Obesity is increasing in prevalence among pregnant women across the United States.\(^1\)\(^-\)\(^4\) At the University of Alabama, between 1980 and 1999, the frequency of obesity at the first prenatal visit doubled from 16% to 36%, and the frequency of weight over 300 pounds increased 10-fold from 0.5% to 4.9%.\(^1\) In the state of Utah in 2001, 37.8% of white women, 44.2% of black women, 43.8% of Latinas, and 61.1% of Native American women were obese at the time of delivery.\(^5\)

The definition of obesity in pregnancy is a matter of debate. The American College of Obstetricians and Gynecologists (ACOG) recommends using height and weight measured at the first prenatal visit to calculate the body mass index (BMI).\(^5\) Based on World Health Organization criteria,\(^6\) obesity is present when the BMI is 30 or above, and obesity may be further categorized by BMI into Class I (30 to 34.9), Class II (35 to 39.9), and Class III obesity (≥40). Morbid obesity corresponds to a BMI greater than 35 to 40 kg/m\(^2\).

Obesity complicates obstetric management, and has been associated with gestational hypertension, preeclampsia, gestational diabetes, and cesarean section.\(^7\)\(^-\)\(^13\) During the active phase of labor, the cervix dilates more slowly in obese women,\(^14\)\(^-\)\(^16\) and failure to progress is more common, even in patients with spontaneous onset of labor. Obesity increases the risk of emergency cesarean delivery in most but not all cohort studies that have evaluated the topic.\(^16\)\(^-\)\(^18\) For women who deliver by cesarean section, operative and postoperative complications include operative time greater than 2 hours, excessive blood loss, wound infection and endomyometritis, and increased length of hospital stay.\(^19\)\(^-\)\(^21\)

Obesity also impacts anesthetic management. Excessive body fat can obscure anatomic landmarks, complicating epidural and intravenous

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**Anesthetic Management for the Morbidly Obese Pregnant Woman**

**Jill M. Mhyre, MD**

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Obesity is increasing in prevalence among pregnant women across the United States.\(^1\)\(^-\)\(^4\) At the University of Alabama, between 1980 and 1999, the frequency of obesity at the first prenatal visit doubled from 16% to 36%, and the frequency of weight over 300 pounds increased 10-fold from 0.5% to 4.9%.\(^1\) In the state of Utah in 2001, 37.8% of white women, 44.2% of black women, 43.8% of Latinas, and 61.1% of Native American women were obese at the time of delivery.\(^5\)

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line placement. Skill in blind epidural placement is essential, and the technique is described below. Almost 75% of massively obese parturients require multiple placement attempts, and 14% require more than 3 attempts for successful epidural placement.\textsuperscript{18} Even catheters that seem to be properly sited are more likely to require replacement. Initial epidural catheter failure has been documented in 42\% of women over 300 pounds compared with 6\% of normal weight controls.\textsuperscript{17}

If general anesthesia is required for cesarean section, intubation is more likely to be difficult. In one case control study, the incidence of difficult intubation was 35\% (6/17) among pregnant women over 300 pounds compared with 0\% (0/8) among controls.\textsuperscript{17} This compares with a 22\% rate among nonpregnant obese surgical patients and 7.6\% among nonobstetric surgical patients with normal weight.\textsuperscript{22}

Maternal obesity, emergency surgery, and general anesthesia have each been associated with anesthesia-related maternal deaths.\textsuperscript{23} The most recent report of the Confidential Enquiries into Maternal Deaths in the United Kingdom found that 35\% of women who died were obese, compared with a general obesity rate of less than 17\%.\textsuperscript{24} The increase in anesthetic risk may be attributed to higher rates of comorbidities, pregnancy-related complications, and urgent and emergent operative obstetric procedures. Maternal deaths have been attributed to airway disaster during induction and emergence, aspiration pneumonitis, and failed resuscitation from hemodynamic collapse. Resuscitation is more difficult in obese patients than those of normal weight.

This paper reviews anesthetic considerations of morbid obesity and outlines a strategy to maximize anesthetic safety for morbidly obese pregnant women. Communication and coordination of the entire health care team are required to lead to the best possible outcomes for both the mother and her infant.

