9
Relief of Labor Pain by Regional Analgesia/Anesthesia
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By far the most popular form of labor pain relief is regional analgesia. A number of techniques are possible for the different phases of labor and are listed in Table 9-1. This chapter will

Table 9–1. Techniques Used for Relief of Labor Pain

First Stage	Second Stage
(1) Epidural analgesia	(1) Epidural analgesia
(2) Continuous spinal analgesia and anesthesia	(2) Spinal anesthesia
(3) Combined spinal-epidural technique (CSE)	(3) Combined spinal-epidural technique (CSE)
(4) Caudal analgesia	(4) Caudal analgesia
(5) Paracervical block	(5) Pudendal nerve block
(6) Bilateral sympathetic block	

focus on central neuraxial techniques, including epidural and combined spinal-epidural analgesia.

Epidural Analgesia

This is the most commonly employed procedure for both the first and second stages of labor. It offers greater benefits when compared with any other anesthetic methods for labor and delivery.

Anatomy of the Epidural Space

Recent cryomicrotome studies of fresh cadaveric specimens have advanced the knowledge of epidural spaces for the anesthesiologist. The epidural space is partially a potential space, in that it is "empty" but the dura and ligamentum flavum are not adherent, so that it may be expanded to accept catheters and drugs. Contents of the epidural space as described by Hogan are contained in a series of "metamerically and circumferentially discontinuous compartments" (parts at each vertebral segment filled with fat and other contents) separated by zones where the dura contacts the canal wall. The dura tapers off inferior to the L4–L5 disc in the sacral canal, and the space is usually filled by the epidural fat.[1] The posterior epidural space is occupied at each segment by a fat pad in the triangular space between the ligamenta flava and dura. Hogan observed no midline fibrous septum. However, the presence of midline fatty tissue can potentially cause uneven spread of local anesthetic and result in a patchy or unilateral block. When unilateral block occurs, it is usually on the right side, though the mechanism of this finding is unclear.[2] The distance from the skin to the epidural space has been observed with graduated needles and by using ultrasound and magnetic resonance examination. The depth varies considerably from 3 cm to 9 cm; the average depth is 4.5–5.5 cm.[3]

The posterior epidural space is triangular in shape, with the apex facing posteriorly (Fig. 9-1), and lies between the dura mater and the ligamentum flavum. The epidural space extends
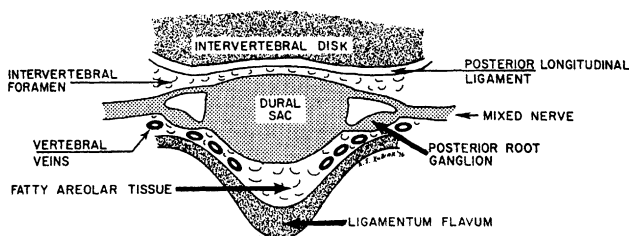
Figure 9–1. Contents of the epidural space. (From Abouleish.[79] Used with permission.)

from the base of the skull to the sacral hiatus *and is bounded* as follows:

1. Superiorly by the dura adherent to the skull at the foramen magnum. The clinical implication of this is related to the absence of total spinal anesthesia via the epidural route.
2. Inferiorly by the sacrococcygeal ligament at the level of the S2–3 interspace.
3. Anteriorly by the posterior longitudinal ligament (lying anterior to the dural sac).
4. Posteriorly by the ligamentum flavum.
5. Laterally by the dural cuffs, pedicles, and lamina.

Contents of the Epidural Space

The epidural space is sometimes characterized as a "potential" space in that it can be expanded by infused local anesthetic. However, the space is not empty prior to the block, and indeed contains several important structures:

1. Anterior and posterior nerve roots with their coverings.
2. Blood vessels that supply the spinal cord.
   a. The posterior spinal artery, which originates from the inferior cerebellar artery and supplies the posterior columns and posterior horns.
   b. The anterior spinal artery, which originates from the two vertebral arteries at the foramen magnum and supplies the anterior portion of the spinal cord.
   c. The artery of Adamkiewicz, which is the major feeder of the anterior spinal artery and arises from one intercostal

or lumbar artery in the T8–L3 region. It supplies the lower two-thirds of the spinal cord.

d. The vertebral veins, which drain blood from the vertebral column and the nervous tissue and ultimately form the vertebral venous plexus. They run via the anterolateral part of the epidural space and ultimately drain into the azygos vein. This venous connection is associated with important clinical implications: *during pregnancy due to obstruction of the inferior vena cava, epidural and azygos vein blood flow is markedly increased. A small dose of local anesthetic injected accidentally into the epidural vein, especially during labor, can reach the heart in a higher concentration*[4] *and thus increase the chances of myocardial depression.*

3. Fatty areolar tissue, deposited between the nervous and vascular structures.

Site of Action

The site of action of the local anesthetic during epidural analgesia is not exactly known; however, several sites have been suggested: (1) spinal roots, the most important site; (2) mixed spinal nerve; (3) dorsal root ganglion; and (4) the spinal cord, which might be the ultimate site of action and plays an important role in regression of a prolonged epidural block.

Techniques

For theoretical purposes, segmental block and complete block techniques have been described; in practice, however, they overlap and form contiguous processes. Segmental block may be used in the first stage to limit the extent of sensory analgesia to the T10–L1 segments. As labor progresses to the second stage, analgesia can be extended to block the sacral innervations. A top-up dose may be required for this purpose while the woman is in the sitting position for about 5 min. If a forceps delivery is planned or if cesarean section becomes necessary, a higher concentration of local anesthetic may be used to achieve motor block and perineal relaxation. In a complete block (T10–S5) sensory analgesia from T10 to S5 is provided

from the very first dose, but theoretically the incidence of hypotension may be higher than when a segmental approach is used.

Epidural Analgesia Procedure

The following materials are needed for epidural placement:

1. An epidural tray (with catheter)
2. Local anesthetic agent: Typically, bupivacaine, 0.0625–0.5%, or ropivicaine 0.1–0.2% (more dilute solutions are popular in present practice); and an epidural infusion, either premixed or prepared from sterile saline solution in a 50- to 100-mL sterile plastic bag. Popular infusions include bupivacaine with fentanyl (0.0625–0.125% bupivacaine with 2 mcg/ml fentanyl).
3. A volumetric infusion pump or commercially available epidural pumps. The latter include important safety features not found on generic infusion pumps.
4. Fentanyl or sufentanil, if no premixed bags of epidural solutions are available, to achieve the final desired concentration (e.g., 2 mcg/ml fentanyl or 0.5 mcg/ml sufentanil)
5. Resuscitative equipment and drugs, including oxygen and delivery apparatus (facemasks, resuscitation bag), oral and nasal airways and endotracheal tubes, laryngoscope, cardiac monitor, induction drugs, and succinylcholine

At the Brigham and Women's Hospital, every effort is made to consult the parturient before induction of epidural anesthesia and informed consent is signed by the patient. Brigham and Women's also provides information via printed booklet and website (www.painfreebirthing.com, or http://www.brighamandwomens.org/painfreebirthing). Depending on the preference of the anesthesiologist, the technique is performed with the patient either in sitting position or in lateral position. One study showed that epidural catheter insertions in the lateral position are associated with decreased incidence of intravascular catheters.[5] The other advantages claimed in favor of lateral position are: *for the mother*, the lateral position is less physiologically demanding and reduces the need to abandon the technique due to vagal reflexes; the lateral position also enables the provision of neuraxial analgesia (and anesthesia) in the event of complex presentation; *for the fetus*, an improvement in blood flow resulting

in better gas exchange.[6] The left lateral position is preferred to the right lateral position as the former is associated with better maintenance of uterine blood flow. The arguments in favor of sitting position include the technical ease of insertion, superior patient comfort, possible improved analgesia for combined spinal epidural (CSE), and decreased aortocaval compression.[7] However, in obese women, physicians at Brigham and Women's, like many others, prefer a sitting position.

