4 Anesthesia for the Morbidly Obese Pregnant Patient

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4.1 Introduction

4.1.1 Epidemiology

Rates of obesity have been increasing exponentially for the past several decades, with an estimated 1.46 billion overweight and 602 million obese adults worldwide [1]. In the United States, approximately 36% of adults are overweight or obese, and this prevalence is higher among women [2]. Depending on the population studied, there is an approximately 20% incidence of obesity in pregnancy [3]. The management of morbidly obese women during pregnancy presents a challenge to obstetric and anesthesia providers alike. This is mainly due to frequently comorbid disease states including hypertension, diabetes, cardiovascular, and thromboembolic disease. However, obesity itself can have negative effects on pregnancy course and outcomes, including increased rates of pregnancy-induced hypertension, gestational diabetes, cesarean delivery, hemorrhage, fetal macrosomia, preterm birth, and stillbirth [4].

Studies evaluating morbidity and mortality associated with a diagnosis of obesity in pregnancy are confounded by variability in widely accepted definitions. The World Health Organization classifies obesity according to body mass index (BMI) which is defined as weight in kilograms divided by the square of height in meters. Overweight is defined as BMI greater than or equal to 25, with obesity further categorized into three categories—class 1 (BMI 30–34.9 kg/m^2), class 2 (BMI 35–39.9 kg/m^2), and class 3 (BMI > 40 kg/m^2).

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4.2 Physiologic Changes of Obesity and Pregnancy

4.2.1 Cardiovascular Changes

Both obesity and pregnancy increase the amount of tissue requiring perfusion as well as oxygen demand; and therefore, both increase overall demand on the cardiovascular system. Heart rate, stroke volume, cardiac output, and blood volume increase with both obesity and pregnancy. Cardiac output (CO) is increased 30–50 ml/min for each additional 100 g of adipose tissue. Pregnancy further increases CO up to 50%. Endothelial dysfunction which accompanies obesity as a result of higher levels of leptin, insulin, and other inflammatory mediators predisposes obese patients to hypertension as a result of increased systemic vascular resistance (SVR). Pregnancy, on the other hand, tends to decrease SVR, and these changes may offset. Pulmonary vascular resistance (PVR) and pulmonary artery pressure (PAP) are also increased as a result of obesity due to potential left ventricular hypertrophy and dysfunction, increased pulmonary blood flow, and sleep apnea with resulting chronic hypoxia. While pregnancy itself does not affect systolic or diastolic function, obesity can impair both, leading to heart failure and other sequelae. The physiologic effects seen in obesity and pregnancy as well as the anticipated combined effects are summarized in Table 4.1.

4.2.2 Respiratory Changes

The respiratory system is considerably affected by both obesity and pregnancy. The most clinically significant ventilatory effects include decreases in functional residual capacity (FRC), residual volume (RV), and expiratory reserve volume (ERV) as a result of cephalad diaphragm movement due to the gravid uterus in pregnancy and abdominal and chest wall adiposity seen in obesity. These changes combined with increased oxygen consumption also seen in both pregnancy and obesity lead to rapid desaturation during apneic episodes. Tidal volume and minute ventilation increase during pregnancy as a result of progesterone's effects on the medullary respiratory centers. Overall, both pregnancy and obesity result in restrictive-type

Table 4.1 Physiologic changes of the cardiovascular system associated with pregnancy and obesity [5]

	Pregnancy	Obesity	Combined
Heart rate	↑	↑↑	↑↑
Stroke volume	↑↑	↑	↑
Cardiac output	↑↑	↑↑	↑↑↑
Systemic vascular resistance	↓↓	↑	↔ or ↓
Mean arterial pressure	↑	↑↑	↑↑
Systolic function	↔	↔ or ↓	↔ or ↓
Diastolic function	↔	↓	↓
Central venous pressure	↔	↑	↑↑
Pulmonary wedge pressure	↔	↑↑	↑↑

ventilatory patterns. Oxygenation can be impaired by both obesity and pregnancy if the FRC falls below the closing capacity (CC), resulting in shunting and ventilation/perfusion mismatching. Both pregnant and obese patients also tend to have lower baseline arterial oxygen partial pressures (P_aO_2), with this change amplified in morbidly obese parturients. Finally, both pregnancy and obesity can be associated with difficult airways as a result of capillary engorgement with mucosal edema or soft tissue adiposity, respectively. These airway changes can lead to the development of obstructive sleep apnea in both populations. For a full list of the physiology effects of obesity and pregnancy on the respiratory system, see Table 4.2.

