Care of the Morbidly Obese Parturient

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INTRODUCTION

Body mass index (BMI) describes a person’s thinness or fatness. BMI is a ratio of weight to height, specifically weight (kilograms) divided by height (meters) squared. The World Health Organization (WHO) classifies BMI as underweight, normal weight, and obese. The obese category is further subdivided (Table 1) [1]. High BMI is correlated with increased prevalence of comorbidities and symptoms that affect quality of life. Overweight and obese individuals are more likely to suffer from obesity-related diseases such as cardiovascular diseases, diabetes mellitus (DM), respiratory symptoms limiting daily activity, low back pain, and overall impairment of life quality [2].

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BMI was initially designed as a measure for population studies, comparing the prevalence of obesity across geographic areas or longitudinal time frames. Health care providers then adopted BMI terminology to facilitate communication regarding patient care management and risk reduction.

Obesity is a growing problem for most parts of the world. It is no longer an epidemic for only the wealthy industrialized nations, such as the United States, United Kingdom, and other European countries. The obesity prevalence is increasing in the developing world too, in places such as India, Mexico, South Africa, and Argentina [3].

With obesity rates on a rapid increase in the Unites States for the past quarter century, the Healthy People Goal 2010 was announced. Health care policy makers were hoping to positively affect the health of the nation by raising awareness of several health issues. The goal focused on nutrition and healthy weight status; maternal and perinatal mortality; cesarean delivery rate; tobacco and substance abuse; access to health care; and mental health awareness [4]. The nutrition and educational efforts envisaged a decrease in the obesity epidemic by more than half. The goal: 15% obesity among adults.

Three years later, the goal has yet to be attained and the reality is moving farther away from the 2010 target. In the most recent National Health and Nutrition Examination Survey (NHANES) report, 2009 to 2010, more than two-thirds (69%) of the US adult population are overweight or obese. More specifically, 33.3% fall into the overweight category (BMI 25–29.9), and 35.7% of US adults are obese (BMI ≥30) [5].

For women in peak childbearing years, ages 20 to 39 years, the obesity statistic is only minimally better, with 23.9% being overweight and 31.9% being obese. There has been a greater increase in obesity in men over the past decade than in women. In addition, the percentage of women battling obesity has held steady for the past two NHANES reports [6]. Despite the steady state of obesity among women, the concerning statistic remains that one-third of all patients admitted to hospital for obstetric care are obese.

Although these statistics seem to paint a stable picture, looked at another way, the problem is worsening because the severity of obesity continues to increase. The obesity table is becoming top heavy, with more people making up

<table>
<thead>
<tr>
<th>BMI kg/m²</th>
<th>Classification</th>
<th>Health impairment [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18.5</td>
<td>Underweight</td>
<td>—</td>
</tr>
<tr>
<td>18.5–24.9</td>
<td>Normal weight</td>
<td>Reference group</td>
</tr>
<tr>
<td>25–29.9</td>
<td>Overweight, preobese</td>
<td>Increased</td>
</tr>
<tr>
<td>30–34.9</td>
<td>Obese class I</td>
<td>Moderate</td>
</tr>
<tr>
<td>35–39.9</td>
<td>Obese class II</td>
<td>Severe</td>
</tr>
<tr>
<td>&gt;40</td>
<td>Obese class III</td>
<td>Very severe</td>
</tr>
</tbody>
</table>

the higher classes of obesity. Although the percentage of people defined as obese is stable, those who are already obese are moving, with increasing speed, into newer categories of extreme obesity. In the past decade, the prevalence of class III obesity (BMI>40) has increased by 70%. Currently, 6.6% of the adult population, approximately 15.5 million Americans, comprise this extreme obesity class [7]. The term super-obese was first coined in 1987 to describe BMI of 50 or greater [8], and there is now a medical term for BMI of 60 or greater: super-super-obese.

Caring for patients in the extreme weight classes can be challenging. Often, standard medical equipment is not adequate for the morbidly obese patient. Health care facilities and health care providers purchase special equipment to accommodate these larger patients. This equipment may include transport devices (wheelchairs, gurneys, hospital beds); monitoring equipment (blood pressure [BP] cuffs, weight scales); imaging tools (magnetic resonance imaging, ultrasonography, and computed tomography); and surgical interventions (operating room tables, surgical instruments). At the author’s institution, we have recently purchased 2 operating room tables for our labor and delivery suite, each of which can accommodate 453.5 kg (1000 lb).