Observation of the fetal heart rate is of paramount importance before the introduction of epidural anesthesia. A volume of 500–1,000 ml of Ringer's lactate solution is used for acute volume replacement unless contraindicated, although evidence supporting this practice in preventing hypotension is lacking.[8] Sodium citrate, 30 mL, is given p.o. routinely before the induction of epidural analgesia. At Brigham and Women's Hospital, the Weiss modification of the Tuohy needle is routinely used. About 50% of anesthesiologists in the authors' institution use the technique of loss of resistance by air. Others prefer loss of resistance to saline technique. The superiority of one technique over the other is debatable (Arendt and Segal, Rev Obstet Gynecol 2008;1:49–55). However, using minimal quantities of air or saline to detect epidural space is equally effective. The L2–3 or L3–4 interspace is usually used for introduction of the epidural needle. *Tuffier's line, a line drawn from the top of the iliac crest, coincides with either the L4–5 interspace or the L4 spinous process, though the accuracy of identification of interspaces is quite low.* Once the space is identified by using either the loss-of-resistance to air or saline, 3–5 cm of the epidural catheter is inserted into the epidural space. The length of the catheter inserted into the epidural space depends on the type of catheter as discussed in the following section. Some practitioners prefer not inserting *more than 3 cm of the catheter into the epidural space unless the patient is obese. This technique may decrease the incidence of a unilateral block.*

Multiorifice Versus Uniorifice Epidural Catheters

Multiorifice catheters have recently become increasingly popular as they decrease the incidence of unilateral

blocks.[9–11] Beilin et al. studied 100 women in a prospective, randomized, and double-blind study. Patients were randomly assigned to have a multiorifice epidural catheter threaded 3 cm, 5 cm, or 7 cm into the epidural space. After placement of the catheter and administration of a test dose with 3 mL of 0.25% bupivacaine, an additional 10 mL of 0.25% bupivacaine was administered in two divided doses. Fifteen minutes later, the adequacy of the analgesia was assessed by a blinded observer. The authors found that catheter insertion to a depth of 7 cm was associated with the highest rate of insertion complications while insertion to a depth of 5 cm was associated with the highest incidence of satisfactory analgesia.[12] In another study[13] 800 healthy parturients requesting epidural analgesia were randomized to have open-tip (i.e., single-orifice) epidural catheters inserted 2 cm, 4 cm, 6 cm, or 8 cm within the epidural space. Epidural catheters inserted 8 cm within the epidural space were associated with more intravenous cannulation. Epidural catheters inserted 2 cm within the epidural space resulted in decreased incidence in unilateral sensory analgesia but were more vulnerable for dislodgement during movements of the laboring women. Twenty-three percent of epidural catheters inserted > 2 cm within the epidural space required manipulation. Therefore, if uniorifice catheters are used, the optimum catheter insertion is a balance between a good bilateral block and dislodgement. Based on these studies, some clinicians choose to insert a uniorifice epidural catheter no more than 3–4 cm or a multiorifice catheter no more than 5 cm into the epidural space. Recently, the practice at Brigham and Women's Hospital has changed to using single-orifice soft-tip catheters (open ended Arrow Flex-Tip®) as these catheters decrease the chances of intravascular insertion and the incidence of parasthesia without significantly increasing the incidence of inadequate blocks (when inserted 3–4 cm).[14]

Changes in the Position of Epidural Catheters Associated with Patient Movement

Epidural catheter movement has been noted with change in patient position and can result in inadequate anesthesia. This was investigated by Hamilton et al. in 255 parturients

requesting epidural anesthesia for labor or cesarean section, where a multiorificed lumbar epidural catheter was inserted with the patient in the sitting flexed position.[15] The distance to the epidural space, length of catheter inserted, and amount of catheter position change as the patient moved from the sitting flexed to sitting upright and then to the lateral decubitus position were measured before the catheter was secured to the skin. Data were grouped according to body mass index (BMI): < 25 kg/m^2, 25–30 kg/m^2, and > 30 kg/m^2. Catheters frequently appeared to be drawn inward with position change from the sitting flexed to lateral decubitus position, with the greatest change seen in patients with BMI > 30. Maximum epidural catheter position change was 4.28 cm in a patient in the > 30 BMI group weighing more than 180 kg. Based on these results, the authors recommend that multiorificed catheters be inserted at least 4 cm into the epidural space and that patients assume the sitting upright or lateral position before securing the catheter to the skin.[15]

Test Dose

An ideal test dose should be able to detect both accidental intravascular and subarachnoid injections of local anesthetics. Moore and Batra originally suggested that the use of 15 μg of epinephrine (1:200,000) with local anesthetic will detect accidental intravascular injections in nonpregnant patients by showing tachycardia.[16] The heart rates of the 175 patients increased from a mean of 79 ± 14 beats per minute to 111 ± 15 beats per minute. The heart rate increased within 23 ± 6 s following the injection and returned to baseline within 32 ± 33 s. However, the investigators used this test dose only in nonpregnant cases that were undergoing elective surgery and were under the influence of heavy premedication. When using 3 mL of 0.5% plain bupivacaine via the epidural route in 100 parturients in active labor, Cartwright and colleagues[17] observed heart rate increases of more than 20 beats per minute in 24 women and more than 30 beats per minute in 12 women in the following 60 s even though the catheters were not intravascular. Leighton and colleagues, using 15 μg of epinephrine intravenously in term parturients, observed heart rate increases

of greater than 25 beats per minute that lasted longer than 15 s in only 50% of cases.[18]

From these early studies it appeared that in pregnant women 15 μg of epinephrine might not be sensitive or specific enough to rule out accidental intravascular injection.[19] On the other hand, Abraham and colleagues, in search of an ideal test dose for both accidental intravascular and subarachnoid injections, used 3 mL of 1.5% hyperbaric lidocaine mixed with epinephrine (1:200,000) via an epidural catheter[20] (Fig. 9-2). The maternal heart rate increased from 76 ± 2 beats per minute to 109 ± 6 beats per minute if the solution was injected intravenously, and the sensory anesthesia reached the S2 level in 1.45 ± 0.12 min if the solution was accidentally injected in the subarachnoid space. Hence, the use of epinephrine, 15 μg, for the diagnosis of accidental intravascular injections remains
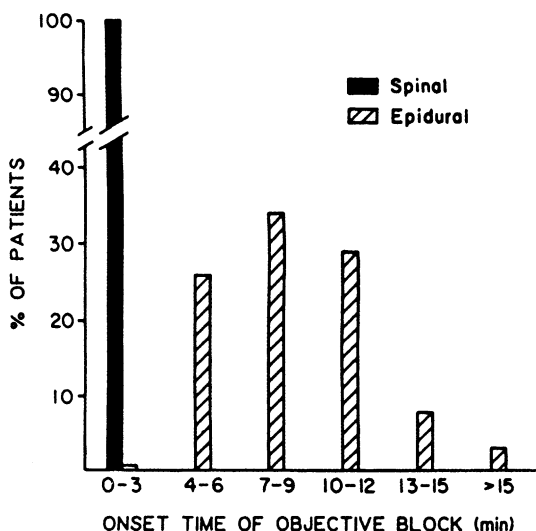

Figure 9-2. Time to onset of objective sensory loss (to pin prick) following epidural and spinal administration of a hyperbaric 1.5% lidocaine solution. (From Abraham.[20] Used with permission.)

controversial. If epinephrine is used in the laboring women as a test dose, one must first observe the maternal heart rate change from base to peak of a uterine contraction. Then one can interpret the effect of intravenous epinephrine.