4.2.3 Gastrointestinal Changes

Both obesity and pregnancy result in increased intra-abdominal pressure, decreased gastrointestinal motility, and decreased lower esophageal sphincter tone, putting morbidly obese parturients at greater risk of pulmonary aspiration of gastric contents. Changes in gastric volume and gastric pH associated with obesity and pregnancy are less clear, with some studies showing higher volumes of more acidic fluid, while others show no difference [6, 7]. Comorbid diabetes is frequently diagnosed in this patient population, which is also associated with delayed gastric emptying.

4.2.4 Endocrine Changes

Diabetes mellitus and gestational diabetes are both more common among obese parturients compared to those of normal weight. This most likely results from increased levels of inflammatory mediators which results in insulin resistance and hyperglycemia.

4.2.5 Hematologic Changes

Both pregnancy and obesity are independently associated with hypercoagulability, venous stasis, and endothelial injury, and together they combine to dramatically

Table 4.2 Physiologic changes of the respiratory system associated with pregnancy and obesity [5]

	Pregnancy	Obesity	Combined
Tidal volume	↑	↓	↑
Respiratory rate	↑	↔ or ↑	↑
Minute volume	↑	↓ or ↔	↑
Expiratory reserve volume	↓	↓↓	↓
Residual volume	↓	↓ or ↔	↓
Functional residual capacity	↓↓	↓↓↓	↓↓
Total lung capacity	↓	↓↓	↓
Compliance	↔	↓↓	↓
V/Q mismatch	↑	↑	↑↑

increase risk of venous thromboembolic events. Obesity increases the levels of plasminogen activator inhibitor-1 which prevents fibrinolysis, leptin which encourages platelet aggregation, interleukin-6 which increases the production of coagulation factors by the liver, and C-reactive protein which activates platelets [8]. Venous stasis results from increased intra-abdominal pressure caused by both the gravid uterus and abdominal adiposity.

4.3 Morbidity and Mortality

4.3.1 Maternal Comorbidities Associated with Obesity and Pregnancy

Obesity is associated with a number of comorbidities which can complicate the care of the parturient. The relative risk of diabetes mellitus type II in obese women is 12 times that of controls of normal BMI and waist circumference. Obesity is additionally associated with increased incidence of hypertension, coronary artery disease, congestive heart failure, stroke, pulmonary embolism, asthma, gallbladder disease, chronic back pain, depression, and gastroesophageal reflux disease [9]. A comorbidity with particular influence on anesthetic management is obstructive sleep apnea (OSA). OSA is more common in obese patients in general; however the definition of OSA in pregnancy is not widely agreed upon, and so the exact prevalence is unknown. Changes associated with pregnancy and labor have varying effects on the physiology of OSA, with weight gain and airway swelling potentially worsening symptoms, while increased minute ventilation and side sleeping may be protective [10].

4.3.2 Maternal Morbidity

Obese women also have a higher incidence of developing pregnancy-related complications, specifically hypertensive disorders of pregnancy, gestational diabetes, thromboembolic disease, and need for operative delivery. A prospective multicenter study found the odds ratio (OR) of developing gestation hypertension to be 2.5 and 3.2 for obesity and morbid obesity, respectively, while preeclampsia was also increased, with OR of 1.6 in obese and 3.3 in morbidly obese versus control patients of normal BMI (11). In addition to the higher likelihood of preexisting type II diabetes, morbidly obese parturients are also four times as likely to develop gestational diabetes, most likely secondary to insufficient insulin production to offset the insulin resistance conferred by pregnancy. The implications of this are far-reaching, with higher chance of fetal malformations, macrosomia, and coexisting maternal cardiovascular and renal disease. Morbidly obese pregnant patients also carry a higher risk of thromboembolic complications, both during pregnancy and after delivery, with a relative risk of 3.5 for pulmonary embolism compared to lean controls [9]. Finally, the risk of operative delivery is increased in obesity, with OR of

1.7 and 3.0 for operative vaginal delivery and cesarean delivery, respectively, in the morbidly obese population [11]. There are many potential explanations for these increases, including higher rates of dysfunctional labor patterns, fetal macrosomia, abnormal fetal presentation, and induction of labor secondary to maternal medical conditions.