It is estimated that the obesity epidemic accounts for 10% to 20% of the annual burden of US health care costs, about $150 to $190 billion dollars per year. On average, an obese patient costs the health care system $1429 to $2741 more per year compared with a normal-weight adult [9,10].

The WHO classification system does not differentiate weight categories for the parturient or take into consideration pregnancy weight gain. In 1990, the Institute of Medicine (IOM) responded to a growing concern among maternal and child health advocates regarding pregnancy weight gain. In the 1970s and 1980s, there was an increase in the prevalence of preterm labor and small-for-gestational-age infants, both of which are associated with prepregnancy underweight status and poor pregnancy weight gain [11]. The 1990 IOM report published optimal maternal weight gain based on prepregnancy BMI.

The report proposed recommendations for low BMI (<19.8), normal weight (19.8–26.0), and high BMI (26.0–29.0). Obesity was minimally acknowledged only in a footnote: “The recommended target weight gain for obese women (BMI>29) is at least 6.8 kg (15 lb)” [11]. This seeming oversight by the IOM investigators may be explained and forgiven because obesity was not the epidemic it is currently. In 1980, the average adult weighed only 71 kg [12]. In the NHANES III report, 1988 to 1994, less than 25% of US adults were obese [13]. Almost two decades later, the most recent IOM guidelines are a well-needed update [14]. However, even these recent recommendations do not differentiate weight gain recommendations between the obesity classes. The most recent IOM recommendations appear in Table 2.

PREGNANCY COMPLICATIONS
Both preconception obesity and excessive weight gain during pregnancy have detrimental effects on mother and fetus during pregnancy and subsequently on
both patients after birth. The most recent American College of Obstetricians and Gynecologists committee opinion states, “preconception assessment and counseling are strongly encouraged for obese women and should include the provision of specific information concerning the maternal and fetal risks of obesity in pregnancy, as well as encouragement to undertake a weight-reduction program” before conception [15].

The list of complications related to obesity is extensive. The list below is based on BMI of 30 or greater at first prenatal visit [16–21]:

**FETAL-RELATED AND NEONATAL-RELATED COMPLICATIONS:**

- Spontaneous abortion
- Congenital cardiac anomalies
- Stillbirth
- Meconium aspiration
- Shoulder dystocia
- Birth injury
- Large for gestational age
- Early neonatal death
- Childhood obesity
- Increased lifetime risk of obesity, DM, hypertension (HTN), dyslipidemia

**MATERNAL COMPLICATIONS:**

- Gestational diabetes
- Hypertensive disorders
- Induction of labor
- Failed induction of labor
- Operative delivery
- Emergency cesarean delivery
- Wound infection
- Urinary tract infection
- Postpartum hemorrhage (PPH)
- Postpartum weight retention
- Increased lifetime risk of obesity, DM, HTN

### Table 2

2009 IOM weight gain recommendations

<table>
<thead>
<tr>
<th>Prepregnancy BMI (WHO category)</th>
<th>Total weight gain (kg)</th>
<th>Rate of weight gain second and third trimester (kg/wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>13–18</td>
<td>0.5</td>
</tr>
<tr>
<td>Normal weight</td>
<td>11–16</td>
<td>0.5</td>
</tr>
<tr>
<td>Overweight</td>
<td>7–11</td>
<td>0.2</td>
</tr>
<tr>
<td>Obese (all classes)</td>
<td>5–9</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Complications from obesity have been reported even earlier than conception. The physiologic milieu of obesity can have detrimental effects on spontaneous ovulation cycles and fertility. Obese women seeking fertility treatment are less likely to experience successful interventions. Among women who undergo in vitro fertilization (IVF), obese patients tend to have fewer successful stimulation cycles, shown by fewer oocytes at egg retrieval [22].

Once IVF is successful, obese parturients have a significant increase in spontaneous abortion compared with overweight or normal-weight women (38% vs 15% and 13%, respectively) [23]. Equally so for natural conception, there is evidence that obesity is an independent risk factor for first-trimester and second-trimester pregnancy loss and recurrent miscarriage [24].

