

Over the past three decades, there has been a sharp increase in rates of obesity worldwide.¹ The World Health Organization defines obesity as a condition with excess body fat to the extent that health and well-being are adversely affected.² For the first time in history, recent estimates suggest that the number of obese individuals now exceeds the number of underweight individuals. Prevalence of obesity in the United States is unevenly distributed geographically, by race and ethnicity and by socioeconomic status. The overall trend is, however, to keep increasing and the prevalence of obesity is expected to reach about 50% by 2030 if trends continue.³ The BMI is used in clinical practice to estimate the degree of obesity: *Obesity* is defined as having a BMI ≥ 30 kg/m². Morbid obesity, defined as a BMI ≥ 40 kg/m², can also be further classified into super obesity (BMI ≥ 50 kg/m²) and super-super obesity (BMI ≥ 60 kg/m²).⁴ Surgery in this patient population is considered high-risk but careful planning, preoperative risk assessment, adequate anesthetic management, strict venothrombotic event prevention, and effective postoperative pain control will all help to reduce the risk.

Preoperative focused evaluation. A preoperative evaluation should be performed with enough time to allow for a thorough assessment and discussion of the risks with the patient and surgical team. The evaluation should include a thorough medical history, physical exam, and testing as clinically indicated.⁵

Airway. Although a recent multicenter analysis of nearly 700 patients with BMI ≥ 30 kg/m² determined that increased BMI was an independent risk factor for difficult mask ventilation and difficult laryngoscopy,⁶ it remains unclear whether BMI alone is a predictor of difficult laryngoscopy.⁷⁻⁹ In addition, obesity played a significant role in the US closed claims related to airway management at induction in a recent analysis.¹⁰ Preoperative airway assessment in obese patients is necessary. In addition, airway difficulty in most studies correlates with increased age, male sex, temporomandibular joint pathology, Mallampati classes 3 and 4, OSA, and abnormal upper teeth.¹¹⁻¹³ Anatomic changes associated with obesity that contribute to a potentially difficult airway include limitation of movement of the atlantoaxial joint and cervical spine by upper thoracic and low cervical fat pads; excessive tissue folds in the mouth and pharynx; short, thick neck; thick submental fat pad; suprasternal, presternal, and posterior cervical fat; and large breasts in females. Excess pharyngeal tissue deposited in the lateral pharyngeal walls may not be noticed during routine airway examination. The patient's neck circumference has been identified as the single biggest predictor of problematic intubation in morbidly obese patients.¹² The probability of a problematic intubation is approximately 5% with a 40-cm neck circumference compared with a 35% probability at 60-cm neck circumference. In this study by Brodsky et al.¹² a larger neck circumference was associated with male gender, a higher Mallampati score, laryngoscopy grade 3 views, and OSA. Multivariate analyses showed that age, BMI, and a recorded Mallampati score were significant independent predictors of failed tracheal intubation.¹⁴ The history obtained from the patient and examination of previous records may help predict airway difficulties.

Cardiovascular evaluation. The morbidly obese patient suffers from increased body mass which increases metabolic demand. Besides increases in preload (blood volume) and afterload, cardiac output increases with increasing weight by as much as 20 to 30 mL/kg of excess body fat because of ventricular dilation and increases in stroke volume. The resulting increased left ventricular wall stress leads to hypertrophy, reduced compliance, and impairment of left ventricular filling (diastolic dysfunction) with elevated left ventricular, diastolic pressure, and pulmonary edema.¹⁵ When left ventricular wall thickening fails to keep pace with dilation, systolic dysfunction ("obesity cardiomyopathy") and eventual biventricular failure results. Obesity also accelerates atherosclerosis.

The history may be indeterminate because symptoms such as angina or exertional dyspnea occur only occasionally. Morbidly obese patients often have very limited mobility and may appear asymptomatic even

when they have significant cardiovascular disease. The physical exam may also be difficult because soft tissue may mask jugular venous distention and heart sounds are often distant. Lower extremity edema is also common but in some cases may indicate elevated right ventricular filling pressures. In the obese, a left-bundle branch block on the EKG is unusual in uncomplicated patients and may be an indicator of coronary artery disease.⁵ Although patients with cardiomyopathy (i.e., diabetic or obesity) or chronic myocardial ischemia should be identified and optimized prior to surgery because of the risk of heart failure, most patients will not require exercise or pharmacological stress testing unless symptoms, functional capacity, or risk factor analysis indicates testing beyond the EKG.