4.3.3 Maternal Mortality

In addition to the significantly increased morbidity associated with obesity in pregnancy, mortality rates are also higher in this cohort. A report published by the Centre for Maternal and Child Enquiries in the United Kingdom showed that half of all women with pregnancy-related deaths were overweight or obese. This percentage was even higher when evaluating women who died of thromboembolic or cardiac disease. Anesthesia-related maternal deaths are also more common in obese women [12]. These findings led to subsequent recommendations by the American Congress of Obstetricians and Gynecologists (ACOG) that all obese women should undergo antepartum consultation with an anesthesiologists and that multidisciplinary care is required to decrease morbidity and mortality in this population [13].

4.3.4 Fetal Morbidity and Mortality

Maternal obesity further has implications for fetal morbidity and mortality. Fetuses born to morbidly obese mothers have higher odds of fetal macrosomia, with ORs 1.9 and 2.4 for birth weight greater than 4000 g and 4500 g, respectively [11]. This higher incidence of fetal macrosomia also increases the risk of shoulder dystocia in the delivery of these infants. Furthermore, the odds of poor obstetric outcomes for the fetus are greater, including higher incidence of large for gestational age, fetal distress, meconium aspiration, intrauterine fetal demise, and early neonatal death [14]. Congenital malformations such as neural tube defects and cardiac anomalies are also more frequent in these infants [15].

4.4 Labor and Vaginal Delivery

4.4.1 Impact on Labor Progress

The progress of normal labor seems to be related to a patient's BMI. Morbidly obese parturients experience slower centimeter by centimeter labor progress with resultant longer latent and active phases of labor as well as higher chance of cesarean delivery performed for abnormal labor. A large multicenter trial conducted in the United States showed that morbidly obese nulliparous women took more than 2 h longer to progress from 4 cm to 10 cm dilation, while multiparous women took approximately 1 h longer. These same results of slower labor progress were demonstrated for both spontaneous and induced labor [16]. This may be due to higher incidence of fetal macrosomia in obese mothers, higher rates of induction, and/or dysfunctional uterine contractility or poor myometrial response to oxytocin. Zhang et al. [17] showed that the myometrium of obese parturients at the time of cesarean delivery contracted with less force and frequency and demonstrated less calcium flux when compared to control women of normal BMI. Thus obese parturients have a significantly increased risk of cesarean delivery, driven primarily by failed or obstructed labor. In an attempt to quantify this increased risk of cesarean delivery among overweight and obese women, Chu et al. conducted a meta-analysis of 33 studies in which they found unadjusted OR of cesarean delivery of 1.46 (1.34–1.60), 2.05 (1.86–2.27), and 2.89 (2.28–3.79) among overweight, obese, and morbidly obese patients, respectively [18]. Another study looking at greater than 16,000 patients found that the rate of cesarean delivery in obese nulliparous women was 47.4% versus 20.7% in those with a BMI less than 30. The odds ratio of having an operative vaginal delivery was also higher among morbidly obese patients compared to controls, with an OR of 1.7 (1.2–2.2) [11].

4.4.2 Anesthetic Management

Neuraxial analgesia represents the most effective option for pain control and is of particular benefit in obese patients given the higher rates of macrosomia, shoulder dystocia, operative vaginal delivery, and cesarean delivery (which may be emergent). A positive correlation between BMI and the severity of labor pain has also been demonstrated [19]. Technical challenges associated with neuraxial placement in this population, however, are numerous. These challenges include adipose tissue obscuring palpation of spinous processes and intervertebral spaces, greater depth of the epidural space which exaggerates needle inaccuracies, and presence of fat pockets which may cause false loss of resistance [20, 21]. Useful techniques to help mitigate these challenges may include the use of visible anatomic landmarks including the seventh cervical vertebrae and gluteal cleft, elicitation of patient feedback on perceived needle position, as well as ultrasound imaging prior to neuraxial placement. While ultrasound imaging in the obese population may not be able to identify depth to the epidural space because of lack of ultrasound penetration, the midline can often be identified which can provide some useful information. The sitting position is preferred by many practitioners for neuraxial placement in obese women because of improved identification of midline and shorter distance from skin to epidural space in this position [22]. After successful placement of an epidural, patients should subsequently be repositioned in the lateral position before securing the catheter. This is because redistribution of subcutaneous adipose tissue in the back may lead to an increased distance from the skin to epidural space and thus dislodgement of the catheter from the epidural space (Fig. 4.1) [23]. If unsecured at the skin, the catheter can instead be drawn in from the outside, preserving the depth residing within the epidural space.