Other approaches have been advocated. Leighton and colleagues examined air as a useful clinical indicator of intravenous placement of the epidural catheter. Using 1 mL of air through the epidural catheter and monitoring heart tones with a Doppler ultrasound probe, these authors observed only a 2% false-positive rate.[21] None of the 303 parturients in their study developed any complications due to the injection of 1 mL of air; the authors concluded that air, with precordial Doppler detection, is a safe and effective test for identifying intravenously located epidural catheters. This technique was not further evaluated and has not gained popularity in clinical practice. In the meantime, while the search continues for an ideal test dose,[22] one should exercise caution in preventing and diagnosing an incorrect placement of the epidural catheter:

1. For elective cases, unless contraindicated, one can use an epinephrine (15 µg)-containing solution as a test dose. Continuous electrocardiographs (ECG) monitor or pulse oximetry is essential to detect tachycardia. In this respect, one must remember that parturients who are being treated with β-*blocking drugs may not show tachycardia even when the epinephrine is intravascular.*[23]

2. Negative aspiration findings may not exclude intravascular catheter placement because the catheter may be against the vein wall and because aspiration can collapse the vein lumen. Aspiration immediately following the injection of local anesthetic may be more effective in recognizing intravascular catheter placement because the local anesthetic will push the vein wall away and may also dilate the blood vessels; placing the catheter 45–50° below the patient's body level at this stage can help the blood to flow through the catheter if it is intravascular.

3. Local anesthetics should be injected only 3–5 mL at a time, and the signs and symptoms of intravascular injection should be closely monitored. Fractionation of boluses of local anesthetic should prevent toxicity even if there is false-negative test dose.

4. Many anesthesiologists have argued for a no test dose technique in which "every dose is a test dose" and signs and symptoms of intravascular injection are sought every time a bolus of local anesthetic is administered. Brigham and Women's Hospital currently prefers this approach.

Initial Bolus Administration

Initial labor analgesia is generally provided with a variety of local anesthetic agents such as bupivacaine, levobupivacaine, or ropivacaine. At Brigham and Women's Hospital, we typically administer 20 ml of 0.125% bupivacaine for the initial establishment of the pain relief. This is administered in fractionated quantities of 5 ml boluses each. This initial volume can be decreased to 15–17 ml if 3 ml of lidocaine with 15 μg of epinephrine has been used for the epidural test dose. Other institutions favor more dilute initial boluses, such as bupivacaine or ropivicaine 0.1% or less.

Maintenance of Labor Analgesia

After obtaining initial pain relief with fractionated boluses of loading dose of the local anesthetic agent, further analgesia can be provided using intermittent injections or continuous infusion techniques.

Intermittent technique. Reinforcement is needed every 1.5–2 h or if the patient is uncomfortable, with the usual aim to maintain sensory analgesia from T10 to S5.

Continuous analgesia. Can be provided with infusion systems and is a more convenient method for providing satisfactory labor analgesia. A 50–100-mL sterile plastic bag is filled with a 0.0625–0.125% solution of bupivacaine and attached to the high-pressure infusion tubing (Luerlock). The tubing is flushed to remove any air and then connected directly to the epidural catheter. All connections must be secured, and the plastic bag must be labeled. The epidural (or generic volumetric) infusion pump is adjusted to deliver the desired dosage per hour. In the past higher concentrations of local anesthetic drugs, such as bupivacaine 0.25%, were used. The present trend is to use lower concentrations of local anesthetics in

attempt to minimize the motor effects of labor analgesia. Drugs commonly used are bupivacaine or levobupivacaine (0.0625–0.125%) or ropivacaine (0.1–0.2%) at 8–10 mL/h. The marginal differences in effectiveness between these agents are debatable but they all provide adequate analgesia with no significant influence on mode of delivery, duration of labor, or neonatal outcome.[24,25] In some studies bupivacaine has been attributed to more motor block than ropivacaine. However, this is not conclusively proved in other studies and may simply reflect a potency difference between the drugs.[26] In addition to the local anesthetic agents that are in use currently, other drugs such as 1% 2-chloroprocaine and 1% lidocaine have also been used in the past. They can be used under exceptional circumstances.

Continuous infusion for epidural analgesia in obstetrics was first described in 1963.[27] However, the technique did not become popular, mainly because of the lack of availability of proper instruments as well as local anesthetics. With the advent of better mechanical infusion pumps as well as better local anesthetics, continuous infusion has indeed become the technique of choice for vaginal delivery. Different authors have compared the intermittent injection technique with continuous epidural infusion (CEI), and the potential advantages of CEI include[28]:

1. a more stable depth of analgesia, which obviously becomes an important part of patient satisfaction;
2. the possibility of lower blood concentrations of local anesthetic, both by absorption from the epidural space and if the catheter is accidentally placed in the vein;
3. a reduced risk of total spinal block in the presence of an inadvertent injection of local anesthetic in the subarachnoid space;
4. a lower incidence of hypotension due to the possibility of decreased sympathetic blockade

Patient-controlled epidural analgesia (PCEA). PCEA has become popular at the present time[29,30] and is standard practice at Brigham and Women's Hospital. At BWH it is used with a background infusion (bupivacaine 0.125% with fentanyl 2 μg/ml, 6 ml/h, 6 ml patient demand bolus, 15 min lockout between demands, no 4 h limit). This technique offers more

patient control over the level of the block and requires fewer physician interventions compared to the continuous infusion technique.

General considerations during epidural maintenance. During the maintenance phase of labor analgesia with any of the techniques described above, parturients should be positioned head-up with left uterine displacement. Head-up position facilitates adequate perineal anesthesia as the patient progresses from first stage to second stage of labor. Routine monitoring of maternal vital signs, the fetal heart rate, and uterine contractions are essential during this phase. Notations about the block and vital signs should be made every 1–2 h on the hospital record. One must remember that even with the continuous infusion technique one should frequently check the block to verify uniformity and rule out subarachnoid or intravascular migration of the catheter.

Local Anesthetic and Opioid Infusion

A combination of lower concentrations of local anesthetics and lipophilic opioids has popularized CEI and PCEA techniques even further. This combination offers a superior analgesia than local anesthetics alone.[31] Different authors have investigated the efficacy of low concentrations of local anesthetics combined with opioids and have claimed moderate to good success.[32–34] The most popular cocktail at present is the combination of 0.0625% or 0.125% bupivacaine and 2 μg/ml of fentanyl infused at the rate of 8–10 mL/h. Alfentanil (5 μg/mL) has been tried in our institution in combination with bupivacaine (0.125% at 8–10 mL/h) with excellent success. However, placental transfer of alfentanil is significant and hence this drug has never become popular. Sufentanil 0.5 μg/ml is used in some institutions, although no clear advantage has been demonstrated, and it is more expensive. Morphine and hydromorphone, which are more hydrophilic opioids, have not proven satisfactory in labor analgesia (though they may be quite effective after cesarean delivery in larger doses).

