



# *From Preop to Postop: Cesarean Delivery From the Anesthesiologist's Point of View*

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## ***Introduction***

Although surgical delivery was described in antiquity, it was not until the development of safe anesthesia techniques for this procedure that it became practical for any but the direst of circumstances. Prior to this, if a parturient and fetus were locked together in obstructed labor, the outcome was almost certain death for the mother or baby or both. Had the increases in newborn birth weight over the past century occurred without the ability to safely make patients comfortable for operative delivery, perinatal deaths associated

with obstructed labor might well have reached epidemic proportions.

As the advent of safe anesthesia has allowed the growth of obstetric surgery, new indications for cesarean delivery have arisen. No longer is cesarean delivery reserved for situations where the mother or fetus is in extremis. Rather, the most common indications for operative delivery are presently dystocia, prior cesarean delivery, and “nonreassuring” fetal heart rate pattern. In addition, the improving safety of obstetric anesthesia permits cesarean delivery to be a reasonable option for conditions such as intrauterine growth restriction, reversal of umbilical artery diastolic flow as measured by Doppler velocimetry, preservation of pelvic floor function, and even maternal refusal of labor. As a result, cesarean delivery rates grew from 5.5% in 1970 to almost 25% by

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the late 1980s.<sup>1</sup> Attempts to reverse this trend using active management of labor and a trial of labor and vaginal birth after cesarean delivery (VBAC) resulted in a transient reduction in the rate of cesarean delivery; however, because Smith et al reported that VBAC is associated with a perinatal death rate 11-fold higher than that associated with planned cesarean delivery,<sup>2</sup> it appears likely that rates will return to those seen in the late 1980s.

### ***Anesthesia-Related Physiology***

Pregnancy, especially when associated with such conditions as pre-eclampsia, hemolysis, elevated liver enzymes, low platelets (HELLP) syndrome, or hyperemesis gravidarum, may affect every organ system of the body. Additionally, medical interventions such as beta-adrenergic agonists and magnesium may significantly alter the effects of anesthetic agents. Finally, the supine position required for cesarean surgery has a significant detrimental effect on cardiorespiratory function. As a result, the obstetrician must be aware of these potential interactions when assessing the risks and benefits of cesarean delivery.

#### **PULMONARY**

Airway edema is associated with pregnancy, particularly during the third trimester; pre-eclampsia further exacerbates this problem because of the associated capillary leak syndrome. In addition, most parturients develop nasal obstruction because of mucosal engorgement, especially when they are supine. Should a complication develop during regional anesthesia or if intubation is difficult during general anesthesia, these patients can be difficult to ventilate using a mask. Furthermore, mucosal tissue tends to become friable; insertion of a naso- or oropharyngeal airway may cause bleeding within the airway, exacerbating airway obstruction and obscuring the laryngoscopic view of the larynx. Breast enlargement may make it difficult to insert a laryngoscope; caudad deflec-

tion of the breasts by an assistant may be necessary.

The gravid uterus causes a cephalad shift of the diaphragm, reducing expiratory reserve volume and functional residual capacity (FRC). (Inspiratory reserve volume is actually increased so that vital capacity remains essentially unchanged.) Under normal circumstances, ventilation-perfusion matching is maintained so that the arterial oxygen pressure (PaO<sub>2</sub>) is normal. But the decreased FRC combined with the pregnancy-induced increase in oxygen uptake results in rapid oxygen desaturation with even short periods of hypoventilation or apnea. For this reason, it is important to provide supplemental oxygen in circumstances when ventilation may be depressed. Prior to induction of general anesthesia, it is especially important to fill the lungs with oxygen, allowing the maximum possible period of apnea before hypoxemia develops. This is best accomplished by 3 minutes of breathing 100% oxygen from a tightly fitting face mask; in emergent situations, 8 vital capacity breaths over a 1-minute period have been shown to be significantly more effective than 4 vital capacity breaths during 30 seconds.

#### **CARDIOVASCULAR**

At term, maternal blood volume and cardiac output are increased by 45% and 50%, respectively, as compared with prepregnant values; during labor, cardiac output may increase by an additional 25% to 40%. The resulting cardiovascular stress is well tolerated by normal parturients but poses an increased risk for those with underlying cardiovascular disease. For example, older parturients with occult coronary artery disease may develop symptoms and electrocardiogram (ECG) changes compatible with myocardial ischemia, whereas patients with valvular heart disease (especially aortic or mitral stenosis) may develop pulmonary edema with or without ventricular failure. Cesarean delivery may be used in these circumstances to reduce labor-related cardio-

vascular stress. The underlying cardiovascular pathology, however, poses unique anesthetic challenges. For example, aortic stenosis can be associated with severe hypotension following spinal or epidural anesthesia, and the stress of endotracheal intubation may cause myocardial ischemia in patients with coronary artery disease.

Gestational hypertensive disorders are associated with endothelial dysfunction. Vasospasm and capillary leak syndrome can lead to the unusual condition of intravascular volume contraction despite increased total body water content. As a result, these patients are particularly susceptible to the hypotensive effects of regional anesthesia. Prophylactic hydration with either crystalloid or colloid solution may be ineffective because of the rapid transudation of fluid from the intravascular space to the interstitium. Additionally, these patients are more sensitive than normal parturients to the effects of catecholamines.<sup>3</sup> Therefore, endotracheal intubation may be associated with extreme tachycardia and hypertension; in rare circumstances, intracranial hemorrhage may result.

When a parturient is supine, the gravid uterus compresses the inferior vena cava, the abdominal aorta, and iliac vessels. Systemic maternal hypotension results from the reduction in venous blood return to the heart (supine hypotension syndrome). Compounding this, uterine perfusion is further impaired by compression of the distal aorta and/or iliac arteries, increasing the potential for fetal asphyxia due to uteroplacental hypoperfusion. To reduce the risk, patients should be positioned with the right hip elevated so that the uterus is preferentially displaced from the lower pressure vena cava system. The recommended 15° displacement corresponds to right hip elevation of approximately 25% of the pelvic width. Adequacy of venous return is confirmed by assessment of maternal systemic blood pressure, although absence of aortic occlusion may be verified by palpation of pulses in the lower extremities.

### **GASTROINTESTINAL**

In parturients, gastric emptying is delayed and incomplete. Additionally, the enlarged uterus displaces the stomach cephalad and alters the angle of the gastroesophageal junction. This leads to incompetence of the lower esophageal sphincter, which increases the likelihood of gastroesophageal reflux. Gastrin production by the placenta promotes increased acid production by the maternal stomach. These factors combine to place parturients at increased risk of developing acid aspiration pneumonitis (Mendelson syndrome) while receiving anesthesia for cesarean delivery.

### **COAGULATION**

During normal pregnancy, the concentration of most clotting factors increases; as a result, normal parturients are in a relatively hypercoagulable state. Consequently, there is an increased risk of deep vein thrombosis and even pulmonary thromboembolism. This risk is exacerbated in patients with pre-existing disorders of fibrinolytic activity, such as lupus anticoagulant or deficiency of proteins C, S, or antithrombin III. Susceptible parturients may be receiving either unfractionated or low-molecular-weight heparin prior to their delivery. The timing of anticoagulant administration with relation to the cesarean section is of particular concern when regional anesthesia is considered.

Pre-eclampsia and HELLP syndrome can cause abnormal bleeding due to intravascular consumption of coagulation factors and platelets. The ability to generate clot is paramount to the safety of spinal and epidural anesthesia, and the presence of a coagulopathy contraindicates its use. It is necessary, therefore, to verify that the coagulation profile is adequate before regional anesthesia can be safely offered to patients at risk.

### **NEUROLOGIC**

Parturients are more sensitive to the effects of general and local anesthetics than non-pregnant patients. The decreased volume of the epidural and subarachnoid spaces also

contributes to an increased dermatomal level of anesthesia from a given dose of local anesthetic, predisposing these patients to “high” or “total” spinal or epidural anesthesia, with resulting respiratory embarrassment.

Because plasma concentrations of albumin and alpha-1 acid glycoprotein are decreased in parturients, there is decreased binding of both acidic and alkaline drugs. The increased free fractions of these drugs are more readily able to cross the blood–brain barrier, leading to an increased effect.

Patients with pre-eclampsia demonstrate significant neurologic alterations, including brisk tendon reflexes, ankle clonus, headache, and blurred vision. These patients are at risk for developing eclamptic seizures in the perioperative period. Should this occur during regional anesthesia, emergency induction of general anesthesia may be necessary to protect the patient’s airway. Magnesium therapy should not be discontinued before induction of regional or general anesthesia. Magnesium does, however, increase maternal sensitivity to anesthetic agents and markedly potentiates both depolarizing and nondepolarizing neuromuscular-blocking drugs. Therefore, these patients may not be strong enough to breathe on their own at the conclusion of surgery, necessitating a delay in extubation.

### ***Preparation of the Patient***

Regardless of the type of anesthesia to be administered, precautions must be taken to minimize the risks associated with anesthesia-related hemodynamic changes, aspiration of gastric contents, airway obstruction, complications associated with regional anesthesia, and intraoperative hemorrhage. Before beginning even an uncomplicated cesarean delivery, patients should have reliable venous access. Ideally, at least 1 freely flowing 18-gauge catheter should be in place; if there is an increased risk of intraoperative bleeding, a larger catheter or multiple catheters should be considered. Although most anesthesiologists would prefer

to administer 500 to 2000 mL of intravenous fluid before initiating regional anesthesia for cesarean section, there may not be time for adequate fluid preloading if crystalloid solutions are used in emergency circumstances. Rout et al demonstrated that the rapid infusion of 20 mL/kg of crystalloid immediately before spinal anesthesia reduced the incidence of maternal hypotension by only 16% compared with patients who did not receive preprocedure intravenous hydration.<sup>4</sup> This can be explained by the findings of Ueyama et al, who found that when 1.5 L of crystalloid solution was given over 30 minutes, only 28% of the infused volume remained in the intravascular compartment, increasing the blood volume (BV) by just 8% with no significant increase in cardiac output.<sup>5</sup> They also found that when a colloid solution (6% hydroxyethyl starch) was administered, 100% of the volume remained in the intravascular space; cardiac output increased by 15% and 43%, after administration of 0.5 and 1.0 L of colloid, respectively. The incidence of spinal-anesthesia–induced hypotension for the patients receiving 1.5 L of crystalloid, 0.5 L of colloid, and 1.0 L of colloid was 75%, 58%, and 17%, respectively. This study suggests that for effective prophylaxis against hypotension, the volume infused must be great enough to increase the cardiac output and that a colloid solution will accomplish this with a smaller infused volume. In an emergency, when time is limited for intravenous volume infusion, colloid may be more effective than crystalloid in preventing regional anesthesia–induced hypotension.

The patient’s blood should be typed and screened for antibodies that might make cross-matching difficult. If antibodies are detected or if abnormal hemorrhage is anticipated, blood should be cross-matched and the units made available in the delivery suite prior to the start of surgery.

To reduce the risk of regurgitation and aspiration of gastric contents, patients scheduled for elective cesarean delivery should be fasted for 8 hours. In urgent circumstances,

patients should receive nothing by mouth from the time the decision to operate is made until they have recovered from anesthesia. Because gastric emptying is impaired by both pregnancy and the pain of labor, it is not clear whether any specific length of fasting for either solids or clear liquids can ensure that the stomach is empty. The acidity of the gastric contents also influences the likelihood of developing Mendelson syndrome. Drinking 30 mL of 0.3 M sodium citrate solution or 2 tablets of Alka Seltzer Gold® antacid (Bayer, Pittsburgh, PA) dissolved in 30 mL of water within 30 minutes of the start of anesthesia quickly and reliably raises the pH of the stomach contents, reducing the risk of severe pneumonitis due to aspiration. Importantly, the use of particulate antacids like Maalox® (Novartis Consumer Health, Parsippany, NJ) in this setting is contraindicated, as the particles can cause small airway obstruction and pneumonitis. Histamine-2 receptor-blocking drugs have been shown to reduce gastric acid production; they do not affect the acid already present in the stomach, however, and therefore must be administered at least 2 hours prior to the induction of anesthesia to be effective.

Strategies to reduce the risk of failure to establish an airway begin with a preprocedure examination of the airway and inquiry into past difficulty with intubation by the obstetric care team. Findings suggestive of airway difficulties include marked obesity, severe edema of the face or neck, short neck, difficulty opening the mouth, small mandible, protuberant teeth, arthritis of the neck, macroglossia, or scar from previous tracheostomy.<sup>6</sup> If any of these factors are identified, an anesthesiologist should be consulted so that a plan can be developed to minimize the need for emergent induction of general anesthesia. In addition, equipment for alternative methods of ventilation (e.g., Combi-Tube® [Kendall-Sheridan, Rancho Cordova, CA], laryngeal mask airway), endotracheal intubation (e.g., Fastrach® intubating laryngeal mask airway [Laryngeal Mask Co., Henley on Thames, UK], light wand, fiber-

optic bronchoscope), or cricothyroidotomy should be immediately at hand. Even when regional anesthesia is planned, general anesthesia may become necessary.

Coagulopathy often accompanies conditions that lead to cesarean delivery. Hypertensive disorders of pregnancy, eclampsia, HELLP syndrome, prophylactic anticoagulation, and trauma all require assessment of the patient's coagulation status. In parturients, the epidural venous plexus is engorged. Inadvertent puncture or laceration of a vessel with a spinal or epidural needle cannot be prevented, and the ability to form a clot is necessary to prevent formation of an expanding hematoma. Symptoms of an epidural hematoma, such as weakness and loss of sensation, are exactly the same as those produced by the anesthetic itself; the diagnosis depends on recognition that the neuraxial anesthetic has not resolved as quickly as expected. If the diagnosis is suspected, it must be rapidly confirmed by magnetic resonance imaging (MRI) scan so that an emergency decompressive laminectomy can be performed. Permanent loss of nerve function is likely if diagnosis and treatment are delayed.

The coagulation system in pregnancy is complex and dynamic in nature, making it difficult to assess the risk of spinal hematoma in a specific patient. Laboratory measurement of the bleeding time, platelet count, prothrombin time (PT), activated partial thromboplastin time (aPTT), and thromboelastography have all been evaluated in clinical studies, although no single test has yet proven to be sufficiently sensitive and specific for clinical use. The American Society of Anesthesiologists Task Force on Obstetrical Anesthesia recognizes that a decreased platelet count may correlate with the severity of a patient's pregnancy-induced hypertension, but that evidence of its value in predicting anesthesia-related complications is lacking. It further recognizes that a specific platelet count predictive of regional anesthetic complications has not been determined.<sup>7</sup> It is our practice to require a prepro-

cedure platelet count in patients with gestational hypertensive disorders; if the count is less than 100,000/mm<sup>3</sup>, we usually avoid regional anesthesia unless the patient's history or physical examination suggests that intubation would be difficult. In those circumstances, PT and aPTT are checked, and if these are normal and there is no other clinical indication of abnormal bleeding, then we may choose to administer spinal anesthesia. (Epidural anesthesia is less desirable under these circumstances because the larger needle increases the risk of bleeding.)

In patients receiving therapeutic anticoagulation, anticoagulants should be discontinued long enough before cesarean delivery to allow coagulation to return to normal. In urgent situations, anticoagulation may be reversed with protamine in patients who have received unfractionated heparin; adequacy of reversal should be confirmed with an aPTT test. Low-molecular-weight heparins are not pharmacologically reversible and have a long duration of action; depending on the dose, The American Society of Regional Anesthesia (ASRA) recommends waiting 12 to 24 hours after the last dose of low-molecular-weight heparin before administering regional anesthesia. Additionally, anticoagulation should not be reinitiated until 24 hours after surgery and at least 2 hours after removal of an indwelling epidural or spinal catheter.

A thorough discussion of anesthetic options with the patient during a preoperative visit by the anesthesiologist is the best way to alleviate patient anxiety. An understanding of the rationale for choosing a particular technique and the plans for managing potential complications, along with thoughtful answers to her questions, will go a long way toward establishing confidence. Managing a patient's expectations by having her take an active role in her anesthesia plan will increase her satisfaction and build trust in her care team.

An occasional patient may require intravenous sedation before the initiation of regional or general anesthesia. For example,

patients who are extremely anxious may be unable to "hold still" during insertion of a neuraxial needle, and patients who require awake intubation will be more cooperative if moderately sedated before the procedure. Under these circumstances, small doses of midazolam and/or fentanyl have been shown to have little if any ill effect upon neonatal well being. Any resulting neonatal depression may be readily reversed with naloxone or flumazenil.

### ***Anesthesia Options for Elective Cesarean Delivery***

The techniques most commonly employed for cesarean deliveries are major conduction anesthesia (spinal, epidural) and general anesthesia. In rare circumstances, it may be necessary to use local infiltration anesthesia. Each option has its benefits as well as risks, and selecting the best technique requires consideration of patient characteristics, the anticipated duration of surgery, and the urgency of delivery. Equally important are a patient's previous experience and bias for or against a particular type of anesthesia. Because problems such as failed intubation and inadequate regional anesthesia may occur, a contingency plan must also be in place.

#### **GENERAL ANESTHESIA**

General anesthesia was the first modern technique widely employed for cesarean delivery. Its reliability and speed of administration make it indispensable to the obstetric anesthesiologist. General anesthesia is the technique of choice when surgery needs to start without delay because it avoids the time-consuming technical problems sometimes associated with location of the subarachnoid or epidural space. It can be used safely when there are contraindications to regional anesthesia such as severe hypovolemia, hemorrhage, coagulopathy, sepsis, infection over the lumbar spine, spinal pathology, a history of extensive spinal surgery, or maternal refusal of regional anesthesia. The problems of intraoperative nausea and retching are avoided as well.

The intravenous induction medications work every time, and all trained anesthesiologists are capable of quickly rendering a parturient unconscious and insensitive to surgical pain. Intraoperative patient anxiety and movement is avoided, providing the surgeon with ideal operating conditions. The anesthetic can be continued for any length of surgery, muscle relaxants can be used as needed, and the patient can be awakened promptly upon the completion of the operation.

The patient's protective airway or "gag" reflexes are eliminated, and her respiratory drive is depressed by general anesthesia. Because of these effects, the patient is routinely intubated with a cuffed endotracheal tube, both to protect her lungs from aspiration of acidic stomach contents should regurgitation occur and to allow ventilation to be assisted. To avoid vomiting or regurgitation during the vulnerable period between loss of consciousness and inflation of the endotracheal tube cuff, a rapid-sequence induction is routinely used. After filling the lungs with oxygen (see above), the patient is rendered unconscious with a rapidly acting hypnotic such as thiopental or propofol. Simultaneously, the patient receives a rapidly acting muscle relaxant; succinylcholine is most commonly used, but may be contraindicated in patients with a history of neuromuscular disease or malignant hyperthermia. Currently, the nondepolarizing alternative to succinylcholine is rocuronium; its onset is not quite as fast, however, and an intubating dose may last longer than an uncomplicated cesarean delivery. As consciousness is lost, 30 to 40 N (6–8 lbs) of pressure is applied to the cricoid cartilage, occluding the upper esophagus and preventing any regurgitated material from reaching the pharynx. Cricoid pressure is only released after the anesthesiologist confirms successful endotracheal intubation.

Induction of general anesthesia and muscle relaxation carries the inherent risk that the airway might be lost. Because of the anatomic changes described above, intuba-

tion is more likely to be difficult or impossible in parturients than in nonpregnant patients. Recognition of this risk has led to the popularity of regional anesthesia for cesarean delivery. In circumstances where regional anesthesia is contraindicated but preprocedure evaluation suggests a difficult airway, awake intubation using topical anesthesia and intravenous sedation will allow safe induction of general anesthesia.<sup>8</sup>

Induction of general anesthesia typically causes hypotension; if a patient is hypovolemic, this may cause uteroplacental hypoperfusion. In contrast, laryngoscopy and endotracheal intubation typically cause hypertension; in susceptible patients (especially those with hypertensive disorders of pregnancy), myocardial ischemia or intracranial hemorrhage may occur. Medications used to prevent the hypertensive response include opioids and beta-adrenergic antagonists. These, in turn, may cause neonatal depression and/or bradycardia, which may require treatment after delivery.

General anesthesia may also cause neonatal depression. Datta et al found that induction to delivery intervals of greater than 8 minutes are associated with lower Apgar scores.<sup>9</sup> However, because the depression is a readily reversible effect of the anesthetic agents rather than an indication of fetal distress, there is no need to "operate faster" when general anesthesia is used. One can postulate that the risk of injury to bowel, bladder, and other adjacent structures as well as to the fetus itself could be unnecessarily heightened due to surgical haste under these circumstances. The relative safety of general anesthesia for the fetus is confirmed by the observation of Mueller et al that the likelihood of fetal acidemia ( $\text{pH} < 7.10$ ) was 4 times greater with regional than with general anesthesia.<sup>10</sup>

#### **REGIONAL ANESTHESIA**

The decreased risk of airway-related maternal complications has been the primary driving force behind the increased use of regional anesthesia for cesarean delivery.

Other factors include patient-driven interest in being consciously aware of the moment of birth and the desire to share the experience with a loved one.

Some patients are very fearful of being awake after receiving regional anesthesia, but having a spouse or a “support person” with them in the operating room can go a long way toward relieving their anxiety. Recognizing that the surgical environment can be disturbing and that their presence may be disruptive, care should be taken when determining whether a support person should be permitted to be in the delivery room and whom that person should be. Rare is the anesthesiologist who cannot recount a story or two of fainting “companions” during a cesarean delivery. Every delivery unit allowing support persons in the operating room should have a plan in place to rapidly remove them from the operating room if necessary. Attending to the needs of the support person must not distract the anesthetist from care of the parturient.

### ***Spinal Anesthesia***

Because of its speed of onset and reliability, spinal anesthesia has eclipsed epidural as the regional technique of choice for cesarean delivery. The end result of both techniques, blockade of afferent nerve transmission, is similar, but the method by which this is accomplished is substantially different.

Spinal anesthesia is produced by injection of a relatively small dose of local anesthetic solution (e.g., bupivacaine 12 mg) into the cerebrospinal fluid (CSF). The site of action is at the nerve roots and dorsal root ganglia. The liquid anesthetic solution mixes freely within the CSF, easily penetrating the unsheathed nerves and assuring complete blockade of the affected dermatomes. For this reason, onset is rapid and the phenomenon of a “window,” often seen with epidural anesthesia, is thankfully absent.

The subarachnoid space is relatively large and easily located as compared with the epidural space (see below) and offers a more clear-cut end point for needle place-

ment—return of CSF from the needle. All of these factors contribute to the fact that a suitable level of anesthesia can be more rapidly obtained by the spinal as compared with the epidural route.

The primary disadvantage of using a single subarachnoid injection to provide anesthesia for operative delivery is the inability to prolong the block for longer procedures. For this reason, a long-acting local anesthetic such as bupivacaine or tetracaine is usually selected. Epinephrine or phenylephrine may be added to the local anesthetic in an attempt to prolong its duration; this seems to be more effective when tetracaine rather than bupivacaine is used. Adding fentanyl, sufentanil, or morphine may modestly prolong the block. The alpha-2 agonist clonidine may also be effective; it may, however, further exaggerate anesthesia-related hypotension.

Spinal anesthesia carries its own risks. Despite prophylactic administration of large volumes of intravenous fluids and left uterine displacement, hypotension still occurs in up to 55% of patients.<sup>4</sup> This can be treated by elevation of the lower extremities and/or administration of vasopressors. For years, ephedrine has been the standard treatment of maternal hypotension. Because it works by releasing endogenous catecholamines, tachyphylaxis develops with repeated doses, and it may be ineffective in patients whose catecholamine stores are depleted. Until recently, use of pure alpha-agonists has been discouraged because studies in pregnant ewes demonstrated disproportionate uterine artery vasoconstriction. Recent data in humans indicate that phenylephrine is both safe and effective for treating the hypotension associated with regional anesthesia for cesarean delivery.<sup>11</sup> Additionally, use of phenylephrine avoids the maternal tachycardia commonly associated with ephedrine.

Occasionally, the level of spinal anesthesia may extend too far in the cephalad direction. The major concern here is respiratory embarrassment, which occurs if the phrenic nerve (C3–C5) is anesthetized. Under these

circumstances, it may be necessary to assist patients' breathing until the block recedes. Still higher levels of spinal anesthesia may cause loss of consciousness ("total spinal") requiring endotracheal intubation for airway protection. On the other hand, if the level of anesthesia fails to reach the T4 level, patients may be uncomfortable during intra-peritoneal surgery, requiring urgent induction of general anesthesia after the procedure has started. Occasionally, patients fail to develop any anesthesia despite an apparently successful lumbar puncture; under these circumstances, the subarachnoid block may be repeated or general anesthesia selected, depending upon the clinical circumstances.

Postdural puncture headache (PDPH) has been a recognized complication of subarachnoid block for over a century. The use of small diameter pencil-point needles, which are less likely to cause a persistent CSF leak than the beveled needles they replaced, has reduced the incidence of this complication to 1% to 3%. This corresponds favorably to the incidence of accidental dural puncture during attempted epidural anesthesia (following which most patients will develop a severe PDPH).

The duration of spinal anesthesia can be extended if it is administered through a catheter threaded into the subarachnoid space. Standard epidural catheters can be used for this technique, but dural puncture with the large bore, 17- to 18-gauge needles necessary to insert these catheters is associated with a high incidence of PDPH. Microbore subarachnoid catheters, which can be inserted through a relatively small (typically 22-gauge) needle were withdrawn from the U.S. market because of the possibility of catheter breakage and because some patients developed cauda equina syndrome with repeated doses of lidocaine. Studies are ongoing to determine if they may be safely reintroduced with specific cautions regarding the use of lidocaine.

### **Epidural Anesthesia**

Epidural anesthesia is accomplished by insertion of a specialized needle just deep to the ligamentum flavum while carefully avoiding puncture of the dura. The fact that the distance from the ligamentum flavum to the dura may be as little as 2 mm means that the needle must be advanced to a precise depth, requiring frequent testing of the needle's position as it is advanced. This, plus the fact that the end point for needle insertion is less clear-cut than for subarachnoid block, contributes to the fact that epidural anesthesia is more technically demanding and takes longer to perform. Once the space is located, a catheter is threaded into place, and its functionality is tested. This is necessary to ensure that it is not located in an epidural vein (which could result in local anesthetic toxicity) or in the subarachnoid space (which could result in total spinal anesthesia). Local anesthetic is then injected via the catheter into the epidural space. The site of action of the local anesthetic is at the level of the ensheathed nerve roots as they pass through the epidural space. Thus, a sufficient volume of drug (typically 20 mL or more, corresponding to 400 mg of 2% lidocaine) must be injected so that all the nerve roots from T4 through S5 bilaterally are bathed with anesthetic solution. Failure of the drug to contact and block any one of the roots will result in an area of sensate skin in the dermatomal distribution of the corresponding afferent nerve. This is referred to as a missed segment or "window," which may result in patient discomfort during surgery. Injection of more drug may or may not "close" the window, depending on the anatomy of the patient's epidural space and the location of the catheter.

Drugs administered epidurally must penetrate the epineurium and perineurium covering the nerve root before reaching the site of action in the axon. This, in addition to the fact that the local anesthetic is administered incrementally, helps to explain why epidural anesthesia has a slower onset than spinal. This more gradual onset can be beneficial in

patients at increased risk for hypotension; epidural anesthesia will allow more time for physiologic compensation and/or pharmacologic intervention, reducing the risk of a precipitous drop in blood pressure. The catheter technique allows epidural anesthesia to be maintained indefinitely by repeated administration of local anesthetic. This is especially useful when the avoidance of general anesthesia is a primary goal and surgery is expected to be prolonged.

The recent popularization of combined spinal-epidural anesthesia (CSE) combines the reliability and rapid onset of spinal anesthesia with the flexibility of an epidural catheter to address the possibility that surgery may last longer than expected. Subarachnoid injection and epidural catheter insertion can be accomplished in 2 separate steps or combined using a needle-through-needle technique. With the latter method, a 17- or 18-gauge epidural needle is positioned in the lumbar epidural space and a longer, small diameter spinal needle is advanced through the epidural needle to puncture the dura and arachnoid membranes. After the spinal anesthetic is injected, the needle is removed, and a catheter is threaded into the epidural space for subsequent use if needed. Patients who are at risk for complications of an excessively high spinal level (e.g., short stature, morbid obesity, and pulmonary disease) may also benefit from CSE: a reduced dose of spinal medication can be initially injected, and if the resultant level of blockade is inadequate for surgery, additional epidural local anesthetic can be injected to raise the level of anesthesia.

#### ***Infiltration Anesthesia***

Use of local infiltration anesthesia for elective cesarean delivery has been described.<sup>12</sup> This technique avoids the potential complications associated with both general and major conduction (spinal/epidural) anesthesia. It does, however, introduce the significant risk of local anesthetic toxicity. Local infiltration anesthesia for cesarean delivery requires that a large volume of anesthetic (100

mL or more) be injected; even with such large doses, pain during intraperitoneal surgery is likely. From the practical point of view, local infiltration anesthesia does not completely avoid the risks associated with general anesthesia, because this must always be the backup plan should infiltration anesthesia prove inadequate.

#### ***Anesthesia Options for Emergency Cesarean Delivery***

There is no call like “Anesthesia STAT to labor and delivery” to quicken the pulse of an obstetric anesthesiologist. So much runs through the clinician’s mind while en route to the labor suite: what sort of catastrophic situation is developing? What does the patient look like? The indications for unscheduled cesarean delivery are myriad, ranging from the “semielective” (e.g., nonreassuring fetal heart rate, failure of labor to progress, dystocia) to the truly life threatening (e.g., obstetric hemorrhage, amniotic fluid embolus, prolonged fetal bradycardia, cord prolapse, eclamptic seizure). Clearly, the anesthesia options and associated risks differ depending on the underlying condition of mother and fetus and the urgency of the situation.

Communication between the obstetrician and anesthesiologist is pivotal to safe emergency obstetric anesthesia. At the first sign of trouble, the obstetrician should contact the anesthesiologist to alert him or her to the possibility that the patient might need emergency anesthesia care. This allows the maximum possible time to examine the patient, obtain informed consent, administer nonparticulate antacid, and insert catheters for fluid administration and monitoring. In situations where intubation is judged to be potentially difficult or where there are other factors that increase the risk of general anesthesia, an epidural or subarachnoid catheter can be inserted and tested in advance of the potentially urgent situation. This allows regional anesthesia to be initiated without delay once the decision is made to proceed with emergency cesarean delivery. Early

communication will also facilitate calling in backup anesthesia personnel if assistance is needed.

In cases where there is no early indication of problems, there must still be direct communication between obstetrician and anesthesiologist regarding the need for emergency anesthesia. The anesthesiologist needs to know the degree of urgency, as well as the mother's obstetric, surgical, and medical history and the condition of the fetus. There is a huge difference between the appropriate anesthesia management for an obese patient with a prior history of difficult intubation who requires cesarean delivery of a footling breech with a normal fetal heart rate pattern versus that of a thin, healthy patient with a normal airway who requires delivery of a fetus with severe bradycardia and a prolapsed cord. Only when these pertinent details are concisely relayed to the anesthesiologist can the best option for anesthesia be chosen in a timely manner.

The American College of Obstetricians and Gynecologists Committee Opinion on anesthesia for emergency deliveries recognizes that, "Although there are some situations in which general anesthesia is preferable to regional anesthesia, the risk of general anesthesia must be weighed against the benefit for those patients who have a greater potential for complications."<sup>6</sup> This acknowledges that general anesthesia should no longer be given in all cases of "fetal distress" without consideration of maternal risk factors.

If an epidural or spinal catheter has not already been inserted, general anesthesia is usually indicated for emergent cesarean deliveries when fetal decompensation is evident because it enables surgery to commence most quickly. Nonetheless, some experienced obstetric anesthesiologists feel they can prepare a patient for surgery with spinal anesthesia as rapidly as with general anesthesia. A spinal anesthetic can be promptly injected while the surgical team is scrubbing and gowning themselves. In the time it takes to "prep and drape" the patient's abdomen, the spinal will have devel-

oped, and surgery may commence without delay. Furthermore, regional anesthesia seems to be well tolerated by the fetus in this situation. Marx et al found no difference in neonatal outcome when urgent cesarean section is performed with spinal anesthesia or with the extension of a pre-existing epidural block versus general anesthesia, but 1-minute Apgar scores were better following regional anesthesia.<sup>13</sup>

In our practice, it is often necessary to wait for the surgical team to get ready, even in "acute" emergencies. Thus, administration of a "quick" spinal can often be accomplished without delaying surgery. Maternal conditions such as morbid obesity, scoliosis, or previous spinal surgery are associated with difficulty performing a lumbar puncture. Therefore, when evidence of severe fetal decompensation is present in these patients, it may be best to not waste time in a futile attempt to establish regional anesthesia but to plan instead for general anesthesia.

Regional anesthesia can be associated with cardiovascular collapse and profound hypotension when administered to patients with hypovolemia. In situations where apparent or occult hemorrhage is present, such as placental abruption, placenta previa, and maternal trauma, the use of regional anesthesia is contraindicated unless there is time for adequate fluid resuscitation. The presence or absence of hemorrhage is an important point to convey to the anesthesiologist when requesting emergency anesthesia. When fetal distress is evident in these scenarios, general anesthesia can be used to rapidly deliver the infant.

Local infiltration anesthesia may be a technique of last resort or a way to allow truly emergent surgery to begin prior to the arrival of qualified anesthesia personnel. However, because patients are almost always uncomfortable during intraperitoneal manipulation when this technique is used, general anesthesia is almost always induced once the anesthetist arrives.

All anesthetic techniques are associated

with risk. Maternal deaths due to cesarean anesthesia have declined dramatically since 1965 to an estimated 1.7 per 1,000,000 live births during the years 1988 to 1990.<sup>14</sup> This is due in large part to the increased use of regional anesthesia and a decreased incidence of regional anesthesia-related complications. (Withdrawal of the 0.75% concentration of bupivacaine from obstetric use and administration of epidural anesthetics in fractionated doses has minimized the likelihood of fatal local anesthetic toxicity.) In contrast, the fatality rate for general anesthesia has not declined. As a result, the case-fatality risk ratio for general anesthesia in the period from 1985 to 1990 was estimated to be 16.7 times that for regional anesthesia. This figure may be biased, because patients receiving general anesthesia may have had more comorbidities than those receiving regional. Obstetric deaths associated with general anesthesia are almost entirely due to hypoxia from loss of the airway or to complications associated with inhalation of stomach contents. Mandatory use of pulse oximetry and capnography since the late 1980s has essentially eliminated the risk of unrecognized esophageal intubation. This, along with improvements in alternative airway devices, the development of an algorithm for dealing with the difficult airway,<sup>15</sup> and a heightened awareness of the problems associated with general anesthesia in obstetrics, will likely lead to future reductions in the relative risk of general anesthesia for operative delivery.

The best choice, be it regional, general, or even local infiltration, requires an understanding of the patient's current physiologic state, anatomy, and anesthetic history along with the condition of the fetus. The technical considerations and pharmacologic effects of the various options are then evaluated to determine the safest plan.

### ***Postanesthesia Care***

Care of the mother during the immediate postoperative period requires continuation of the monitoring established in the operat-

ing room. Maternal blood pressure, heart rate, ventilation, oxygenation, consciousness, and level of regional anesthesia (if applicable) should be assessed when patients arrive at the recovery area and at frequent intervals thereafter. Patients are often hypotensive on arrival because of fluid losses and residual spinal or epidural anesthesia. If hypotension does not respond appropriately to intravenous fluids and modest doses of vasopressors, the possibility of occult bleeding related to uterine hypotonus or retained products of conception must be considered. Recovery may take place either in a dedicated recovery room or in a "labor-delivery-recovery room." Regardless of venue, the parturient must be under continual observation by her nurse so that changes in status can be immediately recognized and appropriate therapy initiated.

Following cesarean delivery, patients are frequently hypothermic. This results both from redistribution of heat from the patient's core to the periphery during anesthesia and from evaporation of fluid during the surgical procedure. Efficient forced-air warming devices can help to reduce heat loss during surgery, allowing patients to be more comfortable and shiver less during the recovery period.

Patients recovering from cesarean delivery under general anesthesia often complain of pain upon arrival at the recovery area. This may be treated with both opioids and nonsteroidal anti-inflammatory drugs (NSAIDs). Ketorolac, an NSAID, offers the advantage of being available in a parenteral preparation; because it is not COX-2 selective, it may be associated with increased bleeding. When opioids are administered, the residual effects of inhalation anesthetics can potentiate the associated respiratory depression and somnolence. Airway patency and ventilation must be regularly monitored and supplemental oxygen provided to maintain adequate oxygenation. Unless the patient has pre-existing pulmonary disease, the need for oxygen therapy rarely continues following discharge from the recovery area.

Patients recovering from regional anesthesia may also require analgesia as their block resolves; for best results, systemic analgesics should be started before pain becomes severe. The addition of a neuraxial opioid to an epidural or spinal anesthetic will reduce the requirement for systemic analgesics as the level of regional anesthesia recedes.

Recovery from regional anesthesia is also associated with the return of vasomotor tone. This increases central blood volume, cardiac filling pressures, and systemic blood pressure. Patients with risk factors for pulmonary edema (e.g., pre-eclampsia, pulmonary hypertension, cardiomyopathy, or aggressive fluid resuscitation) must be closely monitored for signs of fluid overload and treated with diuretic or vasodilator therapy as indicated.

The patient recovering from either regional or general anesthesia may also need symptomatic relief from nausea or vomiting. Ondansetron 4 mg intravenously and dexamethasone 8 mg intravenously, alone or in combination, are very effective in this regard. Refractory cases may respond to droperidol 0.625 mg intravenously, although some sources suggest that the ECG should be monitored to detect prolongation of the QT interval (see below).

Following regional anesthesia, recovery of both sensation and motor function should be assessed at regular intervals. If blockade has not resolved by the expected time (which depends on the specific medication and dose administered), the anesthesiologist should be informed so that the patient can be further evaluated. Once the patient is able to perform simple motor tests in bed such as knee flexion and straight leg raising against resistance, she may be allowed to stand with assistance at the bedside. Then, if she is able to bend and straighten her knees without assistance, she may be given full ambulatory privileges.

Discharge of patients from the recovery area is the responsibility of a physician. Either the anesthesiologist or the obstetrician decides when the patient has recovered sat-

isfactorily from anesthesia, is hemodynamically stable, is adequately oxygenated, and has no evidence of surgical complications.

### ***Postdural Puncture Headache***

After recovering from the acute effects of a spinal or epidural anesthetic, some patients will begin to complain of headaches when sitting or standing. The pain resolves when the patient is recumbent, only to return again upon arising. This postural headache results from leakage of CSF through the dural puncture site leading to decreased CSF pressure. Being in the upright position (sitting or standing) shifts the remaining CSF surrounding the brain to the spinal canal, causing the brain to “sag.” This results in painful traction on the supporting structures and intracranial vasodilation.

The routine use of small-gauge, pencil-point needles has reduced the incidence of PDPH associated with spinal anesthesia to less than 3%. Theoretically, epidural anesthesia is not associated with PDPH, because the dura is not entered. However, accidental dural puncture during attempted epidural anesthesia occurs with an incidence of approximately 1.5% to 3%, depending on the experience of the anesthetist. Because epidural needles are so large (17–18 gauge), the risk of PDPH following a “wet tap” during attempted epidural exceeds 50%. Postdural puncture headache usually develops within 3 days after the dural puncture, although the onset of symptoms may be delayed for up to 7 days.

Not all postpartum headaches following regional anesthesia are caused by loss of spinal fluid. It is important that the clinician rule out other causes of headache that may require emergent treatment before instituting treatment of PDPH. If the patient has fever, nuchal rigidity, or changes in mental status, the possibility of a “high pressure” headache resulting from meningitis, intracranial hemorrhage, or venous thrombosis must be considered.

Mothers with mild symptoms of PDPH may get relief with acetaminophen alone or

in combination with caffeine (a cerebral vasoconstrictor). These drugs only give short-term relief and therefore should be administered every 4 hours while patients are awake rather than being offered on an “as needed” basis. Tight abdominal pressure (e.g., abdominal binder with a pillow to compress the abdomen) may provide transient relief. Although dehydration must be avoided, the putative advantages of forced hydration are offset by the increased need to assume the uncomfortable upright position to use the lavatory.

Almost 90% of PDPH after spinal anesthesia with a 24-gauge or smaller pencil-point needle resolve with conservative therapy. Postdural puncture headache following inadvertent dural puncture with an epidural needle is much less likely to resolve with conservative therapy. Even in those cases where a PDPH resolves with conservative therapy, symptoms can last 7 days or more. It is unreasonable to expect a mother to care for her newborn while suffering a severe headache every time she gets up, so “waiting it out” is not an attractive option.

For those unfortunate patients with severe symptoms, an epidural blood patch is the treatment of choice. This procedure entails injection of up to 20 mL of fresh autologous blood into the epidural space near the site of the previous dural puncture. This provides immediate relief in over 95% of patients. Initial pain relief is thought to be related to the space-occupying effect of the injected blood, with CSF being displaced cephalad to restore intracranial CSF volume and pressure. Long-term relief is achieved by the formation of an organized clot sealing the dural hole. Intracranial pressure is then normalized through ongoing CSF production. Unfortunately, relief is permanent in only about 60% of patients; 25% of patients will require a second (or third) epidural blood patch to achieve long-term relief.

Epidural blood patch is not without risk. Accidental dural puncture may occur resulting in further loss of CSF, adding insult to injury. Backache and leg pain frequently oc-

cur during the procedure, limiting the amount of blood that can be injected. Infection caused by bacterial contamination of the injected blood, a risk frequently disclosed to patients considering a blood patch, is a very rare occurrence. Of course, strict aseptic precautions must be followed during the performance of this procedure.

There are also risks associated with the inadequate treatment of a PDPH. Hearing loss, abducens nerve palsy, and subdural hematoma are possible sequelae of untreated or inadequately treated CSF leakage.

When should an epidural blood patch be performed? If patients have an incapacitating headache, cranial nerve palsy, diplopia, or hearing loss, epidural blood patch should be performed without delay. In patients whose headache is less severe, conservative therapy should be initiated for 24 to 48 hours. If the headache persists, or the patient is about to be discharged from the hospital, epidural blood patch should then be offered.

### *Postcesarean Analgesia*

The Joint Commission on the Accreditation of Hospital Organizations has recognized that postoperative pain is often inadequately treated; as a result, they have declared that pain is the “fifth vital sign” that must be assessed and recorded in the patients’ medical record. The benefits of adequate pain control, such as earlier ambulation, improved interaction between mother and newborn, fewer thromboembolic complications, and better sleep are well documented. Research is ongoing into the best way to provide postcesarean analgesia while minimizing the associated side effects.

#### **SYSTEMIC ANALGESIA**

In the past, postcesarean analgesia was most commonly provided by intramuscular or subcutaneous injections of an opioid on an “as needed” basis. Problems associated with therapy include the facts that the injections are painful and that the correct dose may be difficult to determine. If the dose is too small, pain will be inadequately treated and

frequent injections required, whereas if the dose is too large, somnolence and respiratory depression may result.

These problems have been largely overcome by the use of patient-controlled intravenous opioids (patient controlled analgesia, or PCA). This technique allows a patient to self-administer a small, incremental dose of analgesic medication as needed. Judicious selection of the dose and “lock out” interval minimizes the risk of inadvertent overdose while allowing for patient comfort. This technology places the individual who both benefits from the analgesia and suffers the side effects of therapy squarely in the center of the decision to administer pain medication. Critical to the safety of intravenous PCA is that only the patient push the actuator button; if it is pressed by well-meaning friends or care givers, the main safety feature of the technique will be bypassed. A unique advantage of intravenous PCA is that the patient can self-administer additional analgesic medication in anticipation of the increased discomfort associated with activity. Some practitioners use a continuous (basal) opioid infusion in combination with patient-administered incremental doses. Such regimens do not improve patient comfort but do increase the risk of opioid-related complications.<sup>16</sup>

#### NEURAXIAL ANALGESIA

The frequent use of regional anesthesia for obstetric surgery makes attractive the administration of analgesic drugs by the subarachnoid and epidural routes. The dorsal horn of the spinal cord possesses opioid receptors that mediate analgesia when activated by exogenous opioid drugs. Less opioid is needed to activate these receptors when the drug is injected into the subarachnoid or epidural space as compared with systemic administration (potency gain). Thus, for a given degree of analgesia, plasma opioid levels are lower, and patients are less sedated and have less respiratory depression. Abboud et al showed less profound depression of the ventilatory response to CO<sub>2</sub> in

patients receiving either 0.1 or 0.25 mg of morphine intrathecally as compared with those who received 8 mg of morphine subcutaneously.<sup>17</sup>

In patients receiving single-dose spinal anesthesia, spinal opioids must necessarily be administered preoperatively, concomitantly with the spinal anesthetic. Lipid-soluble opioids, like fentanyl and sufentanil, are frequently administered by this route to improve the quality and duration of operative anesthesia. Their relatively short duration of action does not offer significant postoperative analgesia. Morphine, by contrast, is less lipid-soluble and therefore more slowly resorbed from the CSF. Thus, it can provide postoperative analgesia lasting 12 to 24 hours. The persistence of morphine within the CSF is not without risk. As the CSF circulates, morphine is carried rostrally to the brain stem, where it causes sedation, respiratory depression, and nausea. Initial reports of delayed respiratory depression following subarachnoid morphine typically occurred in patients who received 2 to 5 mg of the drug. More recently, dose-ranging studies have determined that the optimal dose of subarachnoid morphine is 0.075 to 0.10 mg. Palmer et al found that 24-hour intravenous PCA morphine use following cesarean delivery was 45.7 mg lower in patients who received 0.075 mg intrathecal morphine compared with those who did not receive an intraspinal opioid.<sup>18</sup> These doses provide adequate analgesia while minimizing the risk of respiratory depression; however, patients still need to be monitored appropriately. The rate and depth of respiration and level of consciousness should be assessed hourly for up to 24 hours after subarachnoid administration, keeping in mind that opioid-induced respiratory depression is not always accompanied by a decrease in respiratory rate. If the respiratory rate is less than 8 breaths per minute, breathing is shallow, or the patient is difficult to arouse, the nurse should apply supplemental oxygen and call the anesthesiologist. Naloxone and equipment for positive pressure ventilation

should be immediately available. In selected cases, a low-dose naloxone infusion (50–100 mcg/hour) will reverse respiratory depression without affecting analgesia.

Less serious but still troublesome side effects of spinal morphine include nausea, pruritus, and recrudescence of herpes simplex virus (HSV) infections. Pruritus occurs in 40% to 80% of obstetric patients receiving subarachnoid morphine. If mild, the symptoms may be relieved by diphenhydramine 25 to 50 mg orally or intravenously. Although this drug is sedating, it does not increase the risk of respiratory depression.<sup>19</sup> More severe pruritus may require the use of a low-dose naloxone infusion (see above).

Nausea, with or without vomiting, occurs in 20% to 60% of patients receiving subarachnoid morphine. This may be initially treated with ondansetron 4 to 8 mg intravenously or orally. If nausea proves refractory, droperidol 0.625 mg should be considered. Although concerns about electrocardiographic QT interval prolongation have curtailed its use, arrhythmias are extremely unlikely at this low dose. Scopolamine 0.1 mg intravenously may be effective, but is associated with sedation and an uncomfortable antisialagogue effect. Transdermal scopolamine may be an effective prophylactic strategy if initiated before the onset of symptoms, but the latency of effect of this route of administration reduces its usefulness for treatment of established symptoms. Intractable nausea and vomiting may require low-dose naloxone similar to that used for relief of pruritus.

Because of the risk of recrudescence of infection, patients with a history of herpes simplex labialis virus may not be appropriate candidates for the use of spinal morphine. The level of risk for maternal-to-neonatal transmission of HSV is not known but should be discussed with the patient before choosing this analgesic technique. Neither the administration of other opioids by intraspinal injection nor the use of morphine by the intramuscular, subcutaneous, or oral route is associated with reactivation of HSV.

Opioids may also be administered into the epidural space. This technique is useful in 2 circumstances. First, if a patient has received epidural anesthesia for cesarean delivery, morphine can be administered into the epidural space before the epidural catheter is removed at the end of surgery. The optimum dosage as determined by Palmer et al is 3 to 4 mg, which is appreciably smaller than the 10 mg doses used in the early days of this technique.<sup>20</sup> The reason that a larger dose is required, and that onset of analgesia is delayed when morphine is administered epidurally as opposed to intrathecally, is that the drug has to penetrate the meninges (particularly the arachnoid owing to the “tight junctions” between its cells) before reaching its site of action in the dorsal horn of the spinal cord. Hydromorphone, a hydroxylated derivative of morphine, has also been given by the epidural route for postcesarean analgesia. It is somewhat more lipid soluble than morphine; therefore, its onset is somewhat faster than that of morphine, whereas its duration of action is somewhat less. Because it is more rapidly removed from the CSF than morphine, there may be a reduced risk of rostral spread and the associated complications of nausea and respiratory depression.

Alternatively, an epidural catheter may be left in place following surgery allowing for the continuous infusion of opioids, with or without local anesthetics, during the postoperative period. Under these circumstances, shorter acting, lipid-soluble opioids (fentanyl and sufentanil) may be used. Because these drugs bind more avidly to the surrounding tissues, they are less likely to remain in solution in the CSF and circulate rostrally; thus, the risk of delayed respiratory depression is reduced. Notably, these drugs are rapidly absorbed into the bloodstream from the epidural space, resulting in plasma levels similar to those obtained with intravenous fentanyl and sufentanil infusions, raising questions about the neuraxial selectivity of the epidural route. The rapid onset of these drugs makes them useful for patient-controlled administration by the epi-

dural route and allows for faster offset of action should problems occur. Disadvantages of leaving an epidural catheter in place following cesarean delivery include the small risk of catheter-related infection and the fact that the patient is “tethered” to the infusion pump and medication supply. Additionally, if local anesthetic is included in the analgesic mixture, it is important to ensure that adequate muscle strength is present for safe ambulation. Indwelling epidural catheters are contraindicated in patients who are at risk for developing postoperative coagulopathy or are scheduled to be therapeutically anticoagulated after delivery. Pruritus, nausea, vomiting, sedation, and urinary retention may occur during continuous infusion of lipid soluble opioids; the treatment options are the same as those recommended when symptoms occur with spinal morphine (see above).

#### ENTERAL ANALGESIA

Although oral analgesics are simple to administer, they may be impractical in this patient population. Gastrointestinal motility is often diminished after abdominal surgery, thereby delaying drug absorption and reducing effectiveness; in fact, many patients are not permitted to take oral medications until motility has returned. Also, the presence of nausea and vomiting may preclude use of this route of administration. When enteral medication is indicated in patients who cannot yet take anything by mouth, the rectal route of administration should be considered. Siddik et al reported a 46% reduction of intravenous PCA morphine use by postcesarean patients who received diclofenac 100 mg rectally every 8 hours after bupivacaine spinal anesthesia.<sup>21</sup>

Once gastrointestinal motility has returned, most postcesarean patients can transition from parenteral to oral analgesia. Most commonly, an oral opioid in combination with either acetaminophen or an NSAID will provide sufficient analgesia. If the mother is nursing, the potential for neonatal depression from maternal opioids must

be considered. Codeine, oxycodone, morphine, and meperidine all accumulate in breast milk (milk:plasma ratio >1). Because drugs freely diffuse between the plasma and milk, neonatal effects can be minimized by judiciously timing nursing to coincide with low plasma levels of these medications (i.e., just before the next dose of analgesic is to be taken).

Because they have a different mechanism of action, NSAIDs may significantly potentiate the effects of opioids in these patients, reducing the amount of opioid necessary to provide adequate analgesia. Nonspecific NSAIDs like ibuprofen appear to be safe during lactation; however, there are no studies to demonstrate the safety or efficacy of COX-2 specific analgesics under these circumstances.

#### Summary

The last 20 years have seen marked improvements in the safety of obstetric anesthesia. Introduction of technologies such as pulse oximetry and capnography has essentially eliminated the possibility of unrecognized esophageal intubation or respiratory insufficiency. New needle technology has reduced the incidence of PDPH, improving the acceptability of this highly effective technique; improved fine-gauge subarachnoid catheters may be reintroduced in the near future, opening the door to continuous subarachnoid analgesia. Improved “test doses” and fractionation of epidural medications have reduced the risk of local anesthetic toxicity when epidural anesthesia is used for cesarean delivery. These changes may be reflected in statistics gathered over the next decade, which will hopefully show a continued improvement in the safety of anesthesia for patients undergoing cesarean delivery.

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