Because of these many anatomical and positioning challenges associated with maternal obesity, epidural catheter placements on average require more attempts, take more time, are less likely to result in adequate analgesia for delivery, and are more likely to fail outright and require replacement [24, 25]. Although data is conflicting, inadvertent dural puncture may be more common in obese patients as a result of these technical difficulties [26]. Whether or not adjustments should be made to epidural dosing in morbidly obese patients remains unclear; although, data suggests that higher weight and BMI are likely associated with greater cephalad extent of neuroblockade [27, 28]. Finally, the decision of whether to utilize standard epidural or combined spinal-epidural (CSE) technique for labor analgesia in obese parturients is practitioner-dependent. The primary goals of neuraxial anesthesia in morbidly obese parturients are to provide patient comfort but also to ensure a properly functioning catheter in the high likelihood (compared to lean patients) that operative vaginal and cesarean delivery are necessary. Avoidance of general anesthesia in this patient population is of utmost importance because of the higher chance of encountering a difficult airway. Both the epidural and CSE techniques offer advantages and disadvantages in this respect. The CSE technique indirectly confirms correct positioning of the epidural needle and may be associated with higher initial success rates and decreased need for catheter replacement [29, 30]. On the other hand, the epidural catheter inserted with a CSE technique is unable to be

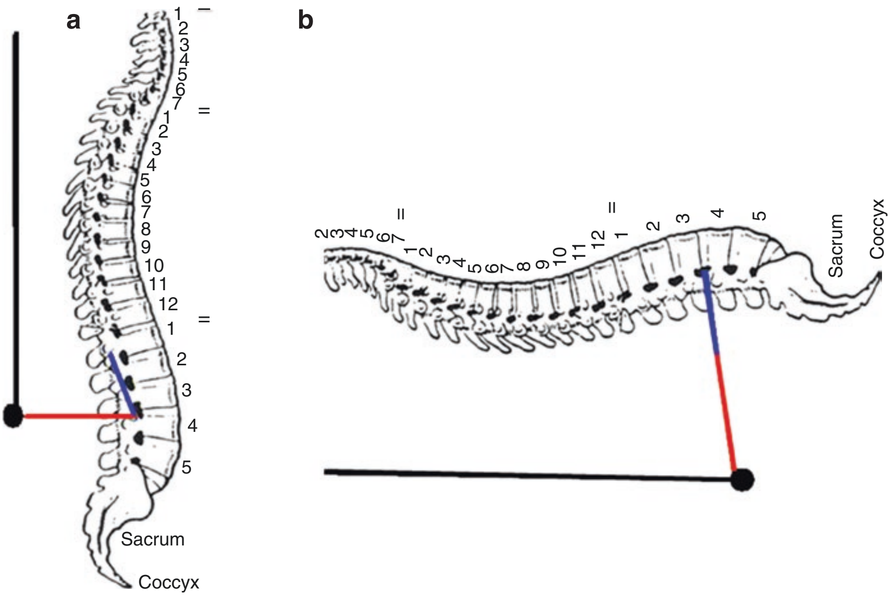

Fig. 4.1 Depth to the epidural space can increase with transition from sitting (**a**) to supine (**b**) position secondary to redistribution of subcutaneous adipose tissue. When this occurs, the catheter previously in the epidural space (blue line) can be dislodged leading to subsequent catheter failure

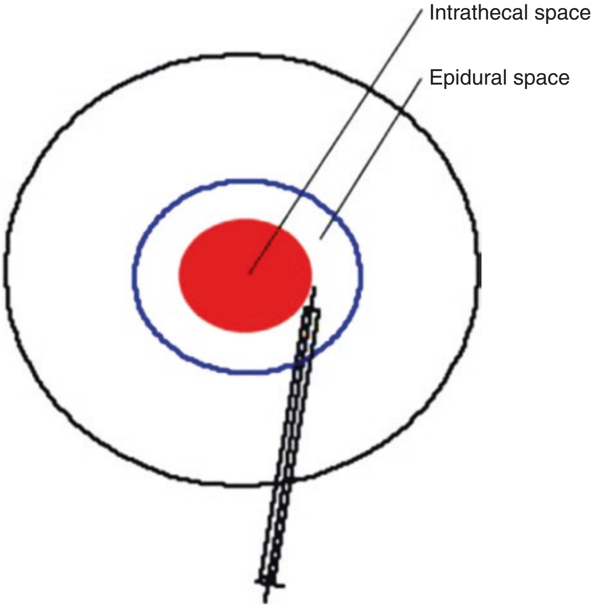

Fig. 4.2 Despite identifying the epidural space, the tip of the epidural needle may be off-midline. Confirmation with dural puncture (as with a CSE technique) confirms midline placement with flow of CSF