Obesity also has a negative impact during the critical period of organogenesis: children born to obese parturients are more likely to have congenital anomalies. Some of these anomalies include cardiac defects, spina bifida, cleft lip and palate, and limb reduction anomalies [21,25].

Salihu and colleagues [26] reported a 40% increase in stillbirth among obese mothers compared with normal and overweight mothers. The risk of fetal death after 20 weeks’ gestation increases in a dose-dependent fashion with increasing BMI. The adjusted hazard ratios (HRs) are reported for obesity class I: HR 1.3; class II: HR 1.4; and class III: HR 1.9. When the investigators looked closely at race, specifically black versus white, class III obese black women had the highest HR for stillbirth, at 2.3 HR.

Obese parturients also have other comorbidities, which might go unnoticed until the first prenatal care visit. Many women of childbearing age may seek medical care only during pregnancy; therefore, chronic indolent illnesses such as HTN, dyslipidemia, and diabetes may be present for months to years without overt impact. For women who do seek interim medical care, often their comorbidities are classified as borderline or predisease, such as borderline HTN or prediabetes. The metabolic stress of gestation affects these physiologic aberrations and the predisease entities become a reality. Often, treatment is then indicated during pregnancy, which includes diet, lifestyle modification, or drug therapy.

DM

Gestational diabetes prevalence has been increasing over the past two decades [27,28]. Current estimates are that 2% to 10% of pregnancies are complicated by diabetes [29]. Risk factors for gestational diabetes include advanced maternal age, preconception obesity, family history, and a previous pregnancy complicated by insulin resistance or diabetes [30]. Maternal ethnic and racial origins also play a role in diabetes. White, non-Hispanic heritage is protective against the risk of DM; African American, American Indian, Indian, and Asian descent is associated with greater risk [27].

The first-line therapy for gestational DM (GDM) is medical nutrition therapy (MNT). Diet modifications supplemented with education and counseling are more likely to have positive impact. A recent meta-analysis of physical
exercise reports that overall glycemic control was improved and insulin use was decreased when physical exercise complemented diet modifications [31]. It seems that physical exercise is more effective in the treatment of GDM (71% success rate) than the prevention (38% success). However, compliance may improve once the diagnosis of DM is a reality.

When glycemic control fails with MNT, an oral hypoglycemic (most commonly metformin) or insulin is added to the regimen. Failure of MNT is related to a higher BMI, earlier gestational age at diagnosis, previous history of GDM, and higher fasting glucose levels [32].

The hyperglycemic milieu of preexisting DM during organogenesis can have a negative impact on the fetus. Rosenn and colleagues [33] quote a 5% to 10% incidence of major malformations among women with prepregnancy type I diabetes. Congenital defects include caudal regression, situs inversus, spina bifida, anencephaly, and cardiac defects. Cardiac defects include transposition of great vessels, ventricular-septal defects, and atrial-septal defects.

Delivery plan of the diabetic parturient is based on obstetric history, fetal well-being, and estimated fetal weight (EFW). There is consensus among obstetricians that cesarean delivery should be offered when EFW is greater than 4500 g to reduce the risk of shoulder dystocia and birth trauma [34]. Tight glucose control intrapartum is necessary to avoid neonatal hypoglycemia. Intrapartum insulin is typically required for those patients who are insulin dependent during pregnancy. If insulin is required, the infusions are adjusted to maintain capillary glucose level at 110 mg/dL or less [34]. Taylor and colleagues [35] found that neonatal hypoglycemia of less than 45 mg/dL is more likely to occur when maternal glucose is greater than 145 mg/dL at the time of delivery. For this reason, elective cesarean deliveries may be delayed until the maternal glucose levels are 110 mg/dL or less. After delivery of the placenta, human placental lactogen levels decrease and insulin resistance rapidly improves. Diabetic parturients are at risk for hypoglycemia post partum; therefore, insulin dosing should be adjusted and glucose levels monitored closely.

HYPERTENSIVE DISORDERS
Hypertensive disorders are estimated to affect 8% to 10% of pregnancies [36]. This number is on the rise. The increasing incidence is likely related to baseline maternal characteristics, which mirror the declining health of the general population: obesity epidemic, poor physical activity, DM, HTN, and dyslipidemia. Obstetric characteristics such as older maternal age at conception and growing incidence of multifetal gestations both also play a role in the greater incidence of maternal HTN. Most influential is the fact that chronic HTN, the biggest risk factor for preeclampsia, has doubled in the United States in the past 20 years [37].

