Regional anesthesia is used extensively for obstetric patients. Of the estimated 4 million women that give birth in the United States each year, approximately 60% receive regional anesthesia. Of these, the overwhelming majority receive spinal or epidural analgesia or anesthesia. The purpose of this chapter is to review the anatomy, physiology, and techniques relevant to the administration of neuraxial anesthesia in obstetric patients. Technical features represent only one element of the successful use of spinal or epidural anesthesia. Conversely, sound medical judgment is of little benefit if a physician uses inadequate technique.

ANATOMY

Obstetric Pain Pathways

Pain during the first stage of labor results primarily from changes in the lower uterine segment and cervix. Pain is transmitted by visceral afferent nerve fibers that accompany the sympathetic nerves and enter the spinal cord at the T10 to L1 segments. During the late first stage and second stage of labor, pain results from distention of the pelvic floor, vagina, and perineum. Pelvic pain is transmitted by somatic nerve fibers, which enter the spinal cord at the S2 to S4 segments (Figure 12-1).

During cesarean delivery, additional nociceptive pathways are involved in the transmission of pain. Most cesarean deliveries are performed with a horizontal (e.g., Pfannenstiel) skin incision, which involves the infraumbilical T11 to T12 dermatomes. During surgery, stretching of the skin may involve dermatomes two to four levels higher. Intraperitoneal manipulation and dissection involve poorly localized visceral pain pathways. Visceral pain may be transmitted by pathways as high as the celiac plexus. Additional somatic pain impulses may occur as a result of diaphragmatic stimulation, because the intercostal nerves innervate a portion of the peripheral diaphragm.

Anatomic Changes of Pregnancy

The normal anatomic changes of pregnancy affect the use of neuraxial anesthesia techniques. Uterine enlargement and vena caval compression result in engorgement of the epidural veins. Unintentional intravascular cannulation and injection of local anesthetic are more common in pregnant patients than in nonpregnant patients. In addition, the vertebral foraminal veins, which are contiguous with the epidural veins, are enlarged and obstruct one of the pathways for anesthetic egress from the epidural space during administration of epidural anesthesia. The enlarged epidural veins also may displace cerebrospinal fluid (CSF) from the thoracolumbar region of the subarachnoid space, as does the
greater intra-abdominal pressure of pregnancy; this displace ment partly explains the lowered dose requirement for spinal anesthesia in pregnant women. Subarachnoid dose requirements are also affected by the lower specific gravity of CSF in pregnant patients than in nonpregnant patients.

The hormonal changes of pregnancy affect the perivertebral ligamentous structures, including the ligamentum flavum. The ligamentum flavum may feel less dense and “softer” in pregnant women than in nonpregnant patients; thus, feeling the passage of the epidural needle through the ligamentum flavum may be more difficult. It may also be more difficult for a pregnant woman to achieve flexion of the lumbar spine. Progressive accentuation of lumbar lordosis alters the relationship of surface anatomy to the vertebral column (Figure 12-2). At least three changes may occur. First, a pregnant woman’s pelvis rotates on the long axis of the spinal column; thus, the line joining the iliac crests assumes a more cephalad relationship to the vertebral column (e.g., this imaginary line might cross the vertebral column at the L3 to L4 interspace rather than the L4 to L5 interspace). Second, there is less space between adjacent lumbar spinous processes during pregnancy. It may be more difficult to use the midline approach to identify the epidural or subarachnoid space in pregnant women. (Thus the often-heard comment, “She has a narrow interspace.”) Third, magnetic resonance imaging has shown that the apex of the lumbar lordosis is shifted caudad during pregnancy, and the typical thoracic kyphosis in women is reduced during pregnancy. These changes may influence the spread of intrathecal anesthetic solutions in supine patients (Figure 12-3). Finally, labor pain makes it more difficult for some women to assume and maintain an ideal position while the anesthesia provider performs neuraxial anesthesia.

Vertebral Anatomy

The administration of neuraxial anesthesia requires a complete understanding of the lumbar and sacral vertebral and perivertebral anatomy. Local anesthetics ultimately produce anesthesia through their effects on the spinal cord and nerve roots. The cephalad aspect of the spinal cord is continuous with the brainstem through the foramen magnum. In women of childbearing age, the spinal cord terminates as the conus medullaris at the level of the lower border of the first lumbar vertebral body. The conus medullaris is attached to the coccyx by means of a neural-fibrous band called the filum terminale, which is surrounded by the nerves of the lower lumbar and sacral roots, known as the

FIGURE 12-1 Pain pathways during labor and delivery. The afferent pain pathways from the cervix and uterus involve nerves that accompany sympathetic fibers and enter the neuraxis at T10 to L1. The pain pathways for the pelvic floor and perineum include the pudendal nerve fibers, which enter the neuraxis at S2 to S4.

FIGURE 12-2 The surface anatomy used to estimate the lumbar vertebral level. In pregnant women, the interiliac crest line (Tuffier’s line) may be slightly higher in relation to the lumbar vertebral axis because of the difficulty in flexing the lumbar spine.
cauda equina (Figure 12-4). Within the bony vertebral column are three membranes: the pia mater, the arachnoid mater, and the dura mater. The pia mater is a highly vascular membrane that closely invests the spinal cord and distally forms the filum terminale. The arachnoid mater is a delicate nonvascular membrane closely attached to the third and outermost layer, the dura. The subarachnoid space, located between the pia mater and arachnoid mater, contains (1) cerebrospinal fluid (CSF), (2) spinal nerves, (3) a trabecular network between the two membranes, (4) blood vessels that supply the spinal cord, and (5) lateral extensions of the pia mater—the dentate ligaments (these ligaments supply lateral support from the spinal cord to the dura mater). Although the spinal cord ends at the level of the bodies of L1 and L2 in most patients, the subarachnoid space continues to the S2 level. At the end of the spinal cord, the cauda equina begins and continues to the level of S2.

The outermost membrane in the spinal canal is a longitudinally organized fibroelastic membrane called the dura mater. This layer is a direct extension of the cranial dura mater and extends from the foramen magnum to S2, where the filum terminale blends with the periosteum of the coccyx. A potential space (i.e., the subdural space) exists between the dura and the arachnoid mater. The dural border cells have lower collagen content and few cell junctions, allowing for easy shearing after needle penetration and fluid injection. This “space” is not used intentionally by anesthesia providers. Unintentional subdural injection may explain some cases of failed spinal anesthesia; it may also explain the rare, slow-to-develop cases of high spinal anesthesia after the negative epidural test dose result and injection of additional local anesthetic.

Immediately external to the dura mater is the epidural space, which extends from the foramen magnum to the sacral hiatus. The posterior longitudinal ligaments form the anterior boundary of this space. The pedicles and intervertebral foramina form the lateral boundaries, and the ligamentum flavum forms the posterior boundary. The contents of the epidural space include nerve roots, fat, areolar tissue, lymphatics, and blood vessels, including the well-organized venous plexus of Batson. The epidural space is segmented and discontinuous; it is not the uniform cylindrical space many writers have described. As shown in Figure 12-5, the shape and contents of the epidural space vary with the level of cross section.

Epiduroscopy and epidurography suggest the presence of a dorsal median connective tissue band in some individuals. Anatomic dissection and computerized tomographic epidurography have also suggested the presence of epidural space septa. This band (or these septa) may provide an explanation for unilateral or incomplete epidural anesthesia. However, some investigators have suggested that the dorsal median band is an artifact of epidural space distention or an anatomic manifestation of the previously unappreciated epidural space segmentation.
The ligamentum flavum lies posterior to the epidural space. Historically some physicians have described the ligamentum flavum as a single ligament. In actuality, however, it is composed of two curvilinear ligaments that join in the middle and form an acute angle with a ventral opening (Figure 12-6).\(^9,10\) The ligamentum flavum is not uniform from skull to sacrum; indeed, it is not uniform even within a single intervertebral space. The thickness of the ligamentum flavum varies with vertebral level and position,\(^11\) as does the distance between the skin and the epidural space (Table 12-1).\(^12,13\) Hormonal changes may cause the ligamentum flavum to feel “softer” in pregnant women than in nonpregnant patients.

The lamina, the spinous processes of the vertebral bodies, and the interspinous ligaments lie posterior to the ligamentum flavum. Posterior to these structures are the supraspinous ligament (which extends from the external occipital protuberance to the coccyx), subcutaneous tissue, and skin (Figure 12-7).

Successful administration of caudal epidural anesthesia is complicated by widespread variations in sacral anatomy. Developmentally, the five sacral vertebrae fuse to form the sacrum. The sacral hiatus results from the failure of the laminae of S5, and usually part of S4, to fuse in the midline. The sacral hiatus is covered posteriorly by the posterior sacrococcygeal ligament, which is the functional counterpart to the ligamentum flavum. The shape of the bony defect varies from a narrow, slit-like opening to a wide-based, inverted “V.” The sacral hiatus is absent in approximately 5% of all adult patients, and such an absence precludes the administration of caudal anesthesia.\(^14\) The sacral hiatus is less likely to be absent in obstetric patients

<table>
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From Harrison GR, Clowes NWB. The depth of the lumbar epidural space from the skin. Anaesthesia 1985; 40:685-7.

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**TABLE 12-1 Distance from the Skin to the Epidural Space in 1000 Parturients**

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**FIGURE 12-5** A, Sagittal section of the epidural space demonstrates that the contents of the epidural space depend on the level of the section. B, Three-dimensional drawing of the epidural space shows the discontinuity of the epidural contents. However, this potential space can be dilated by the injection of fluid into the epidural space. (Redrawn from the Mayo Foundation. From Stevens RA. Neuraxial blocks. In Brown DL, editor. Regional Anesthesia and Analgesia. Philadelphia, WB Saunders, 1976:323.)

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**FIGURE 12-6** A horizontal section of the ligamentum flavum and associated neuraxis structures is shown next to an oblique parasagittal section of the lumbar vertebral neuraxis. The horizontal section illustrates the posterior ligamentous structures of the spinal column. The ligamentum flavum is composed of two leaves that meet in the midline at 90 degrees. The interspinous and supraspinous ligaments lie external to the posterior portion of the ligamentum flavum.

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**FIGURE 12-7** Midline sagittal anatomy of the vertebral column. When a needle is placed into the cerebrospinal fluid, it must pass through skin, subcutaneous fat, the supraspinous ligament, the interspinous ligament, the ligamentum flavum, the epidural space, and finally the dura mater and arachnoid.
than in older patients, because ossification of this opening seems to increase with age.

The interior of the sacrum contains the sacral canal, which in turn contains the terminal portion of the dural sac. The dural sac terminates cephalad to a line joining the posterior superior iliac spines at the level of the second sacral segment. The sacral canal also contains a venous plexus, which is part of the valveless internal vertebral venous plexus.

**PHYSIOLOGY**

Safe, successful administration of neuraxial anesthesia in pregnant women requires an understanding of the normal physiologic changes of pregnancy (see Chapter 2). Anesthesia providers, obstetricians, and nurses must appreciate the potential for aortocaval compression during spinal and epidural anesthesia. Only 10% of unanesthetized pregnant women manifest clinical evidence of the supine hypotension syndrome. However, the sympathectomy and vasodilation that accompany neuraxial anesthesia cause women to be more susceptible to the effects of aortocaval compression. These undesirable hemodynamic changes can be mitigated by avoidance of aortocaval compression, particularly during the maintenance of spinal or epidural analgesia or anesthesia. Physicians and nurses should maintain left uterine displacement during labor or when performing a vaginal examination or placing a fetal scalp electrocardiogram (ECG) electrode or urethral catheter.

The greater oxygen consumption and diminished functional residual capacity associated with pregnancy result in a faster onset of hypoxemia during maternal apnea. Aortocaval compression hastens the onset of cardiovascular collapse during high/total spinal anesthesia, and resuscitation is more difficult. Anesthesia providers should administer spinal or epidural anesthesia only in a physical setting in which complications, such as unintentional intravenous or subarachnoid injection of local anesthetic, can be rapidly and efficiently managed. In cases of cardiovascular collapse, endotracheal intubation may be necessary to facilitate mechanical ventilation and oxygenation and to protect the lungs from aspiration of gastric contents. Equipment and supplies necessary for laryngoscopy, intubation, and mechanical ventilation should be immediately available.

**Physiology of Neural Blockade**

Hormonal changes, anatomic changes, and decreases in CSF specific gravity likely are responsible for the lower local anesthetic dose requirements during spinal anesthesia in pregnant women. Local anesthetics produce conduction blockade primarily by blocking sodium channels in nerve membranes, thereby preventing the propagation of neural impulses. Differential blockade is manifested as differences in the extent of cephalad blockade of temperature discrimination and vasomotor tone, sensory loss to pinprick, sensory loss to touch, and motor function. Temperature discrimination and vasomotor tone are blocked to the greatest extent (i.e., most cephalad level), and motor function to the least extent. During spinal anesthesia, local anesthetics act directly on neural tissue in the subarachnoid space. Regression of anesthesia can be explained by the simple vascular uptake of local anesthetic from the subarachnoid space and spinal cord.

Epidural anesthesia has a much smaller zone of differential motor-sensory-sympathetic blockade; this difference suggests that the mechanism of epidural anesthesia must involve more than simple diffusion across the dura. For many years, nerve fiber size was presumed to be the primary determinant of susceptibility to local anesthetic blockade (i.e., smaller fibers are blocked more readily than larger fibers). However, later studies have shown that the length of nerve fiber exposed to local anesthetic is as important as the size of the nerve fiber. Fink hypothesized that the length of nerve fiber exposed to local anesthetic affects the extent of the differential zone of motor and sensory blockade. With spinal anesthesia, the local anesthetic concentration required to block sufficient sodium channels to affect motor, sensory, and sympathetic function is less than that needed for the better-protected nerves found in the epidural space; thus, a wider band of differential blockade occurs during spinal anesthesia than during epidural anesthesia.

The understanding of the mechanisms of spinal and epidural anesthesia likely remains oversimplified. Nonetheless, it seems clear that spinal anesthesia results primarily from the effects of local anesthetic on the spinal cord, whereas epidural anesthesia results from the effects of local anesthetic on nerve tissue within both the epidural and subarachnoid spaces.

**TECHNIQUE**

Contraindications for neuraxial techniques include the following: (1) patient refusal or inability to cooperate; (2) increased intracranial pressure as a result of a mass lesion, which may predispose the patient to brainstem herniation after dural puncture; (3) skin or soft tissue infection at the site of needle puncture; (4) frank coagulopathy; (5) uncorrected maternal hypovolemia; and (6) inadequate training or experience in the technique. Whether mild or isolated abnormalities in tests of blood coagulation preclude the use of regional anesthesia is controversial. However, it is clear that the prophylactic administration of low-molecular-weight heparin is a clinical risk factor that mandates caution in the administration of neuraxial anesthesia. The anesthesia provider should weigh the risks and benefits of neuraxial anesthesia for each patient.

**Patient Position**

Pregnant women have an exaggerated lumbar lordosis, and it is more difficult for them to flex the lumbar spine. However, most pregnant women are young, and youth usually allows sufficient flexibility to facilitate the insertion of a needle into the epidural or subarachnoid space. Whether the block is initiated in the lateral or sitting position is a matter of provider and patient preference. Most obstetric patients may assume the lateral decubitus position comfortably during the administration of spinal or epidural anesthesia; this position likely has less adverse effect on venous return and cardiac output than the sitting position and may allow easier fetal monitoring. Vincent and Chestnut performed a study in which they observed that neither the sitting nor the lateral position was
consistently superior with regard to patient comfort. However, pregnant women who preferred the left lateral decubitus position weighed less and had lower body mass indices than women who preferred the sitting position.

An assistant should be present to help the patient and monitor the fetus. If possible, the fetus should be monitored during, or at a minimum, immediately after all procedures. Equipment and drugs should be easily at hand and checked in advance of the procedure. Meticulous sterile technique includes thorough hand washing and the donning of a hat, mask, and sterile gloves by the anesthesia provider; the application of a skin disinfectant over a wide area of the lower back; and the use of a sterile barrier or drape. The donning of a sterile gown by the anesthesia provider is controversial.

When spinal or epidural anesthesia is performed with the patient in a lateral position, the patient’s back should lie at, and parallel to, the edge of the bed, for at least two reasons. First, the edge is the most firm section of the mattress. If the patient lies away from the edge of the bed, the patient’s weight will depress the mattress, and the anesthesia provider must work in a “downhill” direction. Second, this position allows anesthesia providers to keep their elbows flexed, facilitating control of fine hand and wrist muscle movements. The plane of the entire back should be perpendicular to the mattress. When asked to flex the lower back, patients typically roll the top shoulder forward, an action that rotates the spine (which is undesirable) but does not flex the lower back.

Similarly, patients positioned sitting should have their feet supported by a stool with the backs of their knees against the edge of the bed, a maneuver that helps position the patient’s back closer to the anesthesia provider. The shoulders should be relaxed symmetrically over the hips and buttocks. Beds in obstetric units often break at the top shoulder forward, an action that rotates the spine (which is undesirable) but does not flex the lower back.

The sitting position is likely associated with a higher incidence of orthostatic hypotension and syncope. However, the sitting position is preferred—and may be required—in obese parturients, in whom identification of the midline is significantly easier with the sitting position. Further, morbidly obese women may experience hypoxemia when placed in the lateral decubitus position. One study demonstrated a greater reduction in maternal cardiac output with maximal lumbar flexion in the lateral decubitus position than in the sitting position during identification of the epidural space. The investigators in this study speculated that maximal lumbar flexion in the lateral decubitus position results in concealed aortocaval compression.

When spinal anesthesia is performed, the patient’s posture relative to anesthetic baricity should be considered, as it influences the extent of blockade, the latency of blockade, and the incidence of hypotension. The incidence, timing, and extent of hypotension in the period immediately after initiation of the block depend on the type of block (i.e., spinal, epidural, or combined spinal-epidural), drug characteristics (e.g., baricity, concentration), patient position during the procedure, and patient position in the period following the procedure. For example, when spinal anesthesia is initiated with a hyperbaric solution for instrumental vaginal delivery, it often makes sense for the patient to be sitting to ensure the rapid onset of sacral anesthesia. Conversely, spinal anesthesia for cervical cerclage can be initiated in the steep lateral Trendelenburg position with a hypobaric anesthetic solution.

Posture has less influence on the spread of epidural anesthesia. During epidural anesthesia, a unilateral block more likely results from the malposition of the catheter (or perhaps an anatomic barrier within the epidural space) than from patient position, particularly after a bolus injection. Norris et al. observed that gravity did not augment the spread of anesthesia in patients receiving epidural anesthesia for cesarean delivery, and they concluded that posture does not need to be manipulated to ensure adequate bilateral epidural anesthesia. At least two studies have noted that the use of the sitting position is not necessary for the development of good sacral anesthesia when large volumes of epidural local anesthetic are given for cesarean delivery. However, Reid and Thorburn observed that the sitting position appeared to delay the spread of anesthesia to the midthoracic dermatomes. In comparison with the bolus administration of epidural local anesthetic, the extent of blockade may be more gravity dependent when the anesthetic is administered as a continuous infusion over a prolonged period.

Caudal anesthesia is used infrequently in modern obstetric anesthesia practice. However, there remain some circumstances in which a caudal technique is useful and/or advantageous. It is a good choice for the second stage of labor in selected patients in whom the lumbar epidural approach is hazardous or contraindicated (e.g., fusion or instrumentation of the lumbar spine). In most cases, caudal anesthesia can be successfully performed with the patient in a lateral decubitus position. Anatomic variation may require use of the knee-chest position in some patients.

**ULTRASONOGRAPHIC GUIDANCE**

Traditionally, surface anatomy visualization and palpation have been used to assess landmarks prior to initiation of the neuraxial procedure. Anesthesia providers are now beginning to use ultrasonography as a tool to help assess neuraxial anatomy. The use of ultrasonography has been shown to decrease both the number of attempts and the number of bony contacts. In children, ultrasonography was shown to aid in verification of both local anesthetic spread and catheter placement. Color Doppler has also been used to assess epidural vascularity in parturients, and the skin–epidural space distance can be estimated. Unlike for vascular access and peripheral nerve block techniques, ultrasonography for neuraxial techniques is not utilized in real time. Rather, it is a preprocedural tool to aid the operator in the assessment of needle insertion site, needle angle, and estimated depth of the epidural space.

A low-frequency (2- to 5-Hz) curvilinear probe allows visualization of neuraxial structures beneath the skin. The ultrasound beam can be used to identify first the spinous processes if these are not palpable, then the interspinous spaces, and finally, ligamentous structures. The ligamentum flavum and dura mater are dense tissues and will appear hyperechoic, like bone, whereas the less dense epidural and subarachnoid spaces will appear hypoechoic (Figure 12-8). Transverse and median longitudinal as well as paramedian longitudinal approaches have been documented. With the median longitudinal approach, the spinous process will produce a shadow...
when the beam is placed directly over it, thus reducing the ability to appreciate any ligaments beyond it.

Choice of Drug*

SPINAL ANESTHESIA

Anesthesia providers may give spinal anesthesia for cerclage, nonobstetric surgery during pregnancy, instrumental vaginal delivery, cesarean delivery, removal of a retained placenta, or postpartum tubal ligation. Spinal analgesia may be used for labor analgesia. Cesarean delivery represents the most common indication for spinal anesthesia in pregnant women. Most anesthesia providers administer a hyperbaric solution of local anesthetic for spinal anesthesia in obstetric patients. Use of a hyperbaric solution results in a faster onset of block and a higher maximum sensory level with a shorter duration of blockade. The urgency and anticipated duration of surgery dictate the choice of local anesthetic agent. The most common choice in the United States is bupivacaine. Other agents include lidocaine and tetracaine. Ropivacaine and levobupivacaine may be used but are not approved for spinal administration in the United States, and levobupivacaine is not available in the United States. Lidocaine provides a short to intermediate duration of action. Bupivacaine, tetracaine, levobupivacaine, and ropivacaine provide intermediate to long durations of action.

Anesthesia providers often add an opioid to the local anesthetic to improve the quality of anesthesia, particularly with regard to visceral stimulation, and to provide postoperative analgesia. The addition of an opioid to the local anesthetic decreases the incidence of intraoperative nausea and vomiting. The short-acting, lipid-soluble opioids (i.e., fentanyl, sufentanil) contribute to intraoperative anesthesia, and morphine is often administered for postoperative analgesia. Epinephrine may be added to prolong block duration and perhaps improve block density. It was hoped that other adjuncts (e.g., clonidine, neostigmine) might allow for the administration of a lower dose of local anesthetic and thereby minimize sympatholytic side effects and hasten recovery. Side effects from these other adjuncts, however, have precluded their wide use in obstetric anesthesia practice (see Chapters 26 and 28).

EPIDURAL ANESTHESIA

Local anesthetic agents available for epidural administration in obstetric patients include 2-chloroprocaine, lidocaine,
mepivacaine, bupivacaine, ropivacaine, and etidocaine. Mepivacaine and etidocaine are used infrequently in obstetric anesthesia practice.

Bupivacaine remains the most popular local anesthetic for analgesia during labor and vaginal delivery because of its differential sensory blockade, long duration of action, low frequency of tachyphylaxis, and low cost. Anesthesia providers infrequently administer bupivacaine for cesarean delivery because of the risk of cardiac toxicity and maternal mortality after unintentional intravascular injection of the drug.

Ropivacaine has gained popularity as an agent for epidural analgesia and anesthesia because it may result in less cardiac toxicity and greater differential sensory blockade than bupivacaine. Levobupivacaine, although not available in the United States, also has a more favorable safety profile than bupivacaine. Clinical trials have shown that ropivacaine and levobupivacaine have potency and analgesic qualities similar to those of bupivacaine, with the probable exception of less motor nerve block.

Bupivacaine, ropivacaine, and levobupivacaine all have longer durations of action than lidocaine, and they may be preferred over shorter-acting agents when longer duration of anesthesia or analgesia is desirable. They are more commonly used for maintenance of epidural labor analgesia, whereas the shorter-acting agents are used for epidural surgical anesthesia. Despite some variation among reports, published clinical studies suggest no more than slight differences in onset and potency, and no differences in quality or duration of neural blockade, among the three drugs. However, bupivacaine is more cardiotoxic than the other agents in vitro and probably after unintentional intravascular administration. It would seem prudent to use ropivacaine or levobupivacaine rather than bupivacaine when a bolus dose of a concentrated solution is being given. When administered as a low concentration infusion, improved safety has not been demonstrated with ropivacaine and levobupivacaine compared with bupivacaine.

The most popular choice of local anesthetic for epidural anesthesia for cesarean delivery is 2% lidocaine with epinephrine. The addition of epinephrine (5 μg/mL) causes a modest prolongation of the block. The major advantage of epinephrine is that it improves the quality of epidural lidocaine anesthesia. Lam et al. have shown that epidural labor analgesia can be extended to surgical anesthesia for cesarean delivery in 5.2 ± 1.5 minutes with the addition of bicarbonate and fentanyl to 2% lidocaine with epinephrine.

Many anesthesia providers reserve 2-chloroprocaine for cases in which rapid extension of epidural anesthesia for vaginal delivery or urgent cesarean delivery is necessary. The onset of surgical anesthesia was several minutes faster with 2-chloroprocaine compared with lidocaine with freshly mixed epinephrine and sodium bicarbonate in the setting of urgent cesarean delivery after epidural labor analgesia. Therefore, when time is of the essence, 2-chloroprocaine is the drug of choice. Typically, in an emergency, a large volume of concentrated local anesthetic solution is injected quickly. An additional advantage of 2-chloroprocaine in this situation is that it is rapidly metabolized by plasma esterases. Therefore, the unintentional intravascular injection of a large volume of 2-chloroprocaine may be less likely to have serious adverse consequences. A potential disadvantage of 2-chloroprocaine is that it may interfere with the subsequent actions of opioids and bupivacaine, although this possibility is controversial.

As in spinal anesthesia, epidural opioids work synergistically with local anesthetics. Fentanyl 50 to 100 μg or sufentanil 5 to 10 μg is frequently added to an amide local anesthetic for both labor analgesia (allowing a lower dose of local anesthetic and less motor block) and cesarean delivery (resulting in a denser block with better blockade of visceral stimulation). Sodium bicarbonate may be added to lidocaine and 2-chloroprocaine (1 mEq/10 mL local anesthetic) to decrease latency.

CAUDAL ANESTHESIA

The drugs used for caudal epidural anesthesia are identical to those used for lumbar epidural block. However, a much larger volume (e.g., 25 to 35 mL) of local anesthetic solution must be administered to extend a caudal block for cesarean delivery or labor analgesia. Such large volumes entail a greater risk of systemic local anesthetic toxicity.

Equipment and Needle and Catheter Placement

SPINAL ANESTHESIA

The first equipment decision involves determining whether to perform a single-shot or continuous technique. Continuous spinal anesthesia is not a new technique; indeed, some physicians gave continuous spinal anesthesia 50 years ago. Currently, a large-bore epidural needle and catheter must be used for continuous spinal anesthesia, because the U.S. Food and Drug Administration rescinded approval for the use of small-bore catheters in 1992. Therefore, the risk of post–dural puncture headache is significant. This technique is useful after unintentional dural puncture with an epidural needle. In the morbidly obese patient, it may be easier to manipulate and advance a rigid epidural needle than a more flexible spinal needle; thus, the technique is useful for establishing continuous analgesia or anesthesia in this patient population, particularly when the need for anesthesia is urgent. However, for most obstetric patients, a single-shot technique is preferred for spinal anesthesia.

The primary equipment choice for spinal anesthesia concerns the type and size of the spinal needle. Cutting-bevel needles (e.g., Quincke) are rarely used in obstetric anesthesia practice today because of the unacceptably high incidence of post–dural puncture headache associated with their use. Instead, non-cutting needles (e.g., Whitacre, Sprotte, Greene) are used almost exclusively (Figure 12-9). Some anesthesia providers refer to the Whitacre and Sprotte needles as “pencil-point needles.” It is now believed that the pencil-point needles cause more trauma to the dura, which then results in a more intense inflammatory response than occurs with cutting-bevel needles. Presumably, the inflammation results in edematous closure of the dural defect.

Needle size must also be determined. In general, the “ease-of-use” advantages associated with larger needles must be balanced against a lower incidence of post–dural puncture headache with smaller needles. For most anesthesia providers, the two curves cross at the use of a 25-gauge needle (i.e., with smaller needles, the technical difficulties increase enough to offset the small reduction in the incidence of post–dural puncture headache). However, anesthesia providers should make individual decisions based on
their own skills, practice setting, and patient. The urgency of the procedure may also influence the choice of needle size. For example, a 27-gauge needle might be chosen for spinal anesthesia for an elective procedure, and a larger (e.g., 22-gauge) needle might be chosen when the subarachnoid space must be entered quickly because of severe fetal compromise.

With a small-gauge needle (i.e., 24-gauge or smaller), use of an introducer needle is preferable. The introducer needle allows for more accurate introduction of the spinal needle than is possible with use of a small-gauge spinal needle alone. The introducer needle also aids with skin puncture; it is often difficult to puncture the skin with non-cutting needles.

Either the midline or the paramedian approach can be used to enter the subarachnoid space. The midline approach requires the patient to reduce her lumbar lordosis to allow access to the subarachnoid space between adjacent spinous processes (usually L3 to L4, sometimes L4 to L5 or L2 to L3). The interspinous space may be identified with one (usually the thumb or index finger) or two fingers (usually the index and middle fingers) of the anesthesia provider's nondominant hand. The single finger "slides" along the skin in the midline from cephalad to caudad until it "settles" into an interspinous space. The two fingers identify the interspinous space by palpating the caudad border of the more cephalad spine. The fingers identify the midline by rolling in a medial-to-lateral direction (Figure 12-10). Next, the anesthesia provider injects local anesthetic intradermally and subcutaneously. The introducer needle is inserted into the substance of the interspinous ligament. It is helpful if the introducer needle is embedded in the interspinous ligament; therefore, obese patients may require a longer needle. The introducer needle should lie in the sagittal midline plane. It is then grasped and steadied with the fingers of the nondominant hand while the dominant hand holds the spinal needle like a dart. The fifth finger may be used as a tripod against the patient’s back to prevent patient movement from causing
unintentional needle insertion to a level deeper than intended, and to “brake” the needle. As the needle passes through the ligamentum flavum and the dura, characteristic changes in resistance are noted. A “pop” is often perceived as the needle tip traverses the dura mater. The stylet is removed, and CSF should appear in the needle hub. If CSF does not appear, the stylet is replaced, and the needle is advanced a few millimeters and again checked for CSF flow. If CSF does not appear at this point and the needle is at an appropriate depth for the patient, the needle and introducer are withdrawn, and the process is repeated.

The most common reason for lack of CSF flow is insertion of the needle away from the midline. If the anesthesia provider achieves good anesthesia of the skin and subcutaneous tissues, correct use of the midline approach is almost painless. Significant pain suggests that the needle is directed away from the midline; indeed, a patient often indicates that the pain is localized to either the left or right side of the midline. In such cases, correct direction of the needle should be confirmed. Redirection of the needle often eliminates the patient’s pain and results in the successful identification of the subarachnoid space.

Needle contact with bone also mandates redirection of the needle. If the needle is in the midline, the bone is either the cephalad or caudad spinous process, and the needle should be angled up or down in the sagittal midline plane. If the needle tip is angled off the midline or punc
tures the skin off the midline, the bone is probably the lamina of the vertebral arch. Needle contact with bone is usually painful. Again, the patient is often able to articulate whether she feels pain on the right or left side, or in the midline, allowing the anesthesia provider to make needle adjustments in the appropriate direction.

Once CSF is freely dripping from the needle hub, the dorsum of the provider’s nondominant hand steadies the spinal needle against the patient’s back while the syringe with local anesthetic is attached to the needle. After aspirating to ensure the free flow of CSF, the anesthesia provider injects the local anesthetic at a rate of approximately 0.2 mL per second. After completion of the injection, the anesthesia provider again aspirates approximately 0.2 mL of CSF and reinjects it into the subarachnoid space. This last step reconfirms the needle location and clears the needle of the remaining local anesthetic. The patient is then repositioned as appropriate.

For most patients, the midline approach is faster and less painful than the paramedian approach. The midline approach is also easier to teach than the paramedian approach, because it requires mental projection of the anatomy in only two planes, whereas the paramedian approach requires appreciation of a third plane and estimation of the depth of the subarachnoid space from the skin (Figure 12-11). Nevertheless, the paramedian approach is a useful technique that allows for the successful identification of the subarachnoid or epidural space in difficult cases. The paramedian approach does not require that the patient fully reduce her lumbar lordosis. This approach exploits the larger target that is available when the needle is inserted slightly off the midline.

A common error that is made with the paramedian approach is the insertion of the needle too far off the midline; the vertebral lamina then becomes a barrier to needle insertion. With the paramedian approach, the palpating fingers should again identify the caudad edge of the more cephalad spinous process. A skin wheal is raised 1 cm lateral and 1 cm caudad to this point; a longer needle is then used to infiltrate the deeper tissues in a cephalomedial plane. This step contrasts with the midline approach, in which the local anesthetic is not injected beyond the subcutaneous tissue. The spinal introducer is then inserted 10 to 15 degrees off the sagittal plane in a cephalomedial direction, and the spinal needle is advanced through the introducer needle toward the subarachnoid space. Another common error is to use an excessive cephalad angle with initial needle insertion. When the needle is inserted correctly and contacts bone, it is redirected slightly cephalad. If bone is again encountered, but at a deeper level, the slight stepwise increase in cephalad angulation is continued, and the needle is “walked” up and off the lamina.

As with the midline approach, the characteristic feel of the ligamentum flavum and dura can be appreciated. The aim
of the paramedian approach is to puncture the dura in the midline, even though the needle is inserted off the midline. Use of the paramedian approach requires insertion of a greater length of needle. Once CSF is obtained, the block is performed as it is with the midline approach.

The Taylor approach is a variation of the paramedian approach using the L5 to S1 interspace, which has the largest interlaminar space in the lumbosacral region. A 5-inch spinal needle is inserted in a cephalomedial plane from a site 1 cm medial and 1 cm caudad to the lowest prominence of the posterior superior iliac spine. If bone is encountered on the first needle insertion, the needle is redirected in small steps cephalad to walk off the sacrum and into the subarachnoid space.

During the performance of any nerve block technique, needle advancement should stop if the patient complains of pain. If pain is the result of inadequate soft tissue anesthesia, additional local anesthetic should be injected. Pain or paresthesias may also result from needle contact with central nerves or the spinal cord. Patient perception of paresthesias during the initiation of spinal anesthesia may indicate that the needle tip is in the subarachnoid space. The anesthesia provider should remove the stylet and check for CSF. If the paresthesia has resolved, the local anesthetic may be injected. If the paresthesia persists, however, the needle should be withdrawn and repositioned. In any case, the anesthesia provider should never inject the local anesthetic if the patient is complaining of paresthesias or lancinating pain, either of which may signal injection into a nerve or the spinal cord.

**EPIDURAL ANESTHESIA**

Special equipment for epidural analgesia or anesthesia includes an epidural needle, an epidural catheter (for a continuous technique), and a loss-of-resistance syringe (for the loss-of-resistance technique to identify the epidural space). Single-shot epidural anesthesia is rarely used in obstetric practice, because the major advantage of epidural over spinal anesthesia is the ability to provide continuous anesthesia or analgesia without puncturing the dura with a large needle. Most anesthesia providers use the loss-of-resistance technique to identify the epidural space; therefore a syringe is necessary. An epidural needle with a lateral opening (e.g., Hustead, Tuohy) is most commonly used because it allows a catheter to be threaded through its orifice (Figure 12-12).

Several types of single-use, disposable epidural catheters are available. Catheters are made from plastic materials and differ as to the degree of “stiffness.” Wire-embedded catheters are more flexible and are associated with a lower incidence of paresthesias and intravascular placement during catheter insertion. The single-orifice catheter has one opening at its tip, whereas the multi-orifice catheter has a closed “bullet” tip with 3 lateral orifices between 0.5 and 1.5 cm from the tip (Figure 12-13). The proposed advantage of single-orifice, open-end catheters is that the injection of drugs is restricted to a single anatomic site. In theory, this arrangement should facilitate the detection of intravenous or subarachnoid placement of the catheter. Likewise, a theoretical disadvantage of multi-orifice, closed-end catheters is that local anesthetic may be injected into more than one anatomic site (e.g., both the epidural and subarachnoid spaces). A catheter initially placed in the epidural space can migrate into a vein or the subdural or subarachnoid space.

**FIGURE 12-12** Epidural needles often used in parturients. Each needle is shown in an open-bevel view and an oblique orientation. The 18-gauge Hustead and 17-gauge Tuohy needles have lateral-facing openings, which direct epidural catheters to enter the epidural space more easily than if a single-shot Crawford needle design is used. (Other sizes and needle designs are available for obstetric epidural anesthesia.)

![Epidural needles](image)

fortunately, this does not seem to be a common clinical problem. Regardless of the choice of catheter, aspiration should be performed before each dose of local anesthetic is injected.

An advantage of the multi-orifice catheter over the single-orifice catheter is the consistent ability to aspirate fluid (either blood or CSF) when the catheter is in a vessel or the subarachnoid space. Multi-orifice catheters may lead to more even distribution of local anesthetic and a lower incidence of “patchy” or unilateral anesthesia when the anesthetic is injected as a bolus. However, during an infusion into the epidural space, the solution exits only the most proximal hole, and multi-orifice catheters thus behave like single-orifice catheters.

**FIGURE 12-13** Epidural catheters. A, Single-orifice catheter; B, multi-orifice catheter with bullet tip; C, coiled wire reinforced catheter. Bottom, Epidural catheter with centimeter markings along distal end and Luer-Lok connector at proximal end. (Drawing by Naveen Nathan, M.D., Northwestern University Feinberg School of Medicine, Chicago, IL.)

![Epidural catheters](image)
Two methods are used to identify the epidural space during needle advancement: (1) hanging drop method and (2) loss-of-resistance method. The majority of anesthesia providers use the loss-of-resistance method (Figure 12-14). The traditional loss-of-resistance syringe is a finely ground glass syringe with a Luer-Lok connector. Plastic syringes are now available, and the choice is generally a matter of the anesthesia provider's preference. The syringe is filled with 2 to 4 mL of saline, air, or saline with a small air bubble. There is some controversy regarding the use of air versus saline for detecting the point of loss of resistance. Saline causes some syringe plungers to stick and may be confused with CSF during initiation of combined spinal-epidural anesthesia. Conversely, injection of air into the epidural space may contribute to patchy anesthesia, and unintentional pneumocephalus may increase the risk of post–dural puncture headache. We prefer that the syringe contain both saline and a small (e.g., 0.25 mL) compressible bubble of air, although many anesthesia providers successfully use air.

Regardless of the technique used, success depends on correct placement of the needle tip within the ligamentum flavum. The needle should be advanced well into the interspinous ligament, or even into the ligamentum flavum, before the syringe is attached or before the hanging drop of solution is placed into the needle hub. This approach has at least three advantages. First, it encourages the anesthesia provider to use proprioception while directing and advancing the needle. Second, it shortens the time required for successful identification of the epidural space. Third, it lowers the likelihood of a false-positive loss of resistance.

Undoubtedly, this false-positive identification of the epidural space is responsible for many cases of unsuccessful epidural anesthesia; it is even possible to insert a catheter between the interspinous ligament and the ligamentum flavum.

During advancement of the needle-syringe assembly, the needle should be moved toward the epidural space by the provider’s nondominant hand while the thumb of the dominant hand applies constant pressure on the syringe plunger, thereby compressing the 0.25-mL air bubble. Alternatively, the intermittent, oscillating technique is typically employed when using loss of resistance to air. When the needle enters the epidural space, the pressure applied to the syringe plunger causes the solution or air to flow easily into the epidural space (see Figure 12-14).

In most obstetric cases, the anesthesia provider inserts a catheter and uses a continuous technique. The provider must decide whether to insert the catheter before or after the test and therapeutic doses of local anesthetic. Most practitioners insert the catheter before injecting local anesthetic, to allow for the slow, incremental injection of local anesthetic and the more controlled development of epidural anesthesia. However, there is little evidence that the incremental injection of local anesthetic through the catheter results in less significant hemodynamic change than incremental injection through the needle (followed by insertion of the catheter); also, injection through the needle may shorten the time to complete anesthesia or analgesia. Nonetheless, if the principal reason for using an epidural technique is the provision of continuous analgesia, it seems most practical to insert the catheter before injecting the
therapeutic dose of local anesthetic so that correct catheter placement can be verified promptly. Alternatively, both techniques can be combined, in that a small dose of local anesthetic is injected through the needle and the remainder of the dose is injected through the catheter.

If the catheter is placed before the test and therapeutic doses of local anesthetic, it may be helpful to inject 5 to 10 mL of saline before threading the catheter, as this may reduce the incidence of epidural vein cannulation, particularly when using stiffer epidural catheters. Rolbin et al. noted that there was no advantage to the injection of 3 mL of fluid into the epidural space before insertion of the epidural catheter.

Six to eight centimeters of catheter are threaded into the epidural space before the epidural needle is removed. The catheter may then be pulled back until it is at the desired distance at the skin. Occasionally, the anesthesia provider will have difficulty advancing the catheter past the tip of the epidural needle. This difficulty may indicate that the epidural needle tip is not in the epidural space. However, if the provider is convinced that the needle is correctly placed, several maneuvers may facilitate catheter advancement. Often, having the patient take a deep breath allows catheter advancement. Saline may be injected through the epidural needle if this has not been done. Although some providers rotate the epidural needle in an attempt to successfully advance the catheter, we do not recommend this maneuver, because it may increase the risk of dural puncture. Instead, the epidural needle should be withdrawn 0.5 to 1 cm, and again advanced into the epidural space.

Many techniques are available for securing the epidural catheter at the skin entry site. If a catheter will be used for prolonged intrapartum or postoperative analgesia, care providers should be able to assess the skin surrounding the catheter. A transparent, sterile adhesive dressing applied over the catheter after application of skin adhesive generally works well, and the periphery of the dressing can be reinforced with tape. The position of the epidural catheter may change significantly with patient movement from the sitting-flexed to the sitting-upright or lateral decubitus position. D’Angelo et al. found that the risk of catheter dislodgement was higher when catheters were inserted 2 cm into the epidural space, but the risk of unilateral blockade was higher when catheters were inserted 6 to 8 cm. Therefore, if the catheter is to be used for a short period (e.g., cesarean delivery), it should be left 2 to 4 cm into the epidural space. In contrast, if the catheter will be used for many hours (e.g., labor), it should be left 4 to 6 cm into the space. To minimize catheter movement at the skin, the patient should be positioned sitting upright or in the lateral position before the catheter is secured.

The potential for the contamination of local anesthetic solutions has prompted the use of micropore filters during the administration of continuous epidural anesthesia for labor. There is no evidence that filters decrease the rate of infection or of injection of undesirable foreign substances. Additionally, filters may reduce the reliability of aspiration and absorb local anesthetic solution, unless they are primed. We believe that micropore filters have little utility in clinical obstetric anesthesia practice.

**BOX 12-1 Advantages of Combined Spinal-Epidural Anesthetic Technique**

**Compared with Epidural Anesthesia**
- Lower maternal, fetal, and neonatal plasma concentrations of anesthetic agents
- More rapid onset of analgesia and anesthesia
- More dense sensory blockade
- Complete early labor analgesia with opioid alone (no local anesthetic necessary)
- Lower failure rate

**Compared with Spinal Anesthesia**
- Technically easier in obese individuals: The epidural needle acts as an introducer for the spinal needle (it is easier to advance a rigid epidural needle).
- Ability to titrate anesthetic dose (Start with low subarachnoid dose, and titrate to effect using epidural injection.)
- Results in less hypotension
- Ability to extend the extent of neuroblockade (Spinal anesthesia for forceps delivery may be extended to epidural anesthesia for cesarean after failed forceps delivery.)
- Continuous technique: ability to extend duration of anesthesia

**COMBINED SPINAL-EPIDURAL ANESTHESIA**

Combined spinal-epidural (CSE) anesthesia combines the advantages and mitigates the disadvantages of single-shot spinal anesthesia and continuous epidural anesthesia (Box 12-1). Anesthesia is initiated with a subarachnoid injection of local anesthetic and maintained via an epidural catheter. It is useful for both cesarean delivery anesthesia and labor analgesia. The injection of the smaller dose of local anesthetic required for spinal (compared with epidural) anesthesia is inherently safer with regard to the possibility of unintentional intravascular injection. Additionally, the anesthesia provider can inject a local anesthetic dose that is lower than the ED₉₅ (effective dose in 95% of cases) without fear of inadequate anesthesia. If surgical anesthesia is inadequate, the block can be “rescued” with epidural administration of local anesthetic. Lower intrathecal local anesthetic doses reduce the risk of maternal hypotension. Compared with conventional epidural anesthesia for cesarean delivery, CSE anesthesia is associated with a more rapid onset of surgical anesthesia, less intraoperative pain and discomfort (e.g., a more dense block), better muscle relaxation, and less shivering and vomiting.

During labor, CSE analgesia is associated with a faster onset of analgesia. Studies differ as to whether CSE analgesia is associated with higher maternal satisfaction and fewer requests for supplemental analgesia. A 2007 systematic review comparing CSE analgesia with epidural labor analgesia concluded that onset was faster with the CSE technique but that there was no evidence for differences in maternal satisfaction, mode of delivery, ability to ambulate, or incidence of hypotension between the two techniques. Several studies have found a lower incidence of failed epidural analgesia after the initiation of analgesia with a CSE technique. Presumably, verification of the
correct placement of the spinal needle by visualization of CSF increases the likelihood that the tip of the epidural needle is correctly placed in the epidural space.

A disadvantage of the CSE technique is that the correct placement of the epidural catheter in the epidural space cannot be verified until spinal anesthesia wanes. Therefore, if a functioning epidural catheter is important to the safe care of the mother and fetus (e.g., in the setting of a suspected difficult airway or nonreassuring fetal status), a CSE technique is not the technique of choice.

There are several techniques for CSE anesthesia. The most popular is the needle-through-needle technique, in which the epidural needle is sited in the epidural space and serves as an introducer for the spinal needle. The spinal needle passes through the epidural needle to puncture the dura. After injection of the intrathecal dose, the spinal needle is removed and the epidural catheter is threaded through the epidural needle. An alternative technique uses two skin punctures and two different interspaces: The spinal needle and epidural needle and catheter are introduced sequentially in two different interspaces.

The needle-through-needle technique requires a long spinal needle. Typically, a small (25-gauge or smaller) non-cutting needle is used in order to minimize the risk of post–dural puncture headache. The tip of the spinal needle must protrude 12 to 17 mm beyond the tip of the epidural needle when the two needles are fully engaged (Figure 12-15). Failure to puncture the dura and visualize CSF occurred in 25% of patients when the spinal needle protruded 9 mm, compared with no patients when the needle protruded 17 mm. A 127-mm spinal needle is commonly used with a standard 9-cm epidural needle. However, because of differences in hub configurations among needles, the two hubs may not “mesh,” and spinal needle protrusion may vary with specific needle combinations. Alternatively, manufacturers now sell CSE needle "kits," in which the spinal needle is designed for a specific epidural needle. An additional small non–Luer-Lok syringe (1 to 3 mL) is required for the spinal dose.

CSE anesthesia is initiated much like epidural anesthesia. The epidural needle is sited in the epidural space (Figure 12-16). The spinal needle is introduced through the epidural needle with the anesthesia provider’s dominant hand, while the nondominant hand is anchored against the patient’s back to serve as a brake for further advancement of the spinal needle. The provider usually perceives the tip of the spinal needle passing the tip of the epidural needle as a slight increase in resistance. Spinal needle advancement should stop immediately after the anesthesia provider perceives the dural puncture “pop.” Dural puncture is verified by visualization of CSF after removal of the spinal needle stylet. The provider’s nondominant hand is anchored on the patient’s back, and the spinal and epidural needle hubs are grasped together between the thumb and index finger of this hand. The dominant hand attaches the spinal syringe and injects the drug. We do not attempt to aspirate CSF, because it may not be possible to do so through long, small-bore needles and because attempted aspiration may result in movement of the spinal needle. After removal of the spinal syringe and needle as a unit, the epidural catheter is threaded in the usual fashion.

FIGURE 12-15 Combined spinal-epidural needle configuration. *Top.* Spinal needle exits the epidural needle through the normal epidural needle bevel. Because the epidural needle bevel opening faces sideways, the spinal needle exits the epidural needle at a slight angle to the long axis of the epidural needle. *Bottom.* Spinal needle exits the epidural needle through a special orifice. The axes of the spinal and epidural needles are aligned. The spinal needle must protrude from the tip of the epidural 12 to 17 mm when the hubs are engaged, or the ability to puncture the dura with the spinal needle is compromised. (Drawing by Naveen Nathan, M.D., Northwestern University Feinberg School of Medicine, Chicago, IL.)

Failure to puncture the dura with the spinal needle may occur in several circumstances (Figure 12-17). The epidural needle tip may not be located in the epidural space, or the needle tip may be correctly placed, but the spinal needle may fail to puncture the dura or may not reach the dura because of the depth of the posterior epidural space. Alternatively, the epidural needle may be angled away from the midline or in a sagittal plane off the midline, and the spinal needle may traverse the lateral epidural space without puncturing the dura. In this latter circumstance, the anesthesia provider may elect to abandon the CSE technique and continue with epidural anesthesia (if convinced that the epidural needle tip is in the epidural space) or to reposition the epidural needle and reattempt the CSE technique.

CAUDAL ANESTHESIA

Equipment for caudal anesthesia is similar to that used for lumbar epidural techniques, except that a needle with a lateral-faced opening is not needed. A blunt-tipped needle is satisfactory even when a catheter is used, because the angle of needle insertion allows insertion of the catheter. Successful administration of caudal anesthesia requires the accurate identification of the sacral hiatus. The sacrococcygeal ligament (an extension of the ligamentum flavum) overlies the sacral hiatus between the sacral cornua. Identification of the posterior superior iliac spines facilitates
FIGURE 12-16 Needle-through-needle combined spinal-epidural technique. A, The epidural needle is sited in the epidural space. B, The long spinal needle is passed through the epidural needle and punctures the dura mater. C, The operator’s nondominant hand stabilizes the spinal and epidural needles, and the spinal needle stylet is withdrawn. Cerebrospinal fluid is seen spontaneously dripping from the spinal needle. D, The syringe is attached to the spinal needle, and the intrathecal dose is injected.

Continued
the identification of the sacral cornua; the location of the sacral hiatus is approximated by using the line between them as one side of an equilateral triangle (Figure 12-18). Once the sacral hiatus is identified, the palpating fingers are placed on the cornua, the skin is anesthetized, and the caudal needle is inserted with the hub at an angle approximately 45 degrees from the skin. A decrease in resistance is noted when the needle enters the caudal canal. The needle is advanced until it contacts bone (i.e., the dorsal aspect of the ventral plate of the sacrum). Next, the needle is withdrawn slightly and redirected so that the angle of insertion relative to the skin surface is decreased. In pregnant women, the final angle is approximately 15 degrees from a plane parallel to the sacrum.

Accurate placement of the caudal needle is verified primarily from the “feel” of the needle passing through the sacrococcygeal ligament. An additional maneuver may help providers with less experience to verify correct needle placement: Once the needle is believed to be within the caudal canal, 5 mL of saline is rapidly injected through the needle while the anesthesia provider’s other hand is placed over the dorsum of the sacrum. If the needle is placed correctly, no mass or pressure wave is felt by the palpating hand.

The needle should be advanced only 1 to 2 cm into the caudal canal. Dural puncture or unintentional intravascular cannulation is more likely to occur with deeper insertion. A test dose similar to that used during administration of lumbar epidural anesthesia should be administered.

### COMPLICATIONS OF NEURAXIAL TECHNIQUES

#### Unintentional Dural Puncture

Unintentional dural puncture with an epidural needle occurs at a rate of approximately 1.5% in the obstetric population. Approximately 52% of women will experience a post–dural puncture headache after puncture with an epidural needle. Techniques to minimize the incidence of unintentional dural puncture include the following: (1) identification of the ligamentum flavum during epidural needle advancement; (2) understanding the likely depth of the epidural space in an individual patient; (3) advancement of the needle between contractions, when unexpected patient movement is less likely; (4) adequate control of the needle-syringe assembly during advancement of the needle; and (5) clearing the needle of clotted blood or bone plugs. Norris et al. observed that post–dural puncture headache after unintentional dural puncture was less likely to result in headache if the epidural needle bevel faced lateral rather than cephalad. In contrast, Richardson et al. found no difference between the two orientations. An *in vitro* study using cadaver dura found that fluid leakage rate through dural tears was not dependent on the orientation of the dura relative to the needle bevel. We prefer to insert the epidural needle with the bevel oriented in a cephalad...
direction so that there is no need to rotate the needle bevel within the epidural space. Cephalad bevel orientation also increases the likelihood of successful epidural anesthesia.75,77

The management of unintentional dural puncture depends on the clinical setting. One option is to site the epidural catheter within the subarachnoid space and to use a continuous spinal anesthetic technique. Evidence is conflicting as to whether the insertion of an epidural catheter through the dural puncture site decreases the incidence of post–dural puncture headache.78-80 Continuous spinal anesthesia is an attractive option if identification of the epidural space has been difficult, or if the anticipated duration of epidural anesthesia or analgesia is relatively short (e.g., cesarean delivery, or vaginal delivery in parous women). The major disadvantage of an intrathecal catheter is the risk that it may be mistaken for an epidural catheter. Given that the local anesthetic dose required for epidural anesthesia is many times greater than that required for spinal anesthesia, unintentional administration of an epidural dose into the subarachnoid space will lead to total spinal anesthesia. Therefore, on a busy labor and delivery unit where multiple providers are giving anesthesia care, it may be safer to use an epidural catheter rather than an intrathecal catheter in women in whom prolonged analgesia is anticipated.

The new catheter should be placed in another lumbar interspace, if possible. Even if the second catheter is correctly placed in the epidural space, anesthesia providers must be wary of an unexpectedly high level of anesthesia after administration of usual doses of local anesthetic.81,82 Leach and Smith82 reported a patient who had an extensive block after unintentional dural puncture and subsequent epidural injection of bupivacaine. They presented radiologic evidence of the spread of local anesthetic from the epidural space to the subarachnoid space. The extent to which a dural tear affects the movement of substances from the epidural space to the subarachnoid space depends on the size of the hole, the lipophilicity of the drug (highly lipophilic drugs cross quickly regardless of the presence of a hole, whereas water-soluble drugs cross more quickly in the presence of a hole),83 and whether the drug is administered into the epidural space as a bolus or an infusion.

Unfortunately, there is no reliable method to decrease the risk of post–dural puncture headache once dural puncture occurs. Obese patients appear to be at lower risk for the development of headache.84 A prophylactic blood patch (injection of autologous blood before removal of the epidural catheter and before onset of a headache) does not reduce the risk of post–dural puncture headache.85

Unintentional Intravascular or Subarachnoid Injection

The unintentional injection of drugs into blood vessels or the subarachnoid space can lead to catastrophe. The incidence of intravascular catheter placement varies according to catheter type,49 patient population,86 and proper placement of the epidural needle tip in the midline. Pregnant women are at higher risk for unintentional intravenous cannulation. Because the unintentional intravascular or subarachnoid injection of large doses of local anesthetic can be life-threatening, several precautions should be taken to reduce the chances and risks of intravascular injection. These include aspiration before each injection, incremental administration of small amounts of drug, use of an infusion when appropriate, and administration of an epidural test dose.

Epidural Test Dose

The purpose of the test dose is to help identify unintentional cannulation of a vein or the subarachnoid space. The test dose should contain a dose of local anesthetic and/or another marker sufficient to allow the recognition of...
intravenous or subarachnoid injection but not so large as to cause systemic toxicity or total spinal anesthesia. The most common intravascular test dose contains epinephrine, as recommended by Moore and Batra. Intravenous injection of epinephrine 15 μg consistently causes a transient increase in heart rate during the first minute after injection in nonpregnant subjects.

The epinephrine test dose is not without detractors. Some anesthesia providers fear that intravenous injection of epinephrine may decrease uteroplacental perfusion and precipitate fetal compromise. Counterarguments include the fact that changes in uterine blood flow after intravenous injection of epinephrine in pregnant laboratory animals were transient. Similar transient declines in perfusion undoubtedly occur during normal uterine contractions, and the adverse maternal and fetal consequences of intravenous injection of a large therapeutic dose of local anesthetic would likely be more severe. There has been no report of adverse neonatal outcome after intravenous injection of an epinephrine-containing test dose.

The epinephrine test dose is less specific in laboring women because cyclic changes in maternal heart rate complicate interpretation of its effects. For this reason, the test dose should be given immediately after a uterine contraction so there is less confusion as to whether tachycardia is caused by pain or intravenous epinephrine. Another argument against routine use of a test dose is that aspiration of multi-orifice catheters is 98% sensitive in identifying their intravascular location. Finally, because modern epidural labor analgesia involves the infusion of a low concentration of local anesthetic, unintentional intravascular administration is not likely to result in cardiovascular collapse.

Others argue that the epinephrine test dose still has a role in obstetric anesthesia practice. Large volumes of a concentrated local anesthetic solution are still routinely administered for urgent cesarean delivery. Lee et al. summarized injuries associated with regional anesthesia in the American Society of Anesthesiologists (ASA) Closed-Claims Database and identified unintentional intravascular injections as the second most common damaging event in obstetric claims. All events were associated with epidural or caudal anesthesia, and 75% resulted in cardiac arrest. Although a test dose was used in the majority of cases, only 30% of the test doses contained epinephrine.

Other methods of detecting intravascular injection are the injection of subtoxic doses of local anesthetic and the injection of isoproterenol, a small volume of air, or fentanyl (Table 12-2). It is imperative that the anesthesia provider take the time to look for evidence of intrathecal injection of local anesthetic. Intrathecal injection of lidocaine 30 to 45 mg or bupivacaine 5 to 7.5 mg is likely to produce objective evidence of spinal anesthesia within 5 minutes. Asking the patient whether or not she can wiggle her toes several minutes after the test dose injection is not adequate. In one study, the presence of lower extremity warmth and impaired pinprick response was only 93% sensitive for intrathecal injection, whereas impaired leg raise 4 minutes after test dose injection had 100% sensitivity for intrathecal injection.

Finally, every anesthesia provider should remember that no single test dose regimen can exclude every case of unintentional intravenous or subarachnoid injection. Box 12-2 summarizes steps that may be taken to decrease the risk of unintentional intravenous or subarachnoid injection of local anesthetic.

### Inadequate Anesthesia

Pain during anesthesia represents a higher proportion of obstetric malpractice claims than of nonobstetric claims. During labor, inadequate epidural analgesia may result from the inadequate extent of sensory blockade, non-uniform blockade, or inadequate density of blockade. When called to evaluate breakthrough pain, the anesthesia provider should first evaluate the extent of bilateral sensory blockade in both the cephalad and caudal directions. Particularly if labor is progressing quickly, the extent of sacral blockade may not be adequate. In this case, epidural injection of a large volume of local anesthetic may improve sacral blockade. In contrast, if the extent of sensory blockade is adequate but the patient is still experiencing pain, the

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### TABLE 12-2 Test-Dose Regimens Designed to Identify Unintentional Intravascular Injection

<table>
<thead>
<tr>
<th>Test Component*</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephrine 15 μg</td>
<td>15- to 20-bpm increase in heart rate</td>
</tr>
<tr>
<td>Isoproterenol 5 μg</td>
<td>15- to 20-bpm increase in heart rate</td>
</tr>
<tr>
<td>Local anesthetic alone:</td>
<td></td>
</tr>
<tr>
<td>Lidocaine 100 mg</td>
<td>Tinnitus, circumoral numbness, “dizziness”</td>
</tr>
<tr>
<td>Bupivacaine 25 mg</td>
<td></td>
</tr>
<tr>
<td>2-Chloroprocaine 90 mg</td>
<td></td>
</tr>
<tr>
<td>Air 1 mL</td>
<td>Mill-wheel murmur over right heart (use fetal Doppler probe to monitor)</td>
</tr>
<tr>
<td>Fentanyl 100 μg</td>
<td>Dizziness, drowsiness</td>
</tr>
</tbody>
</table>

*Superscript numbers indicate references listed at the end of this chapter.

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### BOX 12-2 Steps to Decrease Risk of Unintentional Intravenous or Subarachnoid Injection of Local Anesthetic

- Lower the proximal end of the catheter below the site of insertion. Observe for the passive return of blood or cerebrospinal fluid.
- Aspirate before injecting each dose of local anesthetic.
- Give the test dose between uterine contractions.
- Use dilute solutions of local anesthetic during labor.
- Do not inject more than 5 mL of local anesthetic as a single bolus.
- Maintain verbal contact with the patient.
- If little or no block is produced after the injection of an appropriate dose of local anesthetic, assume that the local anesthetic was injected intravenously, and remove the catheter.
density of blockade may be insufficient. In this case, the provider should reestablish and maintain analgesia using a more concentrated solution of local anesthetic.

Total block failure usually results from failure to identify the epidural space correctly or from malposition of the catheter tip outside the epidural space (e.g., in a neuroforamen). A unilateral block may occur despite the use of good technique. Unilateral block can often be prevented by limiting the length of catheter within the epidural space to 3 cm or less. The problem with limited insertion of the catheter is that, in some patients, the catheter tends to migrate outward over time. (Patients undergoing surgery remain still; by contrast, laboring women change position frequently.) Obese women seem to be at higher risk for outward migration of the catheter tip. Prospective studies suggest that 4 to 6 cm is the optimal depth of epidural catheter insertion in laboring women.60,61,107

Whether or not catheter withdrawal in the setting of breakthrough pain is beneficial is not clear. Beilin et al.108 compared catheter withdrawal followed by injection of local anesthetic with injection of local anesthetic without catheter withdrawal for the treatment of breakthrough pain. The ability to rescue analgesia was not different between the groups. Additionally, Gielen et al.109 performed a radiologic study in which they observed no consistent relationship between catheter position and the asymmetric onset of sympathetic blockade. Unilateral or patchy sensory blockade likely results from the nonuniform distribution of local anesthetic solution in the epidural space.110 Injection of a large volume of dilute local anesthetic solution into the epidural space usually corrects this problem, regardless of the location of the tip of the epidural catheter (provided it is actually in the epidural space). If analgesia cannot be rescued with a second injection, the catheter should be removed and replaced at another interspace.

The management of inadequate anesthesia is more problematic during cesarean delivery. Failure of spinal anesthesia may result from the maldistribution of local anesthetic within the subarachnoid space.111,112 If inadequate spinal anesthesia is noted before incision, the anesthesia provider may perform a second spinal anesthetic procedure and give additional local anesthetic. However, in the ASA Closed-Claims Database, Drasner and Rigler112 identified three cases of cauda equina syndrome complicating spinal anesthesia. In two cases, “failed spinal” anesthesia had occurred, followed by a repeat injection of local anesthetic. The researchers recommended that anesthesia providers determine the presence of anesthesia in the sacral dermatomes before giving additional local anesthetic into the subarachnoid space. Additionally, they stated that if CSF was aspirated during the original procedure, it should be assumed that local anesthetic was delivered into the subarachnoid space, and the total dose of local anesthetic be limited to the maximum dose a clinician would consider reasonable to administer in a single injection.112 If partial blockade is present (even if it is limited to the sacral dermatomes), the second dose should be reduced accordingly. It may also be advisable to perform the second procedure at a different interspace or make other changes to the original procedure (e.g., alter the patient’s position, use a local anesthetic with different baricity, or straighten the lumbosacral curvature).

If the patient complains of pain after incision, the anesthesia provider must decide between the administration of inhalation or intravenous analgesia and the administration of general anesthesia. Supplemental analgesia may be provided by giving 60% nitrous oxide in oxygen, small incremental boluses of ketamine (0.1 to 0.25 mg/kg), or small boluses of intravenous opioid. Supplemental infiltration of the wound with local anesthetic is sometimes helpful, especially when spinal anesthesia regresses near the end of an unexpectedly long operation. The anesthesia provider must ensure that the patient remains sufficiently alert to protect her airway. In most cases, severe pain unrelieved by modest doses of analgesic drug requires rapid-sequence induction of general anesthesia, followed by endotracheal intubation.

In some cases, inadequate epidural anesthesia results from failure to give a sufficient dose of local anesthetic or failure to wait a sufficient time after its administration. For example, after 0.5% bupivacaine is given epidurally, approximately 20 minutes must pass to achieve an adequate level of anesthesia, and additional local anesthetic may be needed to achieve an adequate density of blockade. In urgent cases or in cases with a “missed” segment, local infiltration with a local anesthetic often results in satisfactory anesthesia. Sometimes it is difficult to separate the beneficial effect of the local infiltration from the beneficial effect of waiting for the obstetrician to obtain, prepare, and inject the local anesthetic solution. Finally, the anesthesia provider should exercise caution when initiating spinal anesthesia after failure of epidural anesthesia because of a higher incidence of high spinal anesthesia in this setting.113 Presumably, the large volume of local anesthetic within, or near, the epidural space results in decreased lumbar CSF volume, which predisposes to high spinal anesthesia. It may be advisable to reduce the dose of intrathecal local anesthetic, particularly in the presence of partial epidural blockade.

**Equipment Problems**

The frequency of major equipment malfunction is very low during the administration of neuraxial anesthesia. Most anesthesia providers in the United States use disposable needles, and the plastic needle hubs are attached to the needles’ shafts with epoxy. Rarely, a needle breaks at the hub-shaft junction.114 If a needle should break, the portion of the needle that remains in the patient should be removed, because it may migrate and cause injury.112

An epidural or spinal catheter may shear and break off if the catheter is withdrawn through a needle; thus an epidural or spinal catheter should never be withdrawn in this manner. Rather, if the catheter must be withdrawn, the needle and catheter should be withdrawn as a unit. It is also possible to break a catheter during attempts at removing it, although this is rare. If resistance to catheter removal is encountered, the patient should assume a position that reduces lumbar lordosis, thereby lessening the kinking of the catheter between perivertebral structures. If position change is not successful, the catheter should be taped under tension to the patient’s back and left undisturbed for several hours. The catheter usually works its way out and is then easy to remove. Once the catheter has been removed successfully, it should be examined to ensure that it has been removed completely. Complete removal
of the catheter should be documented in the medical record. Rarely, catheters do break on removal. We favor aggressive attempts to remove broken spinal catheters. However, it may be unnecessary to remove broken epidural catheters; rather, in these circumstances, the patient can be informed of the complication and observed over time. The incidence of catheter migration or other delayed sequelae appears to be low. Computed tomography may help identify the precise location of a broken catheter, if necessary.\textsuperscript{116}

During use, an epidural catheter occasionally becomes disconnected from the catheter connector. Options include replacing the epidural catheter or reconnecting the connector to the catheter. Langevin et al.\textsuperscript{117} used an \textit{in vitro} model to investigate whether microbial contamination precludes reconnection. They found that an area of the interior of the catheter distal to the disconnection may remain sterile for up to 8 hours if the fluid column within the catheter remains static (i.e., if “fluid does not move within the catheter when it is raised above the level of the patient”\textsuperscript{117}). Therefore, they concluded that it \textit{may} be safe to decontaminate the exterior of the catheter, cut the catheter with a sterile instrument, and reconnect it to a new sterile connector. However, given the potential catastrophic consequences of neuraxial infection, we recommend replacing the catheter. Also, wire-embedded catheters cannot be cut.

\textbf{Resuscitation of the Obstetric Patient}

Intravenous, spinal, or epidural injection of local anesthetic may rarely precipitate maternal cardiac arrest. If this event occurs before delivery, left uterine displacement must be maintained and aortocaval compression avoided during maternal resuscitation. Initially, the ABCs of resuscitation are important; these include (1) the establishment and protection of the patient’s airway, (2) the provision of adequate ventilation, and (3) the restoration and maintenance of circulation.

The American Heart Association (AHA) has reviewed cardiopulmonary resuscitation in pregnant women.\textsuperscript{118} The AHA guidelines state that standard algorithms and pharmacologic therapy should be used without modification for pregnancy. Left uterine displacement should be maintained during the resuscitation. If initial resuscitative efforts are unsuccessful, the obstetrician should consider emergency hysterotomy (cesarean delivery), because it may be impossible to resuscitate the mother until adequate venous return is restored. The decision to proceed with delivery depends on several factors, including gestational age, features of the cardiac arrest (e.g., duration of arrest and hypoxemia), and the professional setting (skills of surgeon, anesthesia provider, neonatologist, and presence of support personnel). If gestational age is less than 20 weeks, a hysterotomy may be performed to facilitate maternal resuscitation, but the fetus will not be viable. After 24 weeks’ gestation, chances of survival for both the mother and baby may be improved with delivery. The resuscitation team leader should consider emergency delivery as soon as the arrest occurs, because best infant survival has been observed when delivery occurs within 5 minutes of the maternal arrest.\textsuperscript{118} Hysterotomy should therefore begin within 4 minutes of the arrest.

\textbf{REFERENCES}