tested for reliability until the spinal anesthetic wears off. For this reason, some practitioners prefer standard epidural technique so that a solid and bilateral epidural anesthetic level can be confirmed from the outset. As previously mentioned, this standard epidural technique may be associated with higher catheter failure rate, potentially due to identification of the epidural space laterally as opposed to midline (Fig. 4.2).

4.5 Cesarean Delivery

4.5.1 Operative Variables

Many operative variables can be affected by a parturient's BMI including operative time, blood loss, and the need for uterotonics. Hood et al. [24] showed that cesarean delivery operative times for morbidly obese patients, which they defined as those weighing greater than 300 lbs., and controls were 76.7 ± 31.2 and 47.1 ± 14.4 min, respectively. Similarly increased operative times were demonstrated by Perlow et al. who reported that 48.8% of morbidly obese women had an operative time >60 min, compared to 9.3% of controls [31]. In this same study, 34.9% of morbidly obese women had an estimated blood loss of >1000 ml during their cesarean delivery, while only 9.3% of controls surpassed this cutoff. In a related finding, morbidly obese women are also more likely to require administration of uterotonics following delivery [31].

4.5.2 Anesthetic Management

4.5.2.1 Regional Anesthesia

In the obese parturient, regional anesthesia is preferred over general anesthesia for cesarean delivery. If a labor epidural is in situ, the catheter can be used for conversion to surgical anesthesia. If cesarean delivery is elective, or if a parturient has no epidural or a poorly functioning catheter, both spinal anesthesia and CSE are options in the morbidly obese population. CSE, however, may be advantageous for multiple reasons. Depending on the distribution of adipose tissue and specifically the degree of adiposity at the site of neuraxial placement, longer needles may be required. Spinal placement using a longer needle is certainly possible, but identifying the epidural space with a larger-gauge epidural needle may be technically easier, which can be followed with a needle-through-needle technique for intrathecal (IT) injection. Also, CSE offers the advantage of extending the timeframe of anesthesia should the duration of surgery be prolonged, which is commonly the case with morbidly obese parturients. The ability to prolong blockade can help to avoid the need to convert to general anesthesia and manipulate the airway, which as stated previously is more likely to pose difficulty with intubation. In patients with super-morbid obesity (BMI > 50 kg/m^2), occasionally a supra-umbilical vertical midline incision is required due to the large abdominal pannus. In these cases, a double neuraxial catheter technique has been described in which a lumbar spinal catheter and thoracic epidural catheter are placed for intraoperative and postoperative anesthesia, respectively [32]. The spinal catheter offers the advantage of reliable re-dosing compared to the epidural placed as part of a CSE technique, which remains untested until intraoperatively.

Deciding on the dose of local anesthetic for IT or epidural administration in the morbidly obese parturient can be challenging. On one hand, there is data to suggest that morbidly obese patients have decreased CSF volume, which is associated with greater cephalad extent of neural blockade for any given IT dose [33, 34]. On the other hand, erring too low on the local anesthetic dose may increase the risk of inadequate block and need for conversion to general anesthesia if a single-shot technique is used. Furthermore, despite the proven concept of CSF volume effecting cephalad spread, dose-finding studies in the obstetric population have failed to demonstrate differences in ED50 or ED95 of local anesthetics for cesarean delivery in morbidly obese versus nonobese patients [35, 36]. Data regarding the extent of cephalad blockade with epidural dosing is also conflicting; however, this is less of an issue as epidural local anesthetic can be titrated to effect.

Neuraxial morphine with or without the addition of a lipid-soluble opioid (e.g., fentanyl) is typically administered in addition to the local anesthetic for cesarean delivery. Dosing regimens are usually not adjusted for BMI; however, careful postoperative monitoring for respiratory depression is particularly important in the morbidly obese patient (see Sect. 4.5.3).