Bupivacaine in even lower concentrations of 0.04–0.0625% with opioid has also been tried with varying success; obviously,

the lower concentration will be associated with minimal motor blockade, which might benefit the parturients if the sensory analgesia is adequate.[33] Other local anesthetics such as ropivacaine (0.2%) and levobupivacaine (0.125%) with fentanyl have also been used with success.[24]

Possible Block-Related Problems

Inadequate Perineal Analgesia

At the time of delivery one must make sure of the presence of adequate perineal analgesia. If additional analgesia is deemed necessary, bupivacaine 0.125% (6–8 ml), or 0.25% (3–4 ml) with fentanyl 50–100 µg offers good pain relief for pushing the baby without augmenting the motor block. Placing the parturient in the semi-Fowler's position for "pushing" also helps achieve a more complete perineal block. Additionally, lidocaine 1.5–2%, bupivacaine 0.25–0.5%, or 2–3% 2-chloroprocaine may be required to provide sufficient analgesia or anesthesia if forceps delivery or episiotomy is contemplated.

Asymmetric Sensory Block

If a unilateral block is encountered after initial dosing, the epidural catheter can be withdrawn by 1 cm and in most cases the block will become bilateral after supplemental 3–5 ml of bupivacaine 0.25% or 6–10 ml of 0.125%.[2] If a parturient lies continuously on one side, the level of sensory block may become asymmetric. The situation should be corrected by repositioning the patient, and administering 4–6 mL of 0.25% or 8–12 mL of 0.125% bupivacaine mixed with fentanyl 2 µg/ml solution (bolus dose) after appropriate aspiration, and then the infusion should be restarted. The patient should be encouraged to turn from side to side to maintain uterine displacement.

Diminishing Analgesia

Progressive diminution of the sensory block and loss of the block may be due to a number of factors:

1. The pump on/off switch may be off.
2. The tubing may be disconnected.
3. The reservoir bag may be empty.
4. The catheter may no longer be in the epidural space, and intravascular migration must be ruled out.

The differential diagnosis should consist of rechecking the infusion pump setup and testing to determine the correct position of the catheter. After aspiration, a 3-mL test dose of 1.5–2% lidocaine or 0.25% bupivacaine with or without 1:200,000 epinephrine is injected. The patient is observed for signs of intravascular placement of the catheter, and if there is negative response, an attempt is made to re-establish the block with 3–5-mL incremental doses of 0.125–0.25% bupivacaine. If the block cannot be re-established or if aspiration and testing indicate intravascular migration of the tip, then the catheter must be removed. Depending on the clinical setting, either a new catheter may be inserted via a second placement, or alternative analgesia may be initiated. *At the above infusion rates, bupivacaine probably will not produce symptoms of intravascular injection.* The only clue may be diminishing or absent analgesia.

Dense Motor Block

Patients given a continuous infusion of 0.0625–0.125% bupivacaine usually exhibit mild motor blockade of the lower extremities. If a progressively dense motor blockade resembling a subarachnoid block ensues, the catheter must be disconnected immediately and careful aspiration performed to rule out subarachnoid migration. A suspicion of subarachnoid migration after testing mandates either withdrawal of the catheter and reinsertion at another site or management as a continuous spinal catheter (see below).

Patchy Block

If a spotty or patchy block occurs, one should attempt to solidify the block by aspirating to determine catheter placement and injecting 4–6 mL of 0.125–0.25% bupivacaine. Then

the pump is reconnected. Initially patchy blocks may be due to misplacement of the epidural catheter (subdural, paravertebral, catheter threaded over a nerve root) and consideration of immediate replacement should be given.

Miscellaneous

If a woman requires an acute change in the character of the block for operative delivery, simply increasing the infusion rate will be inadequate. The parturient must be disconnected from the pump, the catheter placement must be checked, and the epidural catheter should then be "topped up" with 0.5% bupivacaine, 2% lidocaine with or without epinephrine, or 3% 2-chloroprocaine to obtain the desired level of sensory anesthesia (to at least a bilateral T4 level for cesarean delivery).

Spinal Anesthesia

Single-shot spinal anesthesia has a very limited role in labor and vaginal delivery. Spinal anesthesia will relax the pelvic floor muscle and will thus disturb the integrity of the birth passage; the expulsive powers can also be diminished by blockade of the abdominal segments. Because spinal anesthesia produces an intense motor block of the pelvic floor muscle, it is a desirable technique for forceps delivery. At Brigham and Women's Hospital, we aim for a T10–S5 block in all forceps deliveries except in the case of a trial of forceps, where we may aim for a higher block (T4) in case cesarean delivery is required. Consultation with the obstetrician regarding the likelihood of success with forceps can help guide the level of anesthesia required. Drugs that can be used are (1) lidocaine, (2) mepivacaine, and (3) bupivacaine.

Continuous Spinal Anesthesia

Continuous spinal anesthesia can be used if there is an accidental or intentional dural puncture. The epidural catheter is inserted 3 cm in the subarachnoid space. Advantages of the

continuous spinal catheter technique include the following: (1) small doses of local anesthetics are needed, (2) rapid onset of action, (3) quick recovery because of the small dose, (4) the absence of accidental intravenous injections of large doses of local anesthetic, and (5) the possibility of the use of small doses of intraspinal opioids for the relief of labor pain in a few special situations. At Brigham and Women's, we administer 2.5–3 mg bupivacaine with 25–30 µg of fentanyl via the spinal catheter as an initial bolus, followed by a continuous infusion of bupivacaine 0.125% with fentanyl 2 µg/ml at 1 ml/h. If the patient becomes uncomfortable during the course of the labor, an additional bolus of 1 ml of the mix or 15–25 µg fentanyl provides comfort. Occasionally, the infusion has to be gradually increased to 2 ml/h in a graded fashion. Since the local anesthetic mixture is hypobaric at body temperature, there is a tendency of inadequate block on the dependent side in lateral positions. This is usually remedied by changing the patient one side to the other before reinforcement with local anesthetic mix.

Combined Spinal/Epidural (CSE)

The CSE technique has become popular since the introduction of neuraxial opioids. The epidural needle is first inserted in the epidural space with loss-of-resistance technique. Then a long pencil-point spinal needle (25- or 27-gauge) is inserted via the epidural needle. This spinal needle usually extends 12 mm beyond the tip of the epidural needle. With the appearance of free-flowing CSF, a mixture of lipid-soluble opioid (fentanyl or sufentanil) mixed with plain bupivacaine is injected via the spinal needle. At this point the spinal needle is withdrawn, the epidural catheter is inserted, and the epidural needle is removed. Different lipid-soluble opioids have been tried; 10 µg sufentanil or 25 µg of fentanyl are most popular. The advantages of CSE may include (1) faster onset of analgesia, (2) decreased or nonexistent motor blockade, (3) less cardiovascular instability, (4) lower amount of local anesthetic in the systemic circulation, (5) shorter first stage

of labor in nulliparous women compared to CEI technique, and (6) improved analgesia when administered in advanced labor.[35,36]

Continuous epidural anesthesia, or PCEA, can be started once the expectant mother is comfortable. No loading boluses are needed. However, if the patient is not comfortable, additional epidural boluses should be administered cautiously because of the possible synergistic effect of the local anesthetic and opioid.