A recent review from the United Kingdom reports that the incidence of gestational HTN and preeclampsia increases with higher BMI. Close to one-third of women with BMI of 35 or greater developed preeclampsia (28%)
and almost one-half suffered from gestational HTN (42%) [38]. Hypertensive disorders lead to fetal complications: intrauterine growth restriction, oligohydramnios, nonreassuring fetal testing, and placental abruption, all of which may necessitate labor induction or cesarean delivery.

According to National Inpatient Sample data (NIS), hospitalizations related to preeclampsia or gestational HTN have a significantly higher rate of severe obstetric mortality [36]. These patients often require anesthesiology or critical care team consultations for management of the severe comorbidities. Some of the complications included disseminated intravascular coagulation syndrome, acute renal failure, ventilation disorders, pulmonary edema, and cerebrovascular disorders [36].

Hypertensive disorders are one of the leading causes of maternal mortality [39]. In the United States, HTN ranks third among causes of pregnancy-related deaths, just after cardiac disease (number 1) and hemorrhage (number 2) [40]. The most common cause of death related to HTN disorders and pregnancy is stroke.

Timing of delivery is based on severity of disease, gestational age at diagnosis, and maternal or fetal compromise. An early anesthesiology consult with thorough review of laboratory data and airway examination is important. Some key considerations in the anesthetic management of such patients are listed below:

ANESTHESIA AND HTN DISORDERS:

- HTN management
- Early neuraxial anesthesia may be beneficial
- HELLP (hemolysis, elevated liver enzymes, low platelets)
- Eclampsia
- Edema (airway difficulty); presacral edema (neuraxial landmarks obscured)
- Increased cesarean delivery rate
- Magnesium therapy (toxicity and drug interactions)

Severe HTN is defined as BP 160/110 mm Hg or greater. Severe HTN should be treated to avoid end-organ damage, prominently cerebrovascular accidents. The most common antihypertensives used in obstetrics are labetolol, hydralazine, and nifedipine. These medications are considered safe in pregnancy, they have a rapid onset, and they are all available in intravenous (IV) formulations. The BP goal should be a diastolic BP of 90 to 100 mm Hg. Correcting BP to normotensive levels before delivery may compromise uteroplacental perfusion to an already stressed uteroplacental unit. Subsequently, this may lead to fetal heart rate abnormalities and nonreassuring fetal status.

The obese parturient with no other risk factors does not require any laboratory testing before performing a neuraxial block; however, in patients with HTN, a platelet count should be evaluated before neuraxial placement because of the concern for thrombocytopenia and HELLP. The most common hematologic abnormality associated with preeclampsia is thrombocytopenia [41]. In the patient with mild preeclampsia and a platelet count less than
100,000 mm$^3$, coagulation studies are indicated. Platelet counts greater than 100,000 mm$^3$ in this setting do not require further evaluation [42].

An early labor epidural, when indicated and safe to administer, has multiple benefits in the preeclamptic patient:

1. Decreases levels of circulating catecholamines and provides blunted hypertensive response to painful contractions, thereby improving uteroplacental perfusion
2. Allows the opportunity for rapid anesthetic dosing and potentially avoids airway intervention in the urgent cesarean delivery scenario
3. May optimize the safety of epidural placement in the setting of HELLP when platelet count is still adequate

Eclampsia is a rare event in the Western world. The reported rate is 1 in 2000 to 1 in 3000 pregnancies [43]. Should a seizure occur perinatally, the key initial priorities are:

A. Airway: bag mask with 100% oxygen
B. Breathing: assist ventilation if indicated, check SpO$_2$ (oxygen saturation as measured by pulse oximetry)
C. Circulation: obtain IV access, check electrocardiogram and BP
D. Drugs: magnesium sulfate, 4 to 6 g. Consider benzodiazepines if already on magnesium therapy
E. Effective BP control

Magnesium sulfate is used for seizure prevention in the severe preeclamptic patient. It is superior to placebo and to other antiepileptic drugs; however, side effects such as flushing, hypotension, nausea, and vomiting are common. Magnesium toxicity is characterized by decreased muscle tone, cardiac arrhythmias, and respiratory depression. Toxicity should be treated with IV calcium gluconate, prompt discontinuation of magnesium sulfate, and airway support.