4.5.2.2 General Anesthesia

When general anesthesia is required, a thorough airway assessment is of utmost importance, as the incidence of difficult laryngoscopy in the obstetric population has been reported to be greater than 8%, with a reported incidence of 1 in 390 for failed intubations [37, 38]. Multiple aspects of obesity and pregnancy, including airway edema, enlarged breasts, greater anteroposterior chest diameter, and larger neck circumference, make difficult airway more likely, and difficult intubation is significantly associated with greater BMI [39]. One study reported an incidence for difficult intubation as high as 33% in women weighing greater than 300 lbs. [24]. Predictors of difficult intubation which have been evaluated in obstetric populations include modified Mallampati score (MMT), upper lip bite test, thyromental distance, ratio of height to thyromental distance (RHTMD), sternomental distance, mandible protrusion, neck circumference, and ratio of neck circumference to thyromental distance (NC/TMD). Savva et al. found that the MMT alone was neither sensitive nor specific in predicting difficult intubation [40]. Honarmand et al. subsequently found RHTMD to have the highest sensitivity, positive predictive value, and negative predictive value compared to other variables tested [37]. In obese parturients, however, NC/TMD may have the best combined sensitivity and specificity for identifying difficult laryngoscopy [39]. Positioning on the operating room table can be utilized to optimize laryngoscopic view, with a ramped position providing best alignment of the oral, pharyngeal, and tracheal axes. While retraction of a large panniculus may be necessary for surgical exposure, placement of these retractors should be used with caution, especially prior to intubation, as cephalad retraction of adiposity may hinder laryngoscopy and can also be associated with hypotension, ventilation difficulties, and fetal compromise.

Airway manipulation for cesarean delivery is further complicated by higher risk of aspiration in the obstetric and obese populations. Aspiration prophylaxis is recommended to mitigate this risk. Both nonparticulate antacids and H2 receptor blockers have been shown to increase gastric pH, while metoclopramide significantly decreases both nausea and vomiting when compared to placebo [41–43]. However, due to the extremely low incidence of aspiration events, none of these medications have data to support improved patient outcomes. Risk of aspiration exists during both induction and emergence of general anesthesia, necessitating rapid sequence induction (unless difficult airway is anticipated) and careful emergence and extubation at the end of the procedure.

Induction of general anesthesia should be preceded by adequate denitrogenation ("preoxygenation") as both pregnancy and obesity predispose to rapid oxygen desaturation and hypoxemia. There is evidence to suggest that both eight deep breaths over 1 min (8DB) and tidal volume breathing for 3 min are equally effective in achieving $ETO_2 > 90\%$, with the 8DM method having the advantage of the ability to perform more quickly in emergent situations [44]. Unless difficult intubation is anticipated, rapid sequence induction is indicated in pregnant patients undergoing cesarean delivery. A combination of hypnotic and neuromuscular blocker is typically administered for induction. Dosing of propofol (2–2.5 mg/kg) or thiopental (4–5 mg/kg) should be based on lean body weight (difference between total body weight and fat mass) [45]. Succinylcholine (1–1.5 mg/kg) is the neuromuscular blocker of choice in obese parturients, with dosing based on total body weight [45]. If rocuronium (1.2 mg/kg) is chosen for rapid sequence intubation, the dose should be based on ideal body weight, and sugammadex (16 mg/kg) should be immediately available to reverse the NMB should unanticipated difficult airway arise [45]. Specifically in the case of the morbidly obese parturient, additional airway equipment, including video laryngoscope, fiber-optic scope, various endotracheal tube sizes, and supraglottic airway devices, should be available in case of emergency.

Maintenance of anesthesia is usually accomplished with volatile agent or propofol infusion with or without nitrous oxide. While pregnancy is associated with decreased minimum alveolar concentration (MAC), obesity does not affect MAC any further. Desflurane or sevoflurane may be the preferred volatile agents in obesity as they are less lipid-soluble and therefore are associated with quicker times to extubation at the end of the case. Functional residual capacity (FRC) is decreased by both pregnancy and obesity, and these patients may require higher positive end-expiratory pressure and frequent recruitment maneuvers to prevent atelectasis and hypoxemia. At the end of the procedure, complete neuromuscular blockade reversal should be confirmed, and the patient should be fully awake prior to extubation. Obese parturients are at greater risk of airway obstruction following extubation, and careful monitoring of oxygen saturations should be continued into the postoperative period.