Side effects of CSE technique include:

(1) Pruritus, usually mild and short-lasting. If severe, intravenous nalbuphine (Nubaine) in 5–10 mg doses can be given. Small doses of nalaxone (40–80 μg) or propofol (10 mg) also have been used with success. Eight milligrams of ondansetron has also been used successfully for spinal opioid-induced pruritus.[37]

(2) Nausea and/or vomiting. Less lipophilic morphine may be associated with higher incidences of this side effect.

(3) Respiratory depression is extremely rare with lipophilic opioid.

(4) Fetal bradycardia may be associated with CSE technique.[38] The mechanism is not understood at present. Postulated mechanisms include:

   1. Decrease in maternal epinephrine concentrations; unopposed norepinephrine effect may be associated with increased uterine tone or uterine vessel (macro and micro) vasoconstriction and hence increased uterine tone.[39,40]

   2. Maternal hypotension also may decrease uteroplacental perfusion.

   3. Finally, direct vagotonic effect of the sufentanil on the fetus has been suggested; however, this effect may be just theoretically important.

Treatment should include intravenous ephedrine to increase maternal cardiac output; if the FHR does not improve tocolytic agents (intravenous terbutaline, nifedipine, or nitroglycerin) should be considered. Occasionally urgent delivery may be required in persistent cases.

Monitoring Following Administration of Regional Analgesia

The blood pressure and pulse rate are routinely noted by the nursing staff before and immediately after the induction of anesthesia. Blood pressure is measured every minute for the first 5 min and every 3–5 min thereafter up to 30 min. If the blood pressure remains stable after 30 min, the nursing staff monitors the blood pressure routinely every 15 min throughout labor and delivery. Routine pulse rate measurements are made during the time of blood pressure readings. Continuous pulse oximetry may also be an important tool in selected cases (maternal cardiovascular or respiratory disease, maternal somnolence). In most high-risk pregnant women (e.g., diabetes, preeclampsia) or if there is any sign of fetal distress, a oxygen mask should be used with high-flow oxygen where indicated. Continuous fetal heart rate monitoring becomes absolutely essential after the administration of epidural analgesia. If the parturient complains of tinnitus, circumoral numbness, a metallic taste, dizziness, high sensory anesthesia, or excessive motor blockade, the nursing staff should immediately inform the anesthesiology team for possible migration of the epidural catheter into either the vascular or subarachnoid space.

Contraindications

Besides the usual contraindications for regional anesthesia (e.g., local infection, coagulation problems), continuous infusion or PCEA should be used carefully in a patient with an accidental dural puncture. Frequent checks for excessive sensory and motor block should be performed. If high block is recognized, the infusion rates should be decreased appropriately. In the past, epidural placements were contraindicated if platelet count is below $100,000/mm^3$. However, recent techniques of studying coagulation using thromboelastography have shown that the coagulation status is not altered even with lower platelet counts.[41,42] It is presently accepted as reasonable practice to administer epidural anesthesia if platelet counts are above $70,000/mm^3$, provided there is no other coagulation abnormality.

Complications of Regional Analgesia

Major anesthesia-related neurological problems are extremely rare; the rate may vary from 1:40,000 to 1:100,000.[43] Obstetric-related major complications are much more common, varying between 1:2600 and 1:6400.[44]

Paresthesia

The incidence of transient paresthesia varies from 5% to 25%. If paresthesia persists, the catheter should be removed and reinserted in another space. Modern soft-tipped epidural catheters (e.g., the Arrow Flex-Tip®) are associated with a lower incidence of paresthesia. The incidence of persistent paresthesia lasting for 4–6 weeks varies between 5 and 42.3 per 10,000 (see Table 9-2).[45] The causal relationship between transient paresthesia during catheter insertion and serious neurologic injury is controversial but it appears to be a significant association.[46]

Table 9–2. Incidence of Paresthesia After Epidural Anesthesia*

Source	Number of Cases	Incidence per 10,000
Crawford	2,035	14.7
Eisen et al.	9,532	16.8
Abouleish	1,417	42.3
Lund	10,000	5.0
Bonica et al.	3,637	24.7

From Ong et al.[45] Used with permission.

Accidental Dural Puncture

The incidence of dural puncture varies among institutions, which may relate to practitioner experience or supervision, characteristics of the patient population (e.g., prevalence of obesity), and equipment and techniques used. The incidence at the Brigham and Women's Hospital is between 1% and 2%. Dural puncture by the epidural catheter is very rare; however, the clinical implication of this is important because of

the possibility of total spinal anesthesia. Post-dural puncture headache (PDPH) is the most frequent complication, with a rate varying from 76% to 85% and which appears to have been consistent over several decades of experience.[47,48]

Treatment of Headache Following Accidental Dural Puncture

Following an accidental dural puncture, the anesthesiologist usually places the epidural catheter in a different space. One should exercise caution while injecting local anesthetic via this newly placed catheter because of direct connection with the dural hole as well as seepage of a small amount of local anesthetic via the dural hole. Alternatively, an epidural catheter may be threaded into the intrathecal space and continuous spinal analgesia may be employed for labor. This maneuver may reduce the incidence of headache, although there is considerable controversy. Other measures to prevent or treat PDPH include epidural saline, prophylactic blood patch, and therapeutic blood patch.

Conservative Management

Women are informed about the occurrence of an accidental dural puncture. Although patients often feel better while not upright, absolute bed rest is not mandatory (Fig. 9-3). Women are advised to drink liberal quantities of fluids, although there is no convincing human data to prove that this reduces headache symptoms. At BWH, most clinicians prescribe analgesic tablets (e.g., acetaminophen/caffeine/butalbital [Fioricet[TM]], or acetaminophen with hydrocodone) if there is a headache. Some have advocated abdominal binders, though there is limited data on effectiveness, and this treatment is impractical if there is an abdominal incision.

Epidural Saline

At the termination of the procedure, several investigators have suggested the use of preservative-free normal saline via the epidural catheter (1) in a single dose (60 mL),[49] (2) every
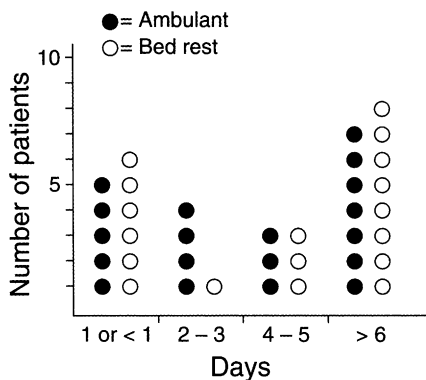
Figure 9–3. Difference in incidence of spinal headache between patients who are ambulatory and on bed rest. (From Carbalt and VanCrevel.[80] Used with permission from Elsevier.)

6 h (30–60 mL),[50] and (3) as a continuous infusion of 1,000 mL over a 24-h period.[51] The success rate has varied considerably.

Prophylactic Blood Patch

A prophylactic blood patch has been used with some success.[52] However, the ultimate validity of this technique is controversial, and a randomized trial failed to show any reduction in PDPH.[53] In our experience, efficacy has been poor, and the majority of the anesthesiologists have abandoned the technique.