Respiratory system evaluation. Respiratory disease is increased in the obese. Pulmonary mechanics, lung volumes, functional residual capacity (FRC), oxygenation, and ventilation are altered in these individuals. Chest wall compliance decreases because of increased weight of excess adipose tissue. Respiratory work and oxygen consumption are increased. The increased work of breathing in combination with reduced functional residual capacity, expiratory reserve volume, as well as increased closing capacity increases the overall risk of atelectasis, especially in the supine position.

Obstructive sleep apnea (OSA) and Obstructive Hypoventilation Syndrome are important concerns in this patient population. Because the rate of OSA is increased in this population, individuals with OSA should be identified preoperatively because OSA is frequently associated with difficult airway management and increased perioperative pulmonary complications. The STOP-bang questionnaire can be used as a screening tool.¹⁶ (<http://www.sleepapnea.org/assets/files/pdf/STOP-BANG%20Questionnaire.pdf>) It is validated in the obese population: 1) score of 0 – 3 indicates a low risk of OSA; 2) 4 – 5 indicates an intermediate risk of OSA; and 3) 6–8 indicates a high risk of OSA. Recently the American Society of Anesthesiologists updated the Practice Guidelines for the Peri & Operative Management of Patients with Obstructive Sleep Apnea to include new evidence from the most recent literature.¹⁷ Arterial blood gas measurements help evaluate ventilation if obesity hypoventilation syndrome is suspected, as well as the need for perioperative oxygen administration and postoperative ventilation. Routine pulmonary function tests are not cost-effective in asymptomatic obese patients.

Endocrine Disease. Patients scheduled for repeat bariatric surgery should be screened preoperatively for long-term metabolic and nutritional abnormalities. The high prevalence of insulin resistance and diabetes in obese patients justifies the need of considering glycemia checks preoperatively, and correcting abnormalities if present. Preoperative evaluation should include assessment of therapies for glycemia control, last time and dose of preoperative administration, and usual glucose values for a specific patient. Electrolytes should be checked before surgery, particularly in patients with poor compliance to medications or acutely ill patients. Vitamin and nutritional deficiencies can lead to a collective form of postoperative polyneuropathy, known as acute postgastric reduction surgery (APGARS) neuropathy, a polynutritional multisystem disorder characterized by protracted postoperative vomiting, hyporeflexia, and muscular weakness.¹⁸ Close attention to dosing and monitoring of neuromuscular blocking agents is recommended in cases of suspected or diagnosed APGARS neuropathy. Chronic vitamin K deficiency may lead to coagulation abnormalities, requiring administration of vitamin K analog or fresh-frozen plasma.

Gastrointestinal Frequency of gastroesophageal reflux is strongly correlated with increasing BMI.¹⁹ Although hiatal hernia is more common in obese individuals compared to the non-obese, it is unknown whether the effects of obesity are additive in reducing lower esophageal sphincter tone. Obesity is also associated with increased abdominal pressure, gastric volumes, incidence of gastroesophageal reflux and hiatal hernias, as well as lower pH and fatty infiltration of the liver.

General considerations

Preparation should include placement of adequate intravenous access. Central venous access may be necessary if peripheral access is unobtainable or inadequate. Blood pressure (BP) monitoring may be particularly problematic in these patients. If the BP cuff is too small, the BP reading will be overestimated. The forearm can be used if the upper arm is too large or cylindrical in shape. In some cases, an arterial line will be necessary to accurately determine the BP as well as obtain arterial blood gases in patients with respiratory compromise.

Operating room considerations. Weight limits of standard OR tables range from 130 to 160 kg. Although some newer tables will support up to 454 kg, recent concerns were raised when an operating room table's floor locks were released and the fulcrum of the table shifted ~3 inches to the patient's feet.²⁰ This changed the OR table's weight capacity and made the table prone to tipping. The authors recommend that it is necessary to comply with manufacturer (Amsco 3085 SP surgical table) recommendations and "DO NOT RELEASE FLOOR LOCKS WHILE PATIENT IS ON TABLE." It may also be necessary to extend the width of the table with side extensions. If extensions are unavailable, it may be possible to improvise with arm boards placed along the sides of the OR table. Adequate padding should be used to prevent pressure-related injuries. Transport gurneys should be of similar size limits. Patients must be properly secured on the operating room table. Furthermore, if patient-moving assistance devices are unavailable, additional personnel are required to prevent lifting injuries.