**CARDIAC DISEASE**

Maternal cardiac disease, including cardiomyopathy and cardiovascular diseases, are the number 1 cause of maternal mortality in the United States. Despite advances in medical technologies and interventions, overall maternal mortality is increasing in recent decades. At the turn of the twentieth century, the maternal mortality rate (MMR) was 850 deaths per 100,000 live births. Over the next 80 years, maternal health and medical care improved, and MMR decreased to a record low of 7.5 deaths/100,000 births in 1980. The most recent MMR has increased to 15.5 deaths/100,000 live births [44]. Poor health characteristics at conception lead to poor outcomes for mothers, and even maternal death.

The incidence of acute myocardial infarction (MI) during pregnancy seems to be on the increase [45,46]. Ladner and colleagues [46] reviewed hospital discharge data and birth and death certificates from California to evaluate risk factors for pregnancy-related MI. The investigators determined that chronic HTN, DM, and advanced maternal age are independent risk factors
for MI in parturients. Also, the incidence of MI tripled during their study: 1 MI per 73,000 deliveries in 1991; 1 per 24,000 in 2000. James and colleagues reviewed the NIS from 2000 to 2002. Acute MI complicated 1/17,000 deliveries, which was 3 times the risk of MI compared with their nonpregnant age-matched female peers. The death rate from MI was 1/35,000 deliveries. James and colleagues identified similar risk factors to the Ladner study. Obesity was not shown to be a significant risk factor in either study. However, both reports were obtained from discharge data sets, which rely on administrative data not clinical data. Discharge data are notoriously poor at accounting for obesity, with a reported sensitivity of less than 60% [47].

Practitioners in the United Kingdom have been collecting maternal and child health data for decades, known as the Confidential Enquiry into Maternal and Child Health (CEMACH). The triennium reports have been published continuously for more than 60 years, the most recent entitled *Saving mother’s lives: reviewing maternal deaths to make motherhood safer: 2006–8: a review* [48].

The CEMACH report is a clinical audit, which presents more robust clinical information compared with administrative discharge data. The medical record of each maternal death is reviewed by maternal health practitioners, who determine the cause of death, assess for substandard care, and make recommendations based on trends throughout the case series [48].

The United Kingdom is also experiencing an increase in cardiac disease in recent years. In the triennium 2000 to 2002, the incidence of acute MI in pregnancy was 1/30,000 maternities compared with 2006 to 2008 (1/20,000 maternities). The death rate related to cardiac disease is also increasing: 2.20 (2000–2002) versus 2.31 (2006–2008) deaths per 100,000 maternities [49].

It might be postulated that the increase in maternal cardiac disease is caused by greater success in repairing congenital cardiac disease, and that the pediatric cardiac surgery success stories of 20 to 30 years ago are entering childbearing years and account for the increase in cardiac comorbidities and subsequent deaths. CEMACH reviewers looked specifically at this issue, and congenital cardiac disease made up only 6% (n = 3) of all cardiac-related deaths in the most recent report. Acquired cardiac diseases such as ischemia, sudden adult cardiac death, aortic dissection, and cardiomyopathy made up the other 94% (n = 50). Obesity was noted as a significant risk factor for cardiac-related maternal deaths. Sixty percent of women who died of cardiac disease were obese.

**LABOR AND DELIVERY MANAGEMENT**

Obese parturients are more likely to require induction of labor secondary to medical complications and postdates gestation (defined as gestation >42 weeks or 294 days). When labor induction commences, obese women have longer times to delivery, higher oxytocin dosing requirements, and higher rates of failed induction, leading to higher rates of cesarean delivery [50–52]. The degree of obesity is inversely related to likelihood of successful induction. Patients with class III obesity have a 2.89 adjusted odds ratio of failed induction and cesarean delivery compared with normal-weight women. Diabetes, the number
1 risk factor for macrosomia, is an independent risk factor for cesarean delivery, as discussed previously. However, when researchers control for diabetes, the risk of cesarean deliveries is reduced in obese women who are not diabetic, but not abolished [52]. Consequently, nondiabetic, obese women still have a greater rate of cesarean deliveries than their nonobese counterparts.