Therapeutic Blood Patch

A therapeutic blood patch is indicated (1) if the headache is postural and does not improve within 48 h; (2) if there is severe or debilitating headache limiting activities of daily living or infant care (for example, if accompanied by nausea and vomiting); (3) if there is *blurred vision or diplopia that is related to stretching of the sixth cranial nerve (abducens), which supplies the lateral rectus muscle of the eye;* and (4) if there is hearing

loss following dural puncture, which occurs rarely. Blood patch is contraindicated in the presence of any untreated coagulopathy, fever of unknown origin or untreated systemic infection, or localized infection at the injection site.

Procedures for the use of therapeutic blood patches are as follows:

1. An intravenous catheter is inserted and hydration begun if the patient has not been consuming liberal oral fluids. Overhydration should be avoided, because it will cause a need to urinate and require ambulation.
2. The woman's back is aseptically prepared.
3. If there is only one puncture, then the same interspace is selected; however, if there are multiple punctures, one should use the lowermost interspace because it is easier for epidurally injected blood to spread cephalad than caudad.[54] Some advocate loss of resistance by saline to prevent further intensification of the headache by introducing air through the dural hole. Others emphasize using the technique most familiar to the operator, but care should be taken not to inject significant air into the epidural space.
4. Once the epidural needle is positioned properly, blood should be drawn from a large vein (20–30 ml) after proper aseptic care.
5. Blood should be injected slowly until patient feels consistent pressure in the back.
6. The woman should lie supine with pillows under the knees for 1–2 h.
7. The woman should be monitored carefully for a few days. Strenuous activity and extreme bending of the back should be avoided for 24–48 h. Modest back pain is common for the first day and may be treated with nonsteroidal anti-inflammatory drugs.

The incidence of success from the first blood patch has been observed to be as high as 70–75%; in a few cases, a second or third blood patch may be necessary. The most common causes of failure of the blood patch are wrong diagnosis and improper placement of the patch. If the blood patch fails, one has to re-evaluate the diagnosis, and if necessary, a neurologist should be consulted. Cortical vein thrombosis, which mimics symptoms after a dural puncture, has to be excluded because a blood

patch can make the clinical condition worse. CT scans may confirm the diagnosis.[55]

Experimental and Alternative Techniques

Recently, alternative techniques for the treatment of post-dural puncture headache have been reported. In one study,[56] a prospective, randomized, double-blind trial was conducted to study the effect of epidural morphine in prevention of post-dural puncture headache in 25 parturients after inadvertent dural puncture. Women were randomly allocated to receive two epidural injections, 24 h apart, of either 3 mg morphine in 10 ml saline (morphine group) or 10 ml saline (saline group). The incidence of headache and need for therapeutic epidural blood patch were reported. There was a significant difference in the incidence of headache between the two groups: 3/25 (12%) in the morphine group and 12/25 (48%) in the saline group ($p = 0.014$). Therapeutic epidural blood patches were required in six patients in the saline group and none of the patients in the morphine group ($p = 0.022$). Another group reported the use of intravenous hydrocortisone 200 mg, followed by 100 mg three times daily for 48 h decreased the intensity of headache following post-dural puncture as compared to the control group (bed rest, acetaminophen, meperidine, and fluids).[57] Anecdotal success has also been reported with adrenocorticotrophin (ACTH) 80 i.u. administered intramuscularly in the treatment of dural puncture headache.[58]

Subdural Injection

This involves an injection of local anesthetic between the dura mater and arachnoid; because of decreased compliance of this space, a higher spread is possible in comparison with epidural anesthesia. The following are characteristics of subdural injection:
1. Incidence, 0.1–0.82%
2. Incidence increased during rotation of the epidural needle after a loss of resistance
3. Incidence increased in patients with prior back surgery

4. Widespread sensory anesthesia with the use of a small amount of local anesthetic
5. Block usually weak and patchy and spread mainly in a cephalad direction
6. Delayed onset of 10–30 min
7. Hypotension possibly the initial symptom
8. Faster resolution, in comparison with epidural or subarachnoid blockade

Treatment is supportive as the block resolves, and in most cases the catheter must be replaced.

Massive Epidural Analgesia

This represents an excessive segmental spread from a relative overdosage of local anesthetic. This problem is more often seen in morbidly obese individuals as well as in parturients with severe arteriosclerosis and diabetes. The onset of this problem is more gradual, and very rarely does it spread high enough to produce unconsciousness. Treatment is supportive while the block recedes (airway, ventilation, blood pressure). With careful dosing and confirmation of an epidural position, the catheter may continue to be used.

Accidental Intravascular Injection

An accidental intravascular injection of local anesthetic can happen either at the time of induction of epidural analgesia or anesthesia or as a result of subsequent migration of the epidural catheter in the intravascular space. Injection of local anesthetic directly into an epidural vein can give rise to a systemic reaction causing convulsions as well as possible cardiovascular collapse. Initiation of immediate management is important:
1. Assure left uterine displacement.
2. Airway patency must be maintained, if necessary, by an endotracheal tube and ventilation with 100% oxygen.
3. Convulsions are usually short-lived, but if they continue, benzodiazepines (diazepam 5–10 mg, midazolam 1–2 mg, or lorazepam 0.5–1 mg) or a small amount of thiopental (50–100 mg) are indicated.

4. Fetal heart rate monitoring will ultimately govern the next step: if the fetal heart rate is normal, labor can continue for a vaginal delivery, but in the presence of a non-reassuring tracing, an immediate cesarean section with general anesthesia should be planned, and active resuscitation of the fetus may be necessary.

Cardiovascular toxicity of local anesthetics may also occur, particularly with lipophilic drugs (e.g., bupivacaine).

Methemoglobinemia

This rare condition is associated with prilocaine especially when the dose exceeds 600 mg. It can also be associated with topical benzocaine. These drugs are rarely used in modern obstetric anesthesia practice. Treatment includes 1 mg/kg of methylene blue, a reducing agent which restores hemoglobin to the normal ferrous state.

Broken Epidural Catheter

The exact incidence is not known. Most authors advise that a broken catheter be left in place if it is in the lumbar epidural space.[4] Studies in cats showed that implanted epidural catheters were ultimately covered with fibrous tissue after about 3 weeks.

Shivering

The cause of this common event (20–35%) is unknown; however, this side effect can be treated with epidural sufentanil or intravenous or epidural meperidine.

Horner's Syndrome

Although rarely of clinical significance, at least some signs occur in 25–75% of parturients who receive high blocks, for example, for cesarean delivery. The incidence is likely lower in labor analgesia, though obstetric patients may experience it even after volumes of local anesthetic typical of such blocks.[59] Nerves involved are the upper four thoracic nerves, which form

the cervical sympathetic ganglion. Signs include ptosis, miosis, anhydrosis, enophthalmos, and ecchymosis.

