric Outcomes Longitudinal Database (BOLD), which shows that 73% of venous thromboembolism (VTE) events occur after discharge. It therefore recommends extended VTE prophylaxis be considered for high-risk patients, but does not offer dosage or duration recommendations.[66] The AACE/TOS/ASMBS Clinical Practice Guidelines recommend either UFH or LMWH to be started within 24 hours postoperatively and consideration of extended chemoprophylaxis in high-risk patients, but also does not give dosage or duration recommendations.[31]

Literature exists to support that BMI or weight-based dosing, monitored by factor Xa levels, is superior to standard dosage, and that 0.5 mg/kg actual body weight subcutaneously daily is an appropriate dosage for morbidly obese patients.[68–70] The target factor Xa level used was 0.2 to 0.4 IU/mL.[68] Singh and colleagues[71] found in their small retrospective study that preoperative and postoperative LMWH is well tolerated. However, randomized controlled trials are lacking. Also in the literature, an extended prophylaxis duration of 28 to 35 days is recommended in high-risk patients.[68]

The use of prophylactic inferior vena cava (IVC) filter placement routinely in obese patients before surgery is controversial. Although no consensus definition of high risk exists, recommendations exist for IVC filters for obese patients with prior venous stasis disease, previous PE/DVT, patients who are superobese or have BMI greater than 55 kg/m^2, or patients with known hypercoagulable conditions.[3,15,18,72,73] The ASMBS does not support the use of IVC filters as the sole method of prophylaxis but as an adjunct to pharmacologic and mechanical prophylaxis in high-risk obese patients.[66] The AACE/TOS/ASMBS mention the Michigan Bariatric Collaborative study, which found that prophylactic IVC filter placement did not decrease VTE-related events or death, as well as the BOLD database, which reported that the risk of VTE was greater with IVC filters and therefore do not recommend it in the guidelines.[31] If a filter is placed, timing of removal is preferably within 3 months to have the best chance for successful removal.[72,73]

SUMMARY

It is hoped that this article explains the complex issues in the management of obese patients who require an integrative and multidisciplinary team for a successful hospital stay and offers a good reference for practicing surgeons in the perioperative management of this challenging, but increasingly common, patient population.

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