The obese patient poses a monitoring challenge. Fetal heart rate and tocometer transmission can be difficult through a deep layer of abdominal adipose. The decision-to-incision is more likely to occur when fetal well-being cannot be determined, and in some cases this may be due to inadequate monitoring.

In addition, we have learned that obesity impair the response of the uterine myometrium to both endogenous oxytocin and exogenous formulations of the hormone. Hood and Dewan [53] reported that morbidly obese parturients are more likely to require oxytocin augmentation compared with nonmorbidly obese parturients (51% vs 28% in their series). The poor response to oxytocin also occurs post partum. Oxytocin is first-line therapy after delivery for uterine atony, but has a decreased efficacy in obese parturients. Obesity is a significant risk factor for postpartum atony, regardless of delivery type [54]. New Zealand researchers reviewed PPH rates among nulliparous women and found that obesity and overweight status were independent risk factors for PPH. These investigators reported a significant difference in PPH rates among obese (15.6%) and overweight (9.7%) compared with normal-weight (7.2%) parturients [54]. Obesity is also an independent risk factor for peripartum hysterectomy, which is commonly associated with postpartum atony and hemorrhage [55].

ANESTHETIC MANAGEMENT

Neuraxial anesthesia

The obese parturient presents many challenges to the anesthesia care team. As mentioned earlier, obesity correlates with the need for labor induction, increased rates of failed induction, operative delivery, and emergent cesarean delivery [1,53]. These obstetric considerations directly affect analgesic and anesthetic interventions. Once the decision for delivery is made, the obese parturient should be offered early neuraxial analgesia. Neuraxial anesthesia is more difficult to place in the obese parturient, because of inadequate positioning, excess adiposity, loss of bony landmarks, and increased depth to epidural space. Obese parturients are more likely to require multiple attempts to identify the epidural space. In one report from 1994, nearly three-quarters of patients weighing more than 136 kg (300 lb) required at least two attempts, and more than 14% required more than three attempts [56]. Accidental dural puncture (ADP) is also more likely to occur in obese parturients (≤4% of the time compared with the 0.5%–2.5% in the general obstetric population) [53,56]. Subsequent failure of labor epidural analgesia, requiring catheter replacement, is more likely to occur in obese parturients. One report suggests that failure occurs up to 42% of the time in obese patients [53].
An early epidural is more likely to give the anesthesia team time to trouble-shoot the catheter or replace as needed. A well-functioning epidural for labor offers better analgesia compared with IV analgesics and the ability to convert to surgical anesthesia if cesarean delivery is indicated, helping to obviate general anesthesia.

Combined-spinal epidural (CSE) is a viable option for labor analgesia. If difficulty is encountered with confirming loss of resistance, as is common in the obese patient, the needle-through-needle CSE technique can confirm placement of the spinal needle in the subarachnoid space and be helpful in confirming proper placement of the epidural needle in the epidural space. CSE may also help to avoid ADP with large-gauge cutting epidural needle.

A retrospective review by Pan and colleagues [57] reported that an epidural technique alone was twice as likely to provide inadequate labor analgesia compared with CSE (8.4% vs 4.2%). A similar outcome was observed for epidural catheters and CSE catheters when laboring patients required cesarean delivery. At the time of cesarean delivery, epidural catheters failed 7.1% of the time versus 3.2% for CSE catheters.

When attempting neuraxial block placement in the obese parturient, some simple maneuvers may be helpful. Placing the patient in the sitting position makes the midline easier to identify compared with lateral positioning. The patient may be asked for assistance either before attempting block placement or if difficulty is encountered identifying the midline [58]. Patient feedback has been reported as helpful by the anesthesia provider when identifying the midline is difficult [59].

Ultrasound guidance can also be incorporated. Cork [60] was the first to describe ultrasonic localization of the lumbar epidural space more than three decades ago. He suggested that ultrasound “may have significant impact on regional anesthetic techniques in the near future.” His report, however insightful, did not gain popularity among anesthesiologists, because the average adult weighed only 71 kg at the time of his report (1980). With current obesity challenges, ultrasound technology now has a role in localizing the midline, identifying the window between spinous processes, and measuring depth to the ligamentum flavum [61,62]. The labor epidural is no longer a blind procedure with ultrasound, and the rates of repeat epidural attempts or replacements are significantly improved [63]. ADP is more likely to occur with increasing depth to epidural space; therefore, obese parturients are at greater risk for ADP [64]. Having the ability to estimate the depth to the ligamentum flavum before the block procedure may decrease this risk.