**The Preanesthetic Evaluation**

Because of increased rates of preexisting medical conditions and antepartum comorbidities that may lead to preterm delivery, the ideal time for anesthesiology consultation is the beginning of the third trimester. However, given the growing prevalence of obesity and production pressures of the current health care system, all but the most morbidly obese patients will likely be seen for the first time in the labor and delivery suite. If an anesthesiology consultation was not obtained antepartum, it should be conducted early in labor to allow adequate time for the development and communication of an anesthetic plan.\textsuperscript{5}

For morbidly obese women, the preanesthesia history and physical examination focuses on the airway, cardiovascular, and pulmonary systems. This examination will identify any comorbidities associated with
obesity, functional impairments, obstetric concerns, and reductions in physiologic reserve. Patient education may highlight potential anesthetic challenges, but should also reassure the patient that specific steps will be taken to maximize her safety and comfort. Discuss modifications in technique that may be considered, and communicate a provisional plan of anesthesia with the patient and obstetrician. To convey respect, refer to the patient’s body habitus by using the term “weight” and avoid descriptors such as obese, fat, unhealthy, excess, heavy, or large which have pejorative connotations.

Obesity and pregnancy each lead to physiologic changes in multiple organ systems. The most important changes are in the airway, the respiratory and cardiovascular systems. Many of the effects of obesity and pregnancy are additive, and lead to significant functional impairment, decreased physiologic reserve, and increased obstetric and anesthetic risk in the morbidly obese pregnant woman. However, the magnitude of resulting abnormalities cannot be predicted based on weight or BMI alone. Knowledge of potential pathophysiology is best used as a guide to individual patient evaluation and tailored management.

**Airway**

Obesity and pregnancy each increase risk for difficult intubation. Both conditions also increase metabolic rate, reduce the functional residual capacity (FRC), and shorten the period of time available for direct laryngoscopy and intubation before hypoxemia develops. Optimal positioning for induction of general anesthesia is critical for the morbidly obese pregnant women, but may be difficult to achieve in patients with limited mobility, particularly in the setting of obstetric emergency. Pregnancy increases mucosal edema of the nasopharynx, oropharynx, and larynx, particularly in patients with pregnancy-induced hypertension.

A careful airway evaluation should be completed just before any anesthetic procedure, and should include a measure of neck circumference, Mallampati score, mouth opening, and evaluation of dentition, thyromental distance, neck range of motion, and the ability to sublux the lower teeth beyond the upper teeth. Symptoms such as stridor, hoarseness, and difficulty breathing through the nose may all help to identify airway edema. Among obstetric patients, the combination of Mallampati score and thyromental distance has a sensitivity of 100% and positive predictive value of 61.5%.

A plan for airway management should be constructed in the event of emergency for all women, regardless of the primary obstetric and anesthetic plan. Although rapid sequence intubation with proper positioning and back up equipment may be safe for most women, the potential for both difficult intubation and mask ventilation should
prompt consideration of an alternative airway management plan. A history of snoring, a diagnosis of sleep apnea, lack of teeth, and large breasts all increase risk of difficult ventilation. Awake direct laryngoscopy or fiberoptic intubation should be considered in women with a limited range of motion of the neck, head or jaw, a short neck, over 15 inches in neck circumference, and a Mallampati score of 3 or above.

**Respiratory System**

Both pregnancy and obesity alter pulmonary mechanics, lung volumes, FRC, oxygenation, and ventilation. In general, these effects are additive. Chest wall compliance is significantly reduced in both conditions. In obese individuals, adipose tissue over the chest wall and abdomen decrease chest wall compliance and limit tidal volumes, particularly in the supine and Trendelenburg positions. In pregnancy, the gravid uterus presses cephalad and increases expiratory reserve volume, encourages flaring of the ribs, expands the transverse diameter of the chest, and leads to further reductions in chest wall compliance. Thoracic muscle weakness induced by spinal anesthesia can exacerbate these adverse effects on pulmonary mechanics. Obese women who receive spinal anesthesia for cesarean section experience significant and prolonged (>3 h) derangements in vital capacity, forced vital capacity, and forced expiratory volume in 1 second. During cesarean section, pulmonary mechanics may improve after abdominal incision and delivery of the fetus.

Both pregnancy and obesity increase metabolic demands, oxygen consumption, and CO$_2$ production. These effects combine with decreased chest wall compliance to significantly increase work of breathing and decrease respiratory reserve. In the supine and Trendelenburg positions, FRC may fall below closing capacity leading to small airway collapse, atelectasis, ventilation perfusion mismatch, and hypoxemia. Measurement of oxygen saturation in the sitting and supine positions may provide evidence of airway closure during normal ventilation, and may indicate the margin of pulmonary reserve.

In some respects, pregnancy may be protective for obese women. Progesterone increases sensitivity of the brainstem to CO$_2$, is a direct respiratory stimulant, and promotes lower airway dilation. In the awake patient in the upright position, oxygenation and ventilation seem to be intermediate between normal weight term pregnant women and obese, nonpregnant women (Table 1). Both obesity and pregnancy decrease expiratory reserve volume and FRC, but these effects are not necessarily additive. For obese women with reduced prepregnancy FRC, further reduction in pregnancy is limited.

