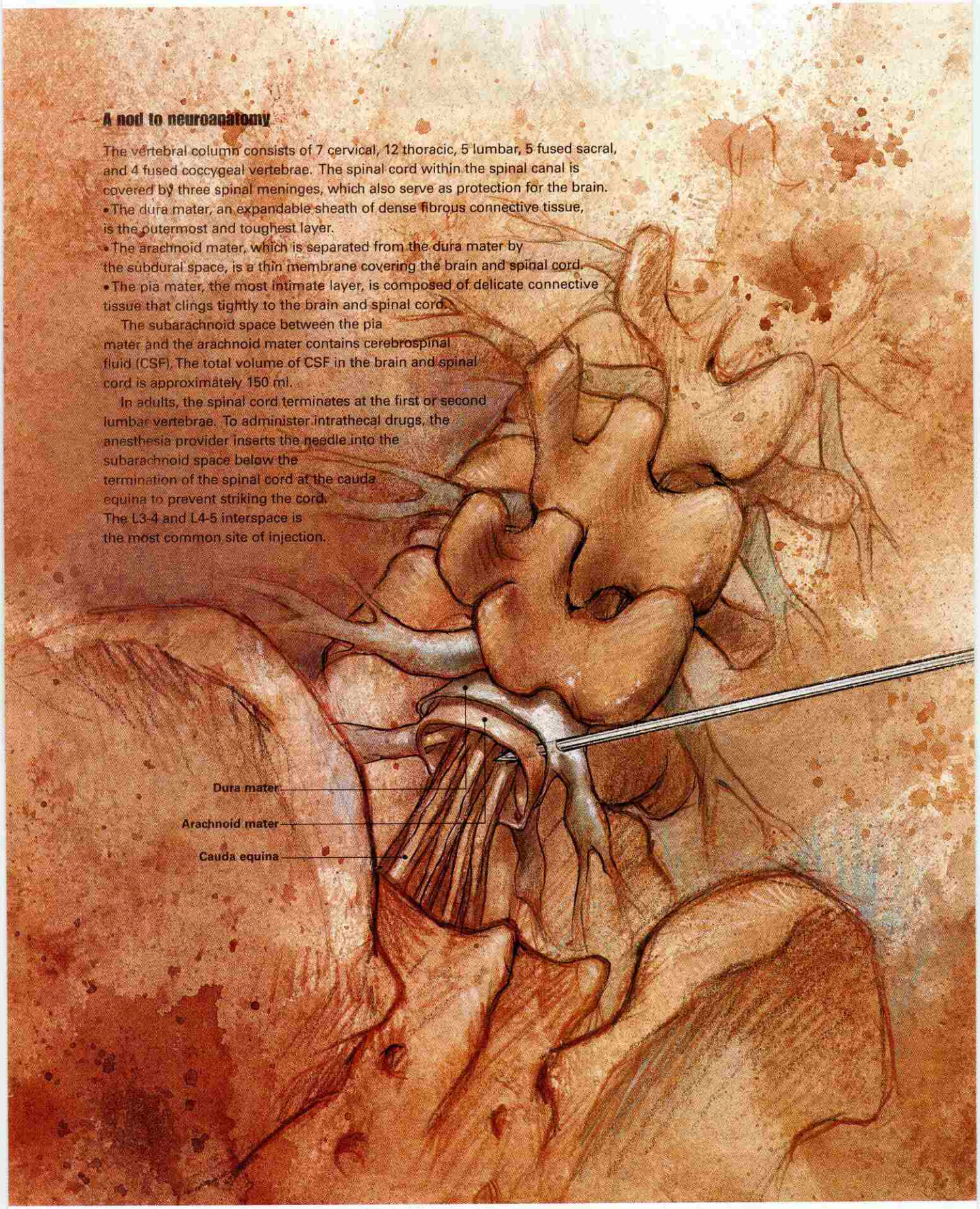
A nod to neuroanatomy