When ADP does occur in the morbidly obese parturient, the anesthesia provider is faced with the decision to reattempt the epidural at another level or thread the catheter into the subarachnoid space. Reperforming the epidural placement at another lumbar level is a common approach; however, it carries a high risk of second dural puncture [65–67]. The reported rate of a second ADP is 9% to 10% in all patients, regardless of BMI.

Continuous spinal anesthesia may be a good option after ADP in the obese parturient when the first epidural attempt was difficult, keeping in mind that
these patients are at increased risk of operative delivery and emergent cesarean delivery. Continuous spinal analgesia is a reliable analgesic, allows for very low dosing of local anesthetics such that the risk of local anesthetic toxicity is negligible, and allows for rapid conversion to surgical anesthesia.

Typical labor analgesia dosing for intrathecal administration can be performed one of two ways. The catheter can be dosed intermittently with plain bupivacaine 1.25 to 2.5 mg (plus fentanyl 10 μg if desired). This regimen can be redosed every 1 to 2 hours as needed. There is a concern for higher infection risk with the repeated uncap-dose-recap of the epidural catheter. However, this concern has not been reported in the literature. The other option for spinal catheter analgesia is a continuous infusion rate of the usual labor epidural medications. Common labor epidural infusions such as 0.05% to 0.125% bupivacaine can be infused at rates of 0.5 to 3 mL/h. A recommended practice is to start at one-tenth the typical epidural dosing (ie, 15 mL/h for an epidural catheter converts to a starting infusion of 1–1.5 mL/h infusion for spinal catheter). Titrate up and down by 0.5 mL/h as needed based on patient response. Infusion rates of these mixtures should be titrated to an upper level of T8 to T10 sensory blockade [68].

Continuous spinal labor analgesia can easily be converted to surgical anesthesia. One milliliter of plain 0.5% bupivacaine with fentanyl 10 to 15 μg may be used for the initial bolus. Dosing should occur in the operating room. The spinal anesthesia has quick onset; therefore, full monitors should be in place, as is standard practice for all surgical anesthetics. The spinal catheter may then be dosed every 5 minutes with half of the initial bupivacaine dose (2.5 mg) until the desired block height is achieved [68].

There are retrospective data to suggest that intrathecal catheter placement through an ADP may limit the rate of postdural puncture headache (PDPH) after dural puncture [65,69,70]. Also, some anesthesiologists recommend that the spinal catheter be left in situ for 24 hours post partum [66,69]. There is a recent prospective controlled study evaluating continuous spinal catheters and the potential role in PDPH [67]. In this prospective design, the spinal catheter did not reduce the risk of PDPH or the need for epidural blood patch. In this prospective review, a second ADP did occur 9% of the time, which is consistent with previous reports. Subsequently, women who experienced two dural punctures suffered extreme headaches, sometimes requiring more than one blood patch.

Considerations with spinal catheters include staff unfamiliarity; wrong drug–wrong route; infection; and neurologic injury. All spinal catheters should be unambiguously labeled. At our institution, only anesthesia providers dose neuraxial catheters, but communication and education occur with nursing staff as well. Aseptic technique is not dissimilar to the American Society of Anesthesiologists practice advisory for all neuraxial procedures [71]. With regards to neurologic injury, cauda equine syndrome has been reported with continuous spinal anesthesia. Case series of such complications were reported both from the obstetric and nonobstetric realms in the early 1990s. These reports were
related to continuous spinal anesthesia with 28-gauge microcatheters [72,73]. It is believed that the high-dose local anesthetic, hyperbaric 5% lidocaine, is more neurotoxic than the spinal catheter; however, the US Food and Drug Administration withdrew microcatheters from the US market in 1992. The larger epidural catheter has not been associated with cauda equina syndrome when used for continuous spinal anesthesia. The decision to leave a spinal catheter in situ after delivery is provider dependent at our institution, and risks and benefits of such practice should always be considered.