Women with obesity are more likely to have obstructive sleep apnea, but the prevalence of sleep apnea in pregnancy is unknown. Sleep disturbance and daytime fatigue are normal at the end of pregnancy, so
sleep apnea may go undiagnosed. Women with a BMI above 35 kg/m², a neck circumference above 16 inches, symptoms of suspected airway obstruction during sleep (including frequent or loud snoring, observed pauses in breathing during sleep, frequent arousals from sleep or arousals associated with a choking sensation), or significant daytime somnolence should be screened by polysomnography for sleep apnea and fitted for continuous positive airway pressure.

Obesity hypoventilation syndrome (OHS) affects a subset of individuals with sleep apnea. In response to chronic hypoventilation and hypoxemia, these patients develop polycythemia, increased cardiac output, cardiomegaly, pulmonary hypertension and eventually right heart failure. Case reports point to a significant increase in morbidity and mortality. Arterial blood gas is useful to screen for hypercarbia, hypoxemia, acidosis, and polycythemia. If OHS is suspected, then a cardiology referral is warranted to evaluate cardiac function using echocardiography.5

Cardiovascular System

Both obesity and pregnancy are associated with increased circulating blood volume, stroke volume, and cardiac output. As a result, the obese pregnant woman may present with a hyperdynamic cardiovascular system and eccentric cardiac hypertrophy including an increase in left atrial size, left ventricular thickness, intraventricular septal thickness, and overall left ventricular mass.33 Vascular resistance is stable through pregnancy, but cardiac output increases and may lead to exacerbation of prepregnancy hypertension and diastolic dysfunction, even when systolic function remains normal.34 Pulmonary blood volume increases in proportion to the increase in cardiac output. Pulmonary hypertension can develop and is exacerbated by the supine position, airway obstruction, and hypoxemia.35

Long-standing morbid obesity is associated with dilated cardiomyopathy and systolic dysfunction that seems to develop if left ventricular hypertrophy is insufficient to meet increased demand for cardiac

<table>
<thead>
<tr>
<th>Blood Gas Measurements by Pregnancy and Obesity Status</th>
<th>( \text{PaO}_2 (\text{SD}) ) mm Hg</th>
<th>( \text{PaCO}_2 (\text{SD}) ) mm Hg</th>
<th>pH (SD)</th>
<th>Mean BMI (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal weight term pregnant(^{36})</td>
<td>101.8 (1.0)</td>
<td>30.4 (0.06)</td>
<td>7.43 (0.006)</td>
<td>23.6 (20)</td>
</tr>
<tr>
<td>Obese term pregnant(^{31})</td>
<td>85 (5.0)</td>
<td>29.7 (2.8)</td>
<td>7.44 (0.04)</td>
<td>43.5 (12)</td>
</tr>
<tr>
<td>Obese postpartum(^{31})</td>
<td>86 (10)</td>
<td>35.5 (3)</td>
<td>7.44 (0.04)</td>
<td>41.4 (12)</td>
</tr>
<tr>
<td>Obese nonpregnant(^{32})</td>
<td>76.7 (16.1)</td>
<td>41.3 (5.7)</td>
<td>Not available</td>
<td>39.5 (62)</td>
</tr>
<tr>
<td>Obese nonpregnant with sleep apnea(^{32})</td>
<td>70.9 (11.7)</td>
<td>42.8 (5.0)</td>
<td>Not available</td>
<td>39.6 (40)</td>
</tr>
</tbody>
</table>

Table 1. 

Morbid Obesity in Pregnancy

Morbid Obesity in Pregnancy

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output.\textsuperscript{36} In addition, sleep apnea and OHS may lead to pulmonary hypertension and right heart failure. There have been several case reports of peripartum cardiomyopathy in the setting of obesity,\textsuperscript{37,38} but it is unclear whether obesity is a risk factor for peripartum cardiomyopathy. Whatever the etiology of heart failure, signs and symptoms in pregnancy include progressive dyspnea, orthopnea, wheezing, nocturnal cough, new regurgitant murmurs, pulmonary crackles, neck vein distension, unexplained tachycardia, and weight gain over 2 to 3 pounds per week.