4.5.3 Postoperative Care

Women who undergo cesarean delivery under regional anesthesia typically receive neuraxial morphine as part of their anesthetic. Although there is some data to suggest that respiratory depression following IT morphine administration occurs more commonly in morbidly obese patients, the incidence is still remarkably low [46]. In women who receive general anesthesia, parenteral opioids are commonly required postoperatively and are usually administered via patient-controlled analgesia (PCA). Minimizing opioids in order to mitigate the risk of respiratory depression can typically be achieved by the use of multimodal analgesic regimens, which can include nonsteroidal anti-inflammatory drugs, acetaminophen, gabapentin, local wound infiltration, and transversus abdominis plane (TAP) blocks. In the general obstetric population, TAP blocks are not effective at reducing pain scores or opioid consumption when combined with IT morphine; however, they may be beneficial in patients who did not receive neuraxial opioids [47]. The performance of TAP blocks may be challenging or impossible in patients with excess abdominal adiposity.

4.6 Postpartum Complications

4.6.1 Respiratory Insufficiency

Obesity has been identified as a significant risk factor for airway obstruction and hypoventilation postoperatively. If a morbidly obese parturient has a diagnosis of obstructive sleep apnea, requires general anesthesia for cesarean delivery, and/or receives opioids for pain control, the American Society of Anesthesiologists recommends continuous pulse oximetry and close monitoring be continued after discharge from the PACU [48]. Supplemental oxygen may also be required until the parturient is able to maintain baseline oxygen saturation on room air.

4.6.2 Infection

Infectious morbidity is also increased in the obese and morbidly obese obstetric populations. In a study evaluating infectious morbidity in patients undergoing cesarean delivery, Myles et al. [49] reported that following elective and nonelective CD, respectively, 89.5% and 81.8% of those who developed postoperative infection were obese. Overall, endomyometritis was the most common infection reported, with 15.9% of obese patients diagnosed compared to 5.0% in normal BMI controls. Although not statistically significant, they also reported that 75% of wound infections occurred in the obese group [49]. In another case-control study of 43 “massively obese” (>300 pound) women who underwent cesarean delivery, 32.6% developed postoperative endometritis, while only 4.9% of controls developed this infectious complication [31].

4.6.3 Length of Stay

Length of stay (LOS) is another postoperative variable which is frequently assessed, both because it has financial implications for the patient and health system and also because it often represents a surrogate for ongoing medical morbidity. Obese patients have been shown to have significantly greater incidence of prolonged LOS, with 34.9% of morbidly obese patients requiring LOS > 4 days following cesarean delivery, compared to 2.3% in normal BMI controls [31]. In another study, morbidly obese patients stayed in the hospital on average 3.8 and 7.3 days following vaginal and cesarean delivery, respectively, while control patients stayed 2.9 and 5.4 days [24].

4.6.4 Venous Thromboembolism

Obesity is a significant risk factor for the development of thromboembolic complications both during and immediately after pregnancy. During pregnancy obesity is associated with venous thromboembolism (VTE) with an overall adjusted OR of 5.3, and this risk is even higher when evaluating patients who develop VTE prior to delivery (adjusted OR 9.7). Obesity is more strongly associated with risk of PE (adjusted OR 14.9) compared to deep vein thrombosis (adjusted OR 4.4) [50].

4.6.5 Postpartum Hemorrhage

Finally, excessive blood loss or postpartum hemorrhage (PPH) is more common in obese patients following both vaginal and cesarean delivery. As stated previously, Perlow et al. showed that 34.9% of morbidly obese women had an estimated blood loss of >1000 ml, which is a commonly utilized definition for PPH. In this study, only 9.3% of controls experienced a PPH [31]. Another study also found that obese women have an increased incidence of excessive blood loss, defined as >600 ml, following spontaneous vaginal delivery, with an OR of 2.13 (1.18–3.84) compared to normal-weight women [17].

Key Learning Points

- Rates of obesity are increasing exponentially in both the general and obstetric populations.
- Physiologic changes in both the cardiovascular and pulmonary systems during pregnancy are exacerbated by obesity.
- Morbidly obese pregnant patients have higher pregnancy-related mortality compared to normal weight controls.
- Fetal morbidity and mortality are higher in the offspring of morbidly obese parturients.
- There are many implications for anesthetic management of obese parturients for both labor and cesarean delivery.
- Morbidly obese pregnant patients experience higher rates of postpartum complications, including infection, thromboembolism, and hemorrhage.

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