Positioning for airway management. Careful positioning is imperative in the care of these patients regardless of the primary anesthetic technique. A study investigating the effects of position on laryngoscopic view in 60 morbidly obese patients determined that the 'ramped' position or head elevated laryngoscopy position (HELP) clearly improved the laryngeal view when compared with the standard 'sniff' position.²¹ The 'ramped' position can be achieved by arranging blankets, or one of the commercially available pillow devices, underneath the patient's upper body and head until horizontal alignment is achieved between the external auditory meatus and the sternal notch. This positioning allows easy access to the airway and facilitates placement of a laryngoscope (short-handled). However, some operating room tables are equipped with a head section capable of angulation. By tilting this section downwards and then flexing the table forwards, the ramped position can be created with the use of only one pillow to produce the exact degree of angulation desired.²² If a patient receives neuraxial anesthesia, it has been associated with a significant decrease in spirometric parameters²³ and a 30-degree head-up position may improve respiratory mechanics and oxygenation.

General anesthesia. Preparations should include availability of experienced personnel and difficult airway equipment. In all cases, proper positioning of the neck, shoulders, and chest the keys to successful intubation. In some cases, an awake fiberoptic intubation may be the safest option but it can be difficult and time-consuming. A recent study of patients with anticipated difficult randomized to either awake fiberoptic (BMI 31 [14-57]) vs. awake video laryngoscopic (BMI 29 [18-47]) tracheal intubation determined that there was no difference of performance between the two techniques,²⁴ suggesting that videolaryngoscopy may be useful as the primary device or first alternative for securing the trachea, even when awake intubation is being considered.²⁵ If the patient's airway appears normal, a rapid sequence intubation in a ramped position can be performed.

Lean body weight is optimal for dosing most drugs used in anesthesia including opioids and induction agents.²⁶ Lean body weight is defined as 20-30% more than ideal body weight. Succinylcholine is often used to secure the airway. The dose of succinylcholine (1.0-1.5 mg/kg up to a maximum of 200 mg) is based on total body weight.²⁷

Verification of proper endotracheal intubation can only be accomplished by capnography. If intubation is unsuccessful, a failed intubation drill should be instituted immediately.²⁸ The goal of failed intubation management is to ensure oxygenation despite the potential risk of aspiration. Mask ventilation may require several people, one to continue cricoid pressure, a second to institute jaw-thrust, and the third to squeeze the bag and monitor the patient. *Repeated attempts and additional succinylcholine are detrimental but a laryngeal mask airway can be lifesaving.*²⁹

In the morbidly obese, there are further reductions in FRC due to supine positioning, use of volatile anesthetics, muscle relaxants, and in some cases, retraction of the panniculus.³⁰ This leads to early closure of small airways and hypoxemia. Increased tidal volumes, high-inspired oxygen concentrations, reverse Trendelenburg positioning, and positive end-expiratory pressure³¹ have been used to maintain oxygenation and ventilation. However, use of positive end-expiratory pressure can worsen cardiac output and barotrauma. Although isoflurane, sevoflurane, and desflurane can be used in standard concentrations, desflurane provides a faster recovery.³² Titration of nondepolarizing muscle relaxants with the help of a twitch monitor is a reasonable approach.

Monitored Anesthesia Care. Monitoring of the adequacy of ventilation and oxygenation is extremely important in obese patients. Obese patients present a higher risk of sedation-induced respiratory depression, so careful titration of benzodiazepines, opioids and propofol is mandatory to avoid hypercapnia and/or hypoxemia. Hypoxemia may require unplanned intubation, so a thorough airway exam and preparation for unintended airway management is critical even in MAC/sedation cases. The prevalence of closed claims related to adverse respiratory events during monitored anesthesia cases is increasing, compared to respiratory complications or airway management complications encountered during general anesthesia.³³ In a closed claim analysis by Bhananker et al,³⁴ obesity and suboptimum monitoring of pulse oximetry, end-tidal capnography or both, were significant key factors in these adverse events during MAC.