Obese women are at risk to develop profound supine hypotensive syndrome. The weight of the uterus and abdominal adipose tissue can compress the inferior vena cava, decrease cardiac preload, and lead to reflex tachycardia or decreased cardiac output. In fact, obese pregnant women often demonstrate resting tachycardia in the sitting position which resolves in the left lateral decubitus position.\textsuperscript{39} Tseuda\textsuperscript{40} reported 2 cases of cardiac arrest in nonobstetric morbidly obese patients who were placed in the supine position.

Finally, women with a BMI above 30 are more likely to be older and to have preexisting comorbidities that affect the cardiovascular system, including type II diabetes, chronic hypertension, and coronary artery disease. Obesity metabolic syndrome includes dyslipidemia, impaired endothelial function, high blood pressure, increased inflammatory mediators, insulin resistance, and hyperinsulinemia even in the absence of diabetes.\textsuperscript{41,42}

A careful history and physical examination, a 12-lead ECG, and a chest x-ray may be used to screen for coronary artery disease, cardiac dysfunction, hypertension, left ventricular hypertrophy, cardiac rhythm disturbance, and cardiomegaly. A cardiology evaluation is helpful for any symptomatic morbidly obese parturient to further evaluate cardiovascular disease and to optimize function before the onset of labor and delivery or cesarean section.\textsuperscript{5}

**Gastrointestinal System**

Obesity may worsen pregnancy-associated changes in lower esophageal sphincter tone, and increase the risk for pulmonary aspiration of gastric contents. Hiatal hernia is more common in obese individuals. Mean gastric volume is increased in obese women in labor compared with women of normal weight.\textsuperscript{43–45} Obesity may be associated with abnormalities in liver function. An increase in transaminase greater than 30 IU or an abnormal coagulation profile should prompt evaluation for hepatic disease.

**Endocrine System**

Type II and gestational diabetes mellitus are both associated with obesity. For obese women, diabetes screening is recommended both during the first trimester, and again later in pregnancy if the initial
screen is negative. The combination of diabetes and obesity further increase risk of fetal macrosomia and obstetric complications including cesarean section. Optimal management of diabetes in the intrapartum period includes an insulin infusion because insulin requirements may escalate in labor and drop precipitously postpartum.

**Anesthetic Management**

In general, standard principles of obstetric anesthesia apply for obese parturients. However, depending on the degree of obesity, the airway examination, perinatal complications, and cardiopulmonary physiology, certain precautions will help maximize maternal and fetal safety.

**Monitoring**

Blood pressure measurement requires an adequate cuff size to avoid overestimation of pressures, but if the upper arm is excessively large or cone-shaped, then a small cuff over the calf or forearm may be more reliable. An arterial line is helpful if noninvasive pressures are unreliable or frequent arterial sampling is indicated. Central venous and pulmonary artery monitoring may be considered for women with severe preeclampsia, hemorrhage, and respiratory or cardiac failure. In morbidly obese women, internal jugular cannulation is most easily achieved using ultrasound guidance. Continuous pulse oximetry is helpful during labor and essential during cesarean section, and may be used to guide analgesic dosing, positioning, and administration of supplemental oxygen.

**Intravenous Access**

Intravenous access may be difficult to achieve. Central venous cannulation is helpful if peripheral access is unobtainable or tenuous, or if the patient needs a second line to accommodate an insulin or magnesium infusion. Intraoperative hemorrhage should be anticipated in extremely obese women and those with prior cesarean section. The need for additional blood products and intravenous access should be considered well in advance.

**Positioning and Transport**

Uterine displacement is necessary even early in pregnancy to avoid aortocaval compression by either the uterus or the heavy abdominal wall. A semirecumbent position will improve pulmonary mechanics and help to avoid hypoxemia. Finally, once a neuraxial catheter is in place, teach the patient how to move to protect the catheter. She should sit up and wiggle on her bottom rather than role or slide on her back.
Morbidly obese women in labor require a clear plan for transport and positioning in the event of urgent or emergent surgical delivery. Additional personnel and equipment may be necessary to transport the patient efficiently to the operating room and position her optimally on the operating table. The anesthesiologist must focus on maternal and fetal well-being, protection of the epidural catheter en route, assessment of catheter function, and the establishment of a surgical level of anesthesia in the operating room.

**Aspiration Prophylaxis**

Standard aspiration prophylaxis should be applied for obese pregnant women. Once labor becomes active or the patient receives opioid analgesia, then restrict the diet to clear liquids. Elective cesarean section patients should fast for 8 hours. A nonparticulate antacid solution should be administered less than 30 minutes before anesthetic induction. Ranitidine and metoclopramide may be used as adjuncts.

**Thromboembolism Prophylaxis**

Graduated compression stockings, hydration, and early mobilization are recommended for obese patients delivering by cesarean section. Postpartum heparin therapy may be considered for patients thought to be at high risk for venous thromboembolism.