Backache

This is a frequent problem following delivery in obstetric patients, occurring in approximately 40% of postpartum women. Multiple attempts with needles may cause temporary localized back pain at the injection site by causing direct trauma and hemorrhage into the intervertebral ligament and vertebral periosteum. More diffuse and longer-lived pain is more common, even after uneventful regional anesthesia. Pre-existing conditions like arthritis or osteoporosis may exacerbate the problem. Importantly, however, epidural analgesia does *not increase this risk of ongoing back pain.* Breen et al. observed the incidence of back pain 1–2 months postpartum was similar in parturients with or without epidural analgesia (44% vs. 45%).[60] A similar study followed women for up to 1 year. The authors observed no increased risk of back pain in women who had used epidural analgesia compared with those who did not (10% vs. 14%).[61]

Major Neurologic Injury

Neurological complications in the obstetric population must be divided into obstetric causes and anesthesia-related causes. Anesthesiologists are often requested to consult postpartum women with neurological problems even if these problems are unrelated to regional anesthesia. A clear clinical picture is absolutely necessary to make a proper diagnosis. The following steps will help with the differential diagnosis: history, physical examination, X-ray films, coagulation studies, electromyography to possibly define the timing of the lesion (Fig. 9-4), computed tomographic (CT) scans, and magnetic resonance imaging (MRI). The authors suggest a neurological consultation for any woman with a complicated neurological deficit that does not resolve within a reasonable period.
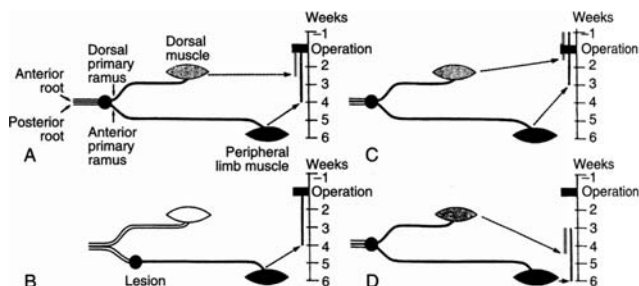
Electromyography in differential diagnosis of postoperative neurological complications. Diagram of spinal roots, dorsal and anterior primary rami, and peripheral nerves.

Symbols:

● = Lesion

⊃ = Normal dorsal (paraspinal) muscle

— = Denervated dorsal muscle

— = Denervated peripheral limb muscle

═ = Normal nerve

▬ = Damaged nerve distal to lesion

Vertical scale shows elapsed time in weeks from time of lesion to appearance of denervation EMG patterns in muscles.

A, Lesion of spinal roots at time of operation. Dorsal muscles show EMG changes 1½ weeks later. Distal limb muscles show EMG changes three weeks later.

B, Lesion of peripheral nerve at time of operation. No change in dorsal muscle. Distal limb muscles show EMG changes three weeks later.

C, Associated but unrelated lesion of spinal roots one week before operation.

D, Lesion of spinal roots occurring two weeks after operation.

Figure 9–4. Electromyography in the differential diagnosis of postoperative neurological complications. (Adapted from Bromage, p. 703.[4] Used with permission.)

Obstetric Causes

The incidence of neurological complications related to obstetric causes varies from 1:2,600 to 1:6,400.[62,63] These neurological complications are often associated with prolonged labor and forceps delivery. Changes in the obstetric practice of difficult deliveries might have decreased the incidence of major obstetric-related neurological complications.[45] Peripheral nerves that might be involved include (Table 9-3):

Table 9–3. Neurological Complications Unrelated to Regional Anesthesia: Obstetric Cause

Nerve	Clinical Findings	
	Sensory deficit	Motor deficit
Lumbosacral trunk (L4, L5)	Hypoesthesia of the lateral aspect of the calf and foot	Weakness of the hip abductor Foot drop Unilateral weakness of the quadriceps
Femoral nerve (L2, L3, L4)	Hypoesthesia of the anterior aspect of the thigh and medial aspect of the calf	Quadriceps paralysis
Lateral femoral cutaneous nerve (L2, L3)	Numbness of the anterolateral aspect of the thigh	
Sciatic nerve (L4, L5, S1, S2, S3)	Pain in posterior gluteal region with radiation to the foot	Inability of flexion of the leg
Obturator nerve (L2, L3, L4)	Decreased sensation over the medial aspect of the thigh	Inability to adduct the leg
Common peroneal nerve (L4, L5, S1, S2)	Sensory deficit over the anterolateral aspect of the calf and dorsum of the foot and toes	Plantar flexion with an inversion deformity
Saphenous nerve (L2, L3, L4)	Loss of sensation over the medial aspect of the foot and anteromedial aspect of the lower portion of the leg	
Lumbosacral plexus (L1, L2, L3, L4, L5, S1, S2, S3, S4)	Variable	Variable

1. A prolapsed intervertebral disk may occur because of the exertional efforts of labor. This may cause spinal root compression, the incidence of which has been documented to be 1 in 6,000 deliveries.

2. The lumbosacral trunk (L4, L5) may be compressed between the descending fetal head and the ala of the sacrum. It might be associated with the use of mid-to-high forceps. Clinical findings may include foot drop, hypoesthesia of the lateral aspect of the foot and calf, a slight weakness of hip adductors, and quadriceps weakness.

3. The femoral nerve (L2, L3, L4) can be injured in the lithotomy position because of hyperacute hip flexion as well as the use of retractors during cesarean section. There will be impaired knee extension due to quadriceps paralysis, an absence of the patellar reflex, and hypoesthesia of the anterior portion of the thigh and medial aspect of the calf.

4. The lateral femoral cutaneous nerve (L2, L3) can be injured by retractors during cesarean section or during incorrect lithotomy positioning. In addition, palsy of this nerve, known as meralgia paresthetica, occurs spontaneously in many women in the third trimester, from musculoskeletal changes of pregnancy. There will be transient numbness of the thigh at the anterolateral aspect.

5. The sciatic nerve (L4, L5, S1, S2, S3) can be injured by incorrect lithotomy positioning along with knee extension and external hip rotation. There will be pain in the gluteal region that radiates to the foot and an inability to flex the leg.

6. The obturator nerve (L2, L3, L4) may be injured due to lithotomy positioning. Acute flexion in the thigh to the groin area, particularly in an obese woman, may lead to compression and cause weakness or paralysis of the thigh adductors.

7. The common peroneal nerve (L4, L5, S1, S2) may be involved in a pressure injury during lithotomy positioning as a result of prolonged compression of the lateral aspect of the knee. The woman may have difficulty standing from a seated position. There will be associated foot drop.

8. The saphenous nerve (L2, L3, L4) can be affected during lithotomy positioning. There will be a loss of sensation over

the medial aspect of the foot and anteromedial aspect of the lower portion of the leg.

9. The lumbosacral plexus (L1, L2, L3, L4 [portion], L5, S1, S2, S3, S4 [portion]) can be injured by the descending fetal head compressing it against the sacrum, particularly in women with unfavorable pelvic anatomy or a large baby. In addition, forceps and retractors during cesarean delivery can compress the plexus. These injuries present with greatly varying sensory and motor deficits, reflecting the site of injury between the nerve roots and the peripheral nerves. When an injury appears not to follow a specific nerve distribution nor be confined to a single root, a plexus injury should be suspected.

Anesthesia-Related Causes

Regional anesthesia used for the relief of labor pain or cesarean section is associated with certain neurological problems. The incidence of motor deficits after the epidural technique varies from 0 to 15/10,000, with the largest studies demonstrating rates of approximately 1/10,000 (Table 9-4).

Prolonged neural blockade. Delayed recovery following epidural analgesia for labor has been described. This was usually associated with the use of tetracaine or bupivacaine in high doses or concentrations. Patchy sensory anesthesia and motor deficit occasionally may last as long as 10–48 h but will ultimately resolve.[64] The etiology of this problem is unknown and may be related to individual patient variation, total dose of local anesthetic used, or physiologic changes of pregnancy altering the pharmacokinetics of the drugs.