Special Clinical Situations

Management of Obesity. Indications for drug treatment include a BMI ≥ 30 kg/m² or a BMI between 27 and 29.9 kg/m² in conjunction with an obesity-related medical complication. Lifestyle counseling is still the most effective long-term weight loss tool that can be combined with the use of medications.^{35,36} Medications used to treat obesity are formulated to reduce energy intake, increase energy utilization, or decrease absorption of nutrients. Orlistat (OTC Alli®, prescribed Xenical®) or tetrahydrolipstatin, blocks the absorption of dietary fat by inhibiting lipases in the gastrointestinal tract. It leads to weight loss and to improvement of blood pressure, fasting blood glucose levels, and lipid profile.³⁷ Fat malabsorption causes digestive symptoms but chronic use of orlistat may result in fat-soluble vitamin deficiency. A prolonged prothrombin time with a normal partial thromboplastin time during orlistat treatment may reflect vitamin K deficiency and this coagulopathy should be corrected 6 to 24 hours before elective surgery.³⁸

Over the counter preparations, plants extracts or herbs that are often used to combat obesity include substances with alleged properties as, among others: pancreatic lipase inhibitors (caffeine, green or black tea), appetite suppressants (hoodia, Korean ginseng, ephedra, sunflower oil), stimulants of energy expenditure (acai berry, caffeine), regulators of lipid metabolism (soybean, fish oil, oolong tea, caffeine).³⁹ The American Society of Anesthesiologists warns patients to tell their anesthesiologists about medications they are taking, including vitamins, herbs and other supplements. Since these products can interfere with anesthesia, they can cause complications during surgery.⁴⁰

Bariatric surgery is currently the most effective treatment for morbid (class III) obesity.⁴¹ Several guidelines for bariatric surgery eligibility exist, most of them agreeing on eligibility with BMI>40kg/m² or BMI>35kg/m² with obesity-related comorbidities not controlled with medical therapy.⁴² Procedures are classified into malabsorptive (jejunioileal bypass and biliopancreatic diversion, rarely used nowadays), restrictive (vertical-banded gastroplasty and adjustable gastric banding), or combined (Roux-en-Y gastric bypass (RYGB), combines gastric restriction with a minimal degree of malabsorption). Roux-en-Y gastric bypass, adjustable gastric banding and vertical-banded gastroplasty can all be performed laparoscopically. Laparoscopic bariatric surgery is associated with less postoperative pain, lower morbidity, faster recovery, and less “third-spacing”.⁴³ Roux-en-Y Gastric Bypass is the most effective bariatric procedure to produce safe short- and long-term weight loss in severely obese patients. Vertical-banded or sleeve gastroplasty also restricts food intake.

Less invasive bariatric techniques are being developed. An implantable gastric stimulator (IGS) is placed laparoscopically and emits electrical impulses to stimulate the gastric smooth muscle to stop peristalsis so that the patient feels full. Intra-gastric balloons and prostheses can be placed endoscopically as a temporary measure to increase satiety.⁴⁴ Adequate control of postoperative nausea and vomiting is critical to avoid possible lead and balloon dislodgement. More recently, the FDA has approved an implantable device that produces intermittent, reversible vagal nerve blockade.⁴⁵ In the yearlong trial, obese adults with the device lost more than 8% of their excess weight compared to controls. Collectively, data suggests that bariatric surgery lowers all-cause mortality at 5y and up to 10y following the procedure.^{46,47}

Ambulatory Surgery in the Obese.^{48,49} Outpatient surgery can be considered under certain circumstances. Identifying obese patients who are suitable candidates for ambulatory surgery depends upon patient comorbidities, invasiveness of the procedure, anesthetic technique, post-operative pain management as well as skill of the surgeon and anesthesiologist. Although a number of studies have identified obesity as a risk factor for perioperative complications, a recent systematic review determined that BMI alone did not increase the risk for perioperative complications or unexpected admission after ambulatory surgery. However, the authors caution that most super-obese (i.e., BMI \geq 50kg/m²) are not candidates for ambulatory surgery.

Because many morbidly obese patients are diagnosed with sleep-disordered breathing, these patients may be considered for ambulatory procedures if their co-morbid conditions are optimized and postoperative pain control is easily achieved with non-opioid techniques. The morbidly obese and those with OSA present unique and increasingly frequent challenges to ambulatory practices. Estimates suggest that 60% to 90% of all OSA patients are obese (body mass index greater than or equal to 30 kg/m²).⁵⁰ However, the problem is further confounded in that many of the patients with OSA do not carry a formal diagnosis. These patients are likely to cause major anesthetic problems throughout the perioperative period. A recent prospective cohort study of ambulatory surgical patients with propensity to OSA, revealed an increase in numbers of laryngoscopy attempts, difficult laryngoscopic grade view and the use of fiber-optic intubation.⁵¹ These patients may also have respiratory insufficiency soon after extubation. Recent examination of large databases has also demonstrated increased risk for emergency intubation, respiratory failure, mechanical ventilation, aspiration pneumonia, atrial fibrillation, and ARDS.⁵²⁻⁵⁴ They are also more likely to suffer from respiratory arrest with preoperative sedation or postoperative analgesia because they are particularly sensitive to the respiratory depressant effects of even small dosages of sedation or analgesics. However, recent data suggests that patients who have a pre or postoperative diagnosis of sleep apnea are twice as likely to have respiratory complications compared to controls.⁵⁵ However, patients with a preoperative diagnosis of OSA and utilized CPAP were less likely to experience cardiovascular complications compared with patients who are diagnosed postoperatively.

Some recommend that a postoperative observational unit with close monitoring of oxygen saturation or an intensive care unit setting be used for monitoring the OSA patients postoperatively.⁵⁶ Use of local or regional anesthesia with minimal sedation, availability of a 23-hour observation post-anesthesia care unit, and when patients can resume oral medication at the time of discharge are useful to facilitate cases in the ambulatory setting. OSA patients on a continuous positive airway pressure (CPAP) device at home should be instructed to bring it with them to the hospital as it may be needed postoperatively. The possibility of invasive monitoring, prolonged intubation, and postoperative mechanical ventilation should be discussed with obese patients.

Recently, the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database identified risk factors for morbidity and mortality with 72 hours after ambulatory surgery.⁵⁷ Although the incidence of morbidity and mortality was only 0.1% in nearly 250,000 cases, independent risk factors for perioperative morbidity included: high BMI, chronic obstructive pulmonary disease, hypertension, history of TIA/stroke, previous cardiac surgery, and longer surgical times. In the cohort, unplanned postoperative intubation, pneumonia, and wound disruption were the most commonly identified comorbidities. Others have determined that increased BMI, ASA ≥ 3 , age > 80 years, and length of surgery >1 hour all increased the risk for unplanned hospital admission. Because increased BMI is a contributor for increased perioperative risk, exclusion criteria should be developed for patients undergoing ambulatory surgery.

Regional Anesthesia.⁵⁸ Neuraxial anesthetic techniques (spinal, epidural, combined spinal epidural) and peripheral nerve blocks are used alone or in combination with general anesthesia in increasing frequency as more obese patients are coming to the operating room. Several studies have demonstrated the efficacy of regional techniques in reducing opioid-related complications^{59,60} but there are other distinct advantages: 1) minimal or reduced manipulation of the airway; 2) administration of fewer medications with cardiopulmonary depression; 3) reduced risk of post-operative nausea and vomiting; 4) better postoperative pain control; and 5) improved postoperative outcomes.⁶¹ When epidural anesthesia is combined with general anesthesia, time to tracheal extubation may be reduced in patients receiving a combined technique compared to general anesthesia alone.⁶² However, studies demonstrate that there is an increased risk of block failure in obese patients compared to those of normal weight.⁶³ Failure is often due to technical difficulties and limitations of regional anesthesia. In addition, these patients also experience an increased risk of complications.⁶⁴ With proper planning, these techniques may be used successfully and should be considered in the anesthetic plan for obese patients who are candidates for regional anesthesia. However, well-functioning intravenous access should be secured prior to block placement in case of high-spinal or local anesthetic systemic toxicity occurs following regional anesthesia.

Neuraxial anesthesia can produce serious cardiopulmonary alterations in obese patients undergoing surgery. Because pulmonary mechanics, lung volumes, functional residual capacity (FRC), oxygenation, and ventilation are altered in these individuals, supine and Trendelenburg positioning during neuraxial anesthesia can lead to deterioration of lung volumes and further reductions in FRC. Functional residual capacity may fall below closing capacity promoting small airway collapse, atelectasis, ventilation perfusion mismatch, and hypoxia, especially during supine and Trendelenburg positioning.⁶⁵ It is often helpful to measure the oxygen saturation in the sitting and supine positions to indicate the degree of pulmonary reserve prior to initiating neuraxial anesthesia. In addition to these pulmonary concerns, there are cardiovascular changes that warrant careful monitoring. The excess weight of the abdominal wall can compress the vena cava, causing decreased cardiac preload, reflex tachycardia, and decreased cardiac output. In a large series of obese patients undergoing non-obstetric surgery who had received spinal anesthesia, more than one-third developed hypotension.⁶⁶ Three of the patients in this series also experienced cardiac arrest. There are other reports of cardiac arrest after supine positioning in morbidly

obese patients.⁶⁷ Changes to the supine position likely contributed to the circulatory changes resulting in these arrests.

Despite these important considerations, use of neuraxial techniques can offer important advantages when compared to general anesthesia alone. Parenteral opioid administration can be hazardous in these patients because of increased sensitivity to opioids, risk of hypoxemia, a high incidence of sleep apnea, and increased incidence of adverse respiratory events following surgery. Administration of patient-controlled opioid analgesia has even resulted in respiratory depression in some obese patients.⁶⁸ The American Society of Anesthesiologists has published guidelines for the care of patients with obstructive sleep apnea (OSA) and recommends that regional anesthetic techniques should be considered to reduce or eliminate the requirements for systemic opioids in patients with sleep apnea.¹⁷

Positioning is an important step in placement of a successful neuraxial anesthetic. Spinal or epidural placement in the sitting position will assist with identification of the midline.⁶⁹ The patient's back should be parallel to the edge of the bed to prevent lateral needle deviation away from the midline. Lateral deviation of the midline will increase the depth to the epidural or spinal spaces and can result in block failure⁶⁹ and an increased risk for intraoperative conversion to general anesthesia in less-than-ideal circumstances. Anatomic landmarks are often obscured in these patients. If spinal processes cannot be appreciated with deep palpation, a line can be drawn from the cervical vertebral spinal process to the uppermost portion of the gluteal cleft. This line approximates the midline of the patient over the vertebral column. Ultrasound imaging can also be helpful to identify spinal processes⁷⁰ and has been shown to significantly reduce the number of needle passes and decrease the time for spinal block placement in morbidly obese patients undergoing orthopedic surgery.⁷¹ Since the iliac crests may also be difficult to appreciate, the patient's skin folds can be used to aid in drawing a line perpendicular to the vertical line so that the intersection point can serve as a reasonable spinal or epidural needle insertion guide.

Neuraxial anesthetic placement can be particularly difficult, especially when bony landmarks are nonpalpable, there is limited back flexion,⁷² and there are false losses of resistance due to fat deposition. It is often difficult to predict the depth to the epidural space but the depth to the epidural space generally correlates with BMI.⁷³ A recent study suggests that prepuncture ultrasonography may be useful to facilitate epidural placement in obese parturients to assist in predicting the depth to the epidural space.⁷⁴ However, ultrasound has limitations in this patient population because the image quality can be compromised due to fat overlying the epidural space and the distance to the epidural space may be inaccurate if the subcutaneous tissue is compressed. Future development of ultrasound technologies may incorporate the use of ultrasound-guided needle techniques to aid epidural placement in challenging patients.⁷⁵ In some cases, a long 25-gauge needle can be used for infiltration of local anesthetic as well as to identify spinous processes. To determine whether needle placement is midline or lateral, the patient is often helpful in directing the needle to the midline (e.g., Does it feel like I'm in the middle of your back?). A recent study demonstrated that morbidly obese parturients were significantly more helpful in identifying the midline compared to non-obese.⁷⁶ Helpfulness also varied by the BMI. In most cases, standard neuraxial needles (9-10 cm) are usually of sufficient length if placement is midline.⁷⁷ However, longer needles (16 cm) are sometimes needed in extremely obese parturients. These needles can cause serious injury so they should only be used after careful assessment of the midline when standard needles are inadequate.

Single injection spinal anesthesia is a popular neuraxial anesthetic technique but there are concerns about technical difficulties, exaggerated spread of local anesthetic, hypotension, and an inability to prolong the block, especially in the obese patient. Spinal anesthesia is reasonable if the airway exam is normal, there is no cardiopulmonary disease, and the surgery is expected to be less than 90 minutes. It is often easier to

insert the spinal needle when a large gauge stiff epidural needle is used as a guide for the smaller flexible spinal needle.

Epidural anesthesia offers several advantages over single-injection spinal anesthesia including titratable dosing of local anesthetics, ability to prolong the block, decreased risk of excessive motor block, more controllable hemodynamic changes, and utilization for postoperative analgesia. However, in laboring patients, a multicenter prospective observational study found that epidural anesthesia failed more often than spinal or CSE techniques.⁷⁸ Increased maternal BMI was significantly related to failure of neuraxial techniques. Incremental dosing of epidural-administered local anesthetics will reduce the risk of hypotension and high block.

Catheter dislodgment is another potential problem in obese patients. Before securing the epidural catheter, a patient should move from an upright sitting position to a lateral position.⁷⁹ In this study by Hamilton et al, the changes in epidural catheter distance to skin with patient position modifications (sitting flexed to up, up to lateral, flexed to lateral) averaged a maximum of 0.67cm to 1.04cm (parturients with BMI<25 and >30 respectively). The changes in epidural catheter depth in this study were significantly increased with the BMI of patients, and the maximum observed changes in distance to skin were also significantly increased with the BMI (with >4cm change in one obese patient).⁷⁹ Because the ligamentum flavum has a mild grip on the epidural catheter, repositioning allows the epidural catheter to be pulled into the subcutaneous fat, sometimes by several centimeters. After repositioning, the catheter is subsequently taped in place without adjusting the catheter. This maneuver is helpful in reducing the incidence of catheter dislodgement and block failure.

Combined spinal-epidural anesthesia is an alternative to conventional spinal or epidural anesthesia, however there is concern that the technique is more complicated than either spinal or epidural alone and the epidural catheter is “unproven” during the duration of spinal analgesia. Although CSE catheters fail at similar rates compared with conventional epidural catheters,⁸⁰ delayed recognition of a non-functional epidural catheter is a disadvantage of this technique and is particularly problematic for prolonged surgical cases. This can increase the risk of intraoperative conversion to general anesthesia. However, even if the patient does not receive a “spinal dose” during CSE placement, the return of CSF in the spinal needle is confirmation of midline needle placement.

Peripheral nerve block. The use of peripheral nerve blocks with and without general anesthesia has been increasing for surgical procedures. In obese patients, these blocks can be technically challenging and have an increased failure rate compared to techniques performed in patients of normal weight.^{64,81} Although experience of the anesthesiologist with these blocks may influence their success, a large prospective study evaluating peripheral nerve blocks determined that the risk of block failure increased proportionately with BMI.⁸¹ Continuous supraclavicular, paravertebral, superficial cervical plexus and continuous epidural blocks had the highest failure rates. Supplemental general anesthesia was also needed to supplement these blocks more often. Another study also evaluated success rates of supraclavicular blocks in obese compared to non-obese patients and determined that success rates were also lower in the obese patients.⁸² However, the rate of successful blocks in obese patients remained high (94.3% versus 97.3%).

Dosing of local anesthetics during regional anesthesia can be challenging in the obese. For instance, if a patient receives too large of a dose, they may be at risk of hypotension, systemic toxicity or respiratory compromise related to diaphragmatic hemiparesis. If the dose is too small, there is a risk of block failure. Although absorption of local anesthetics is dependent on the site of injection (i.e., absorption is fastest with intercostal blocks followed by epidural and spinal blocks), calculation of the local anesthetic dose is an important consideration when performing a peripheral nerve block in these patients. The maximum safe

dose of local anesthetic for a peripheral nerve block is often based on patient weight. However, basing the dose on the actual weight in this patient population will increase the risk for systemic toxicity. Regardless of the route of administration (e.g., local infiltration, peripheral nerve block) local anesthetic dosing should be based on ideal body weight rather than actual weight.

Although there are advantages of peripheral nerve blocks in these patients, placement is often difficult due to difficult positioning, obscure anatomic landmarks, and inadequate needle length. Since increased BMI is associated with increased number of attempts and risk of block failure,⁶⁴ the use of ultrasound in these patients may be a helpful tool to increase block success^{83,84} as well as safety. Unlike techniques that use nerve-stimulators and/or paresthesias to identify proper needle position, ultrasound has the advantage of real-time identification of landmarks below the skin surface. Although real-time ultrasound has been shown to increase success rates,⁸³⁻⁸⁵ decrease procedure time,⁸⁶ and decrease the minimum effective dose of local anesthetic solutions⁸⁷ in patients receiving peripheral nerve blocks who are of normal weight, reports of use of this technique in the obese are more limited. Because a greater penetration depth of ultrasound is needed in the obese, the ultrasound must penetrate greater depths to reach the tissues.⁸⁸ Low-frequency transducers are needed for this degree of penetration. However, higher frequency transducers produce the best images.⁸⁸ Consequently, ultrasound images in the obese may be compromised due to an increased number of reflective surfaces and well as greater depth to the structures. Although success rates and procedure times are increased by the use of ultrasound technology in individuals of normal weight, there are reports of increased success rates in the obese undergoing peripheral nerve blocks.^{83,84} However, successful use of ultrasound for peripheral nerve blocks requires training and experience. Routine use of ultrasound-guided regional techniques in non-obese patients is likely to improve success rates in the obese. The American Society of Regional Anesthesia and Pain Medicine and the European Society of Regional Anesthesia have recommended education and training guidelines for ultrasound-guided regional anesthesia.⁸⁹

POST-OPERATIVE CARE

Morbid obesity increases the risk for postoperative complications, including: hypoxemia, atelectasis, deep venous thrombosis, pulmonary embolus, pneumonia, pulmonary edema, postoperative endometritis, wound infection, and dehiscence. Goals of effective postoperative care should be aimed at enhancing pulmonary function and preventing venous thrombosis. Early ambulation, thromboprophylaxis, chest physiotherapy, and effective postoperative pain control are essential in preventing complications in these patients.

Postoperative respiratory depression Multimodal analgesic techniques (e.g., non-steroidal anti-inflammatory agents) should be used to decrease total opioid requirements.⁹⁰ Obesity and postoperative respiratory complications have been identified as significant risk factors for anesthesia-related mortality.⁹¹ Postoperative respiratory depression from opioids continues to be a significant cause of high-severity injuries often resulting in death or brain damage. After review of the Joint Commission's Sentinel Event Database from 2004-11, the Joint Commission issued Sentinel Event Alert Issue 49 in 2012 regarding the safe use of opioids.⁹² The events included: wrong-dose medication (47%); improper monitoring (29%); and excessive dosing, medication interactions, adverse drug effects (11%). To further evaluate the associated factors for postoperative respiratory depression, The American Society of Anesthesiologists (ASA) Closed Claims Database was examined and identified 341 acute pain claims occurring between 1990 and 2009.⁹³ In the study, there was a higher proportion of claims for respiratory depression in obese patients compared to other acute pain claims. There was also a higher proportion of these claims with death or severe brain damage. The authors concluded that postoperative respiratory depression is a significant cause of death and

brain damage associated with neuraxial and/or patient controlled analgesia use and multimodal therapy. The authors suggested, "poor communication between prescribing physicians and nursing personnel is a common theme in opioid-induced respiratory depression claims. Moreover, many physicians and nurses do not appreciate the synergistic effects that opioids, benzodiazepines, some antiemetics and sleep aids have on respiratory drive."

The ASA has published recommendations for the postoperative care of patients with sleep apnea although they are not pregnancy-specific.¹⁷ Included in the guidelines are recommendations for postoperative monitoring:

- Regional anesthetic techniques should be considered to reduce or eliminate the requirements for systemic opioids in patients with OSA.
- If neuraxial anesthesia is planned, the benefits and risks of using an opioid or opioid-local anesthetic mixture as compared to local anesthetic alone must be considered.
- If patient-controlled systemic opioids are used, continuous background infusions should be avoided or used with extreme caution.
- Nonsteroidal anti-inflammatory agents and other modalities should be considered to reduce opioid requirements.
- Supplemental oxygen should be administered continuously to all patients who are at increased perioperative risk from OSA until they are able to maintain their baseline oxygen saturation while breathing room air.
- Hospitalized patients at increased risk of respiratory compromise from OSA should be monitored with continuous pulse oximetry after discharge from the recovery room.

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