**Antibiotic Prophylaxis**

Because endometritis, postoperative wound infection and dehiscence are all more common in obese women, ACOG recommends antibiotic prophylaxis after clamping of the cord for all obese women who deliver by cesarean section, even if surgery is elective.

**Analgesia for Labor and Anticipated Vaginal Delivery**

Neuraxial blockade with an indwelling catheter is the preferred method for labor analgesia in obese and morbidly obese women. Carefully titrated epidural analgesia allows for an alert mother, high quality pain relief, and a minimal impact on pulmonary, hemodynamic, and physical function. Alternative methods such as inhalational nitrous oxide or systemic opioids may lead to maternal drowsiness, airway obstruction, and hypoxemia. In addition, a neuraxial block can be extended to provide anesthesia for cesarean section and postoperative analgesia. Because obese women are at increased risk for unplanned cesarean section, for difficult and prolonged neuraxial block placement, and for difficult airway management, a well-functioning neuraxial catheter is also a safety device in the event of an urgent or emergent surgical delivery.
Regional anesthesia for a morbidly obese patient can present a technical challenge. Often, a slight indentation between the spinous processes may be appreciated with deep palpation. If this is not the case, the difficulty of placement increases particularly if the patient has scoliosis or another underlying spine abnormality. Increased depth of the epidural space exaggerates minor deflections of the needle tip, and increases the likelihood of placement failure. Early epidural placement should be encouraged to allow ample time in the event that multiple attempts are required. Early placement also ensures that the anesthetic evaluation is completed so that a multidisciplinary plan may be constructed to optimize patient safety.

To improve initial success rate of the epidural placement, the sitting position is recommended. Morbidly obese women tend to be most comfortable sitting on the side of the bed with a stool placed under the feet for support. The sitting position allows the fat of the back and buttocks to settle laterally and symmetrically, and improves identification of the midline. Conversation with the patient, observation of the entire back, and deep finger palpation should all be used to locate the midline and any evidence of spinal landmarks before infiltrating the area with local anesthetic. A long (3.5 cm) 25-gauge needle is helpful to infiltrate a generous dose of local anesthesia and to locate spinous processes. Each pass of this and the epidural needle should be used to build a 3-dimensional map of the spinal anatomy—to locate first the spinous processes, then the space between them, and finally the track that leads to the epidural space. Information from the patient may be invaluable in correcting minor lateral deviations.

Occasionally, a long epidural needle is required to reach the epidural space. Options include 12, 18, and 20 cm needles. These longer needles have the potential to cause serious injury, so the standard needle should be used first. A long needle should only be used after developing a clear idea of the location, direction, and approximate depth of the ligamentum flavum and epidural space.

Using loss of resistance to saline, pockets of fat may feel like the epidural space. If the ligament feels soft, or if the loss of resistance is ambiguous, it may be helpful to clear the bevel of the needle with the stylette and test the loss of resistance a second time. Alternatively, a long 25-gauge Whitacre needle may be inserted through the epidural needle to check for cerebrospinal fluid to test whether the tip of the epidural needle is close to the subarachnoid space.

If attempts at lumbar epidural placement are not successful, ultrasound guidance may be helpful in locating the intervertebral space and in estimating the depth from the skin to the ligamentum flavum. Accurate measurement requires a 5.0-MHz curved array probe. Another option is to place a low thoracic epidural catheter. The standard lumbar epidural catheter should be inserted in a cephalad direction, 4 to 5 cm.
The epidural catheter may be tested with a normal test dose. Because epidural pressure is increased in obese women, the meniscus test or any other technique that relies on subatmospheric pressure may be less useful. Intravascular placement seems to be more common in obese women because of increased engorgement of the epidural veins. If an intravascular catheter is diagnosed, then replacement can be attempted in the lateral and head-down position, although this may increase technical difficulty of locating the epidural space.

If placement results in an inadvertent dural puncture, the epidural catheter may be introduced into the subarachnoid space. Additionally, if attempts to locate the epidural space fail, then an intentional dural puncture and subarachnoid catheter placement may be successful. The catheter should be inserted 2–3 cm into the subarachnoid space, and then aspirated until cerebrospinal fluid fills the catheter and all air is removed. Rather than administer a test dose, the initial bolus is titrated using 1 mL increments of a standard labor epidural solution. Once the desired level is established, it is maintained using an infusion of the same solution at 1 to 2 mL/h. Careful documentation and communication are necessary to ensure that all personnel who may dose the catheter are aware it is sited in the subarachnoid space. The incidence of postdural puncture headache is lower in obese women.