After ADP with an 18-gauge Tuohy needle (large cutting needle), the risk of PDPH has been reported to be 50% to 70% in the obstetric population [67]. Obesity decreases this risk [74]. One of the theories is that the abdominal adipose tissue acts as an abdominal binder, transmitting abdominal pressure to the lumbar epidural and intrathecal spaces. Increased pressure leads to decreased subarachnoid volume in the lumbar spine. With smaller volumes in the lumbar spine, more cerebral spinal fluid is transmitted to the cranial vault, thereby suspending the brain and lessening the severity of headache symptoms.

Spinal anesthesia is the most common anesthetic for cesarean delivery. There has been much debate over the past decade regarding morbid obese parturients and the dose of bupivacaine for cesarean delivery [75–77]. There is concern that commonly used doses of local anesthetic can potentially lead to high spinal in morbidly obese parturients because of their lower lumbar spinal volume. The evidence does not support these concerns. However, the evidence does show a shorter duration of surgical anesthesia with lower dosing [74]. If a smaller dose of spinal anesthetic is chosen, I suggest a CSE technique for epidural backup when duration of initial block is not adequate.

General anesthesia
Parturients have an increased risk of airway complications. Pregnancy leads to weight gain (both adipose and water), vascular engorgement and friable mucosa, incompetent lower esophageal tone, and aspiration risk. The common estimate is that pregnant women are 8 times more likely to have a difficult airway (1/250–1/300 pregnant patients) [78,79]. When the pregnant airway is compounded by morbid obesity, the challenge and subsequent risk of airway management are more significant [1]. Hood and Dewan [53] reported that 33% of their morbidly obese patients were difficult to intubate, requiring more than one attempt at laryngoscopy or awake intubations. A retrospective review of obstetric patients in the United Kingdom found 36 failed intubations over a 6-year period. The average BMI of failed intubation patients was 33 [79]. Despite our experience as anesthesiologists in identifying patients with difficult airways, at our institution a difficult airway cart is immediately available and dedicated to the obstetrics operating theater for the emergent, unanticipated, difficult obstetric airway.

Pulmonary physiologic changes in pregnancy lead to decreased functional residual capacity (FRC) as gestational age increases. Obesity, supine position,
and general anesthesia further impair FRC. In the emergency situation, optimal preoxygenation can be challenging in the obese parturient, but 8 deep breaths with a tight-fitting mask are adequate for preoxygenation [80]. It is also recommended to have an experienced assistant to promote optimal outcomes when emergency airway manipulation is necessary in the pregnant patient.

Obese patients are more difficult to mobilize and position in the operating room because of sheer size. Chesnut [81] suggested that morbidly obese women should be positioned in the ramp position for cesarean delivery regardless of anesthetic technique. Achievement of the recommended ramp position can be facilitated by envisioning Levitan’s suggestion of an imaginary horizontal line from the sternal notch to the external auditory meatus [82]. With optimal positioning, pulmonary mechanics are improved for the awake spontaneously breathing patient, but, more importantly, the airway axis is optimized for intubation when indicated.

**POSTOPERATIVE AND POSTPARTUM CARE**

Despite advances in tools and techniques, anesthesia-related maternal mortality continues. The most impressive observation from recent closed-claims analysis of maternal mortality is that fatal airway complications occur in the postoperative period with greater frequency compared with induction or intraoperatively [39,83]. In Mhyre and colleagues’ report [83], 8 maternal deaths over a 15-year period were deemed anesthesia related. All 8 deaths occurred postoperatively, and 6 of the 8 deaths were related to hypoventilation. In addition, 6 patients were obese and half of the deaths were related to unrecognized coexisting disease. As anesthesiologist we must continue our airway and monitoring vigilance in the postoperative period. Factors that play a role in postoperative respiratory compromise in this population are a greater prevalence of undiagnosed obstructive sleep apnea, increased sensitivity to anesthetics, maternal comorbidities, and a greater likelihood of emergency situations.

As the obesity epidemic continues to grow worldwide, more challenges arise for health care providers, including those involved in obstetric care. The otherwise healthy parturient seems increasingly less frequent in our labor and delivery suite. With greater incidence, pregnant patients present with a multitude of physiologic derangements because of their obesity. Health care providers must be aware of the potential metabolic, cardiovascular, neurologic, and respiratory comorbidities to which obesity contributes. Balancing the obstetric, maternal, fetal, and anesthetic concerns of these patients is best optimized with early interventions, consultation and education, preparation for potential emergent interventions, and a multidisciplinary approach to both patients (mother and fetus).

**References**


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