Bladder dysfunction. Overstretching of the bladder due to prolonged continuous epidural blockade can produce this problem. Longer-acting local anesthetics are more often associated with this complication, as is intrathecal or epidural morphine. Many labor units routinely place urinary catheters once epidural analgesia has begun.

Trauma to nerve roots. Direct trauma by the needle and catheter to the nerve root is extremely rare, but if it occurs,

Table 9–4. Incidence of Neurologic Deficits
Following Epidural Analgesia

First author	Year	Number of cases	Incidence per 10,000
Bonica	1957	3,637	2.7
Lund	1962	10,000	1
Hellman	1965	26,127	0
Dawkins	1969	32,718	Transient, 14.7; permanent, 2.1
Crawford	1972	2,035	0
Moore	1978	6,729	0
Bleyaert	1979	3,000	0
Abouleish	1982	1,417	14.1
Ong	1987	9,403	0.8
Scott	1990	505,000	0.75 (1 case permanent)
Scott	1995	108,133	4.3
Auroy	1997	30,413	2
Aromaa	1997	170,000	0.4
Paech	1998	10,995	0

Adapted from Ong et al.[45] and Munnur U, Suresh MS[81]

it can lead to paresthesia, sensory, or motor loss with a specific dermatomal distribution. Intraneural injections may create neuritis followed by paresthesia lasting weeks to months.

Cauda equina syndrome. This occurs rarely and is characterized by lower extremity and perineal numbness, sphincter dysfunction, and various degrees of lower extremity paralysis. Several cases of neurological problems very similar to cauda equina syndrome following the unintentional spinal (subarachnoid) use of 2-chloroprocaine were described in 1980.[65] Gissen and colleagues[66,67] suggested several factors to explain this problem: (1) the large volume of 2-chloroprocaine injected in the epidural space in the presence of an accidental dural puncture could cause anterior spinal artery syndrome due to increased intraspinal pressure as well as hypotension, and (2) a low pH with a high concentration of the preservative bisulfite can cause neural damage, at least in vitro. However, the bisulfite-pH mechanism has been challenged, and some have argued that chloroprocaine itself may be neurotoxic.[68]

Conversely, there are recent reports of safe use of preservative-free chloroprocaine in human spinal anesthesia.[69]

Another cause of cauda equina syndrome is 5% hyperbaric lidocaine given via spinal microcatheter. The mechanism might be related to high doses of lidocaine that cause nerve damage because of improper mixing with cerebrospinal fluid.[70] Microcatheters were removed from the market in the US in 1991 but are still used in other countries. A large randomized trial recently demonstrated the safety of such devices when appropriate drugs were used (excluding concentrated lidocaine).[71]

Transient neurologic symptoms. A more recently appreciated anesthesia-related neurologic problem that has stirred controversy is transient neurological symptoms (TNS; formerly transient radicular irritation, or TRI). This problem, first described by a group from Switzerland, is characterized by (1) aching pain in the buttocks radiating to both dorsolateral sides of the thigh and calves; (2) association with subarachnoid lidocaine; (3) short duration of symptoms of less than 4–6 days; and (4) surgery in the lithotomy position.[72] Subsequent studies observed that TNS was observed in 30% of cases with 5% hyperbaric lidocaine, 3% with use of 2% hyperbaric prilocaine, and 0% with 0.5% hyperbaric bupivacaine.[73] Interestingly, the incidence of TNS increases significantly when the lithotomy position is used compared to the supine position (13% vs. 5%) with lidocaine, but does not differ between concentrations of lidocaine or addition of dextrose.[74] More recent studies confirmed no difference in the concentrations of lidocaine in the manifestation of TNS in patients undergoing surgery in the lithotomy position.[75] The lithotomy position may stretch L5–S1 nerve roots, which remain in the most dorsal position in the spinal canal. Under this condition, blood perfusion of the nerves or a subset of nerve fibers may be hampered and thus increase the vulnerability to injury. However, careful neurologic studies in volunteers demonstrate no evidence of direct nerve injury in patients developing TNS.[76] Hence TNS is controversial; judicious care is required with the use of drugs that may increase the incidences of TNS.

Epidural hematoma. This is very rare following regional anesthesia, but it may happen following trauma to epidural blood vessels, especially if the clotting parameters are abnormal due to the use of anticlotting medications or because of associated medical problems such as severe preeclampsia or HELLP (hemolysis, elevated liver enzymes, and low platelet count) syndrome. An *immediate diagnosis is necessary, and surgical decompression should be performed within 6 h.*

Epidural abscess and meningitis. Although extremely rare, infection in the spinal canal is usually secondary to infection elsewhere in the body. Four important clinical features include (1) severe back pain, (2) local overlying tenderness, (3) fever, and (4) leukocytosis. Some case reports of epidural abscess have been reported and found to be caused by skin flora, and rarely meningitis has been traced to oral commensals in the anesthesiologist. Meticulous attention to aseptic technique is mandatory.[77] One should avoid regional anesthesia, if possible, in the presence of untreated bacteremia or septicemia. Antibiotic pretreatment appears to be protective in animal models.[78]

Adhesive arachnoiditis. This can take place as a result of clinical irritation of the structures in the subarachnoid space due to contamination of spinal needles or solutions. Observed symptoms include headache, nausea and vomiting, nuchal rigidity, fever, and Kernig's sign.

Anterior spinal artery syndrome. This is an extremely rare complication in which the anterior part of the spinal cord experiences ischemic degeneration associated with motor deficit. This portion of the cord is more vulnerable because of its single arterial supply as well as lack of collateral supply. Hypotension and unfavorable anatomy are risk factors.

Other Methods of Regional Anesthesia

These techniques are largely of historical interest, though some may occasionally still be used in lieu of modern epidural and spinal techniques.

Caudal Anesthesia

The caudal space is the lowermost part of the epidural space and lies in the sacral canal. This technique involves the introduction of a 17-gauge epidural or 19-gauge 3.8–7.6-cm needle. A catheter can be introduced for continuous use, or a one-shot technique can be used just before the delivery for perineal analgesia. This technique has become unpopular because of the requirement of higher doses of local anesthetics.

Paracervical Block

This technique involves blocking nerve impulses from the uterine body and cervix by injecting local anesthetics in the paracervical tissues. Usually it is performed during the first stage of labor. A paracervical block does not relieve the perineal pain. A continuous technique has also been attempted. This technique is rarely used at the present time mainly because of its depressant effects on the fetus. *Fetal bradycardia following a paracervical block is mainly due to two factors: (1) constriction of uteroplacental blood vessels by local anesthetic and (2) vascular absorption of a large amount of local anesthetic that will directly depress the fetal myocardium.*

Lumbar Sympathetic Block

This technique is technically cumbersome, requires special skill, must be performed bilaterally to be effective, and therefore is seldom used at present; it is useful *only for the first stage of labor.*

Pudendal Block

A pudendal block is performed by the obstetrician just before the delivery by blocking the pudendal nerves while passing over the ischial spine. This technique will provide analgesia of the perineum and is useful only for second-stage labor. In selected cases of unblocked sacral nerves, it may find a place in modern practice even when an epidural block is employed.

Uptake of local anesthetic from this technique is very similar to that in an epidural block.

Summary

Epidural and combined spinal-epidural analgesia are the most commonly employed techniques for labor analgesia. Although very safe and usually quite effective, adequate safety preparations, careful technique and knowledge of potential problems and how to address them, and awareness of possible complications are necessary for the provision of these popular procedures.

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