Once the neuraxial catheter is in position, support the catheter manually while the patient lies down in the lateral position before taping. Taping in the lateral position minimizes the chance of catheter dislodgment when the patient places traction on her back. This recommendation is based on the theory that the catheter is secured internally by the ligamentum flavum and that the subcutaneous back tissue slides over the catheter when the patient moves from the flexed sitting to lateral decubitus position. This maneuver maximizes the amount of redundant catheter between the skin and the ligamentum flavum, and is particularly important for women with significant deposition of adipose tissue in the lumbar region.

Some authors recommend avoiding narcotic in the initial epidural loading dose. Although administration of opioid by any route will provide some pain relief, it should not impair assessment of the sensory level, and a catheter should be considered satisfactory only after the patient demonstrates bilateral loss of sensation to pinprick or temperature in a distribution that expands in proportion with epidural dosing. Frequent monitoring of the quality and distribution of the sensory and motor block will allow for adjustment of the epidural dose and early identification of a dislodged epidural catheter. Although some data suggest that obese women have more painful labors, the minimum local anesthetic concentration is lower in obese women compared with those of normal weight. Therefore, if a patient is obese, and pain relief is not optimal, the patient should be examined because the catheter may need to be replaced.
Anesthesia for Cesarean Section

Positioning

All morbidly obese patients undergoing cesarean section should be placed in a ramped position with left uterine displacement, regardless of primary anesthetic technique or intent to induce general anesthesia. The ramped position has been shown to improve laryngoscopic view in morbidly obese patients undergoing elective bariatric surgery\textsuperscript{54} (Fig. 1). The effect may be even more important for parturients with large breasts which can obstruct insertion of the laryngoscopic blade. In the ramped position, blankets are folded under the chest and head to achieve horizontal alignment between the external auditory meatus and the sternal notch.\textsuperscript{54} This position aligns the oral, pharyngeal, and tracheal axes, and frees the mandible to accommodate the tongue and laryngoscopic blade. In addition, regional anesthesia has been associated with a significant decrease in spirometric parameters\textsuperscript{55} and the 30-degree head-up position may minimize the impact on maternal respiratory mechanics and oxygenation. Once the anesthetic is established, blankets may be adjusted to improve surgical access if necessary.

If the panniculus requires significant retraction or suspension, monitoring of maternal hemodynamics and fetal heart tones should follow. In particular, cephalad retraction of a heavy panniculus can cause aortocaval compression, maternal hypotension, nonreassuring fetal heart tones, and even fetal death.\textsuperscript{56}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{image1.png}
\caption{A morbidly obese patient will be in position for direct laryngoscopy when an imaginary horizontal line can be drawn from the sternal notch to the external auditory meatus. From Anesth Analg. 2003;96:1841–1842.}
\end{figure}
A morbidly obese patient who is ramped and tilted may be unstable on the operating table. Lateral table extenders may help. Her legs in particular should be well secured. Confirm that the patient fits within the weight limits of the table. The arm board should be padded with foam or blankets to align the shoulder and arm in a horizontal plane, to maximize patient comfort, to improve patient stability on the table and to avoid an upper extremity neurologic injury.57

The full spectrum of anesthetic options for cesarean section includes epidural, spinal, continuous spinal, combined spinal-epidural, infiltration, and general anesthesia.

**Epidural Anesthesia**

Epidural anesthesia is preferred if a functional catheter is already in place, if the surgery is likely to take longer than 2 hours, if the airway examination is concerning, or if cardiopulmonary function is impaired. Duration of cesarean section can exceed 2 hours in over half of women who weigh above 250 pounds.18 A repeat cesarean section, planned tubal ligation, and a panniculus that requires suspension are other situations where prolonged surgery can be anticipated.

Incremental doses of anesthetic solution (such as 2% lidocaine with epinephrine or 0.25% bupivacaine) are administered until the desired level of anesthesia is achieved. Incremental dosing allows the anesthesiologist to optimize hemodynamic stability during the anesthetic induction and to avoid an excessively high block. The anesthetic is sufficient for surgery when the sensory level to touch reaches the T5 level.58,59 The nipple line is unreliable in an obese parturient. Instead, the xiphoid process and the clavicles should be identified, and the T5 level estimated as one-third of the distance cephalad from the xiphoid process.

**Spinal Anesthesia**

An obese woman is a candidate for spinal anesthesia if the airway examination is normal, cardiopulmonary derangements are minimal, and the obstetricians expect to complete the surgery in less than 90 minutes. Spinal placement may be technically challenging, especially in cases requiring a long Whitacre needle. If initial placement attempts fail, a Tuohy needle may be sited in the epidural space and used as a long introducer for the Whitacre. To avoid an excessively high block, the dose of hypobaric bupivacaine may be reduced. An alternative strategy is to inject a standard dose of hyperbaric bupivacaine with the patient in a sitting position, then rapidly insert a ramp behind the patient and guide the patient into a ramped position (Fig. 1) with left uterine displacement. This position raises the cervical and thoracic spine, and avoids elevation of the lumbar and sacral spine in women with large buttocks.
The bed may be adjusted into a Trendelenburg position to optimize block height. Blankets may be adjusted to improve surgical access, but the ramp should be left in place in the event that induction of general anesthesia is required.

**Combined Spinal Epidural Anesthesia**

Combined spinal epidural anesthesia may be chosen to achieve a dense block over the incision site, a relatively rapid onset, and the option to extend the duration of anesthesia. If the block is sited with the patient in the sitting position, a hyperbaric spinal solution will settle in the sacral dermatomes while the epidural catheter is threaded. By allowing the anesthetic solution a small amount of time to settle caudally, the anesthesiologist ensures that supplementation with epidural anesthesia will be required to achieve a block sufficient for surgery. If the desired block is achieved with the spinal dose alone, then the epidural catheter remains untested before the onset of surgery. General anesthesia may become necessary if the epidural catheter fails.

**Continuous Spinal Anesthesia**

A continuous spinal catheter may be used if epidural placement is difficult or results in an inadvertent dural puncture. It is important to flush the catheter before placement to avoid introducing air into the spinal space which could cause a pneumocephalus headache. Postdural puncture headache is uncommon in obese parturients. Incremental doses of 0.5 to 1 mL of dilute local anesthetic may be administered with the patient in the ramped position. Final density and level are proportional to the dose in milligrams, not the volume delivered.

**Infiltration Anesthesia**

Infiltration anesthesia may be considered in rare circumstances when alternative anesthetic techniques fail or present unacceptable risks. One case report describes use of infiltration anesthesia for cesarean section in a morbidly obese parturient (150 kg) with pre-eclampsia and generalized edema. The skin incision was infiltrated with 8 mL lidocaine 1% with epinephrine (80 mg). The rectus sheath and peritoneum were infiltrated with a total of 60 mL of 0.5% lidocaine with epinephrine (300 mg). Nitrous oxide in oxygen (50:50) was used to supplement the infiltration anesthesia.

**General Anesthesia**

When general anesthesia is indicated, safety may be enhanced by considering awake intubation, optimizing patient position, locating back-up airway equipment, and recruiting additional experienced
personnel. Urgency of the obstetric indication must be balanced against the time required to achieve a safe anesthetic induction. Ongoing readiness for the possibility of general anesthesia will facilitate efficiency and safety in the event that it becomes necessary.

The optimal position for rapid sequence induction of general anesthesia has been described above. Essential airway equipment includes a short handled Datta laryngoscope, a variety of laryngoscopic blades, cuffed endotracheal tubes, oral airways, a gum elastic bougie, and either a laryngeal mask airway (LMA) or a Combitube. Both the LMA and the Combitube have been used to rescue pregnant patients in scenarios of failed intubation and ventilation. For most anesthesiologists, the LMA is more familiar, and therefore preferred. Equipment for cricothyroidotomy and transtracheal jet ventilation should also be available. Experienced personnel should be on hand to assist in the event that intubation is difficult.

If the airway evaluation indicates that intubation will be straightforward, then rapid sequence induction in a ramped position is appropriate. Complete denitrogenation is essential because both obesity and pregnancy accelerate apneic oxygen desaturation. Preoxygenation in the 25-degree head-up position increases oxygen tension and the time to desaturation for morbidly obese nonobstetric patients. Three minutes of tidal volume breaths or 8 maximal breaths with 100% oxygen are preferred if time allows, but 4 maximal breaths with 100% oxygen may be used in emergency situations.

Induction medications should be based on lean body weight, estimated as 20% to 30% above the ideal body weight. In a stable patient, induction may be achieved with thiopental 4 mg/kg up to 500 mg. Etomidate (0.1 to 0.3 mg/kg) is preferred for patients with cardiac dysfunction, and ketamine (1 mg/kg) may be considered for patients with evidence of significant blood loss. Succinylcholine 1 to 1.5 mg/kg total body weight up to 200 mg is the drug of choice to facilitate tracheal intubation. Capnography and bilateral lung auscultation should be used to confirm successful intubation before surgical skin incision.

If initial attempts to intubate the trachea fail, it is critical to follow a difficult airway algorithm. Focus on adequate maternal oxygenation. Mask ventilation is best achieved with an oral airway and 3 people—one to apply cricoid pressure, a second to maximize jaw-thrust, and a third to squeeze the bag and monitor the patient. If ventilation fails, the team should insert a supraglottic airway device and prepare to create a surgical airway. The LMA is the preferred choice for many anesthesiologists.

In cases where difficult intubation is expected, the obstetrician and patient should know that awake fiberoptic intubation would be required in the event that general anesthesia becomes necessary. Every effort should be made to monitor these patients closely, to make conservative obstetric decisions, and to avoid obstetric emergency. Alternative airway
techniques such as awake direct laryngoscopy, fiberoptic intubation through an LMA, and Bullard laryngoscopic intubation have been described.

**Maintenance of General Anesthesia**

Patients with morbid obesity experience further reduction in FRC under general anesthesia. Techniques to maintain oxygenation include: (1) increased tidal volume (12 to 15 mL/kg ideal body weight); (2) increased fraction of oxygen delivered (FiO$_2$ > 50%); (3) the reverse Trendelenburg position; (4) panniculus suspension. Positive end-expiratory pressure slightly improves PaO$_2$, but can worsen cardiac output and oxygen delivery to the fetus. Increasing FiO$_2$ seems to be the most effective way to improve oxygenation in a morbidly obese patient. However, if over 50% oxygen is required to maintain maternal saturation, then nitrous oxide may not be sufficient to ensure amnesia and alternative amnestics should be administered. Isoflurane, sevoflurane, and desflurane have all been used at standard concentrations in obese parturients. In nonobstetric patients with morbid obesity, desflurane allows for faster recovery compared with sevoflurane or isoflurane, but with 0.5 MAC used at the end of cesarean section, any of the 3 agents should yield a reasonably rapid emergence. Dense intraoperative neuromuscular blockade is best achieved by titrating intermediate acting agents using a twitch monitor.

Emergence, extubation, and recovery represent critical periods for obese women who deliver under general anesthesia. To maximize safety during this period: (1) ensure adequate return of muscle function with a twitch monitor and neostigmine reversal; (2) insert an orogastric tube to empty the stomach just before emergence; (3) use a LITA endotracheal tube (Laryngotracheal Instillation of Topical Anesthetic) and anesthetize the trachea just before emergence; (4) delay extubation until the patient is completely awake, sitting upright and is able to meet intensive care extubation criteria; (5) administer supplemental oxygen in recovery; (6) monitor the patient with pulse oximetry throughout the recovery period.

**Postoperative Care**

After cesarean delivery, the semirecumbent position maximizes oxygenation by increasing FRC, and continuous pulse oximetry may be used to guide the administration of supplemental oxygen. For patients with sleep apnea, continuous positive airway pressure or bilevel positive airway pressure will help to maintain airway patency and minimize atelectasis. Five-lead EKG is added to routine cardiovascular monitoring for women with cardiac disease or long standing diabetes. Hemodynamic monitoring must be vigilant, and staff caring for the patient should be aware that a morbidly obese abdomen may obscure intra-abdominal hemorrhage.
Postoperative analgesia is important to enhance pulmonary function, avoid respiratory and venous thrombotic complications, and accelerate functional recovery. Opioid analgesia may be delivered by intravenous patient-controlled analgesia, but analgesia and functional recovery seem to be better when the opioid is dosed via the epidural catheter or intrathecal injection. Each method has the potential to cause respiratory depression, particularly for patients with extreme obesity or sleep apnea. Apnea monitors and continuous pulse oximetry are prudent in the first 24 hours. A patient at high risk for postoperative respiratory complications may be best managed with an epidural catheter dosed with a dilute solution of local anesthetic and lipophilic opioid.

**Conclusions**

There is no single cure for the obesity epidemic, but all health professionals, including anesthesiologists, have opportunities to contribute solutions. Anesthesiologists should be prepared to discuss weight with obese patients. Few individuals are aware of the impact of obesity on their health or health care, but for many, motivation to control weight depends on the recognition that obesity has caused significant harm. The postoperative visit is an opportunity to discuss the impact of the patient’s weight on her birth experience and her anesthetic care, and the importance of losing weight before her next pregnancy.

At the same time, anesthesiologists must strive to maximize safety and comfort for obese women throughout the peripartum period. A coordinated team approach, with frequent consultation between the anesthesiologist, obstetrician, nurse and patient, will facilitate medical management, minimize anesthetic and obstetric risk, and optimize the birth experience for the patient and her family.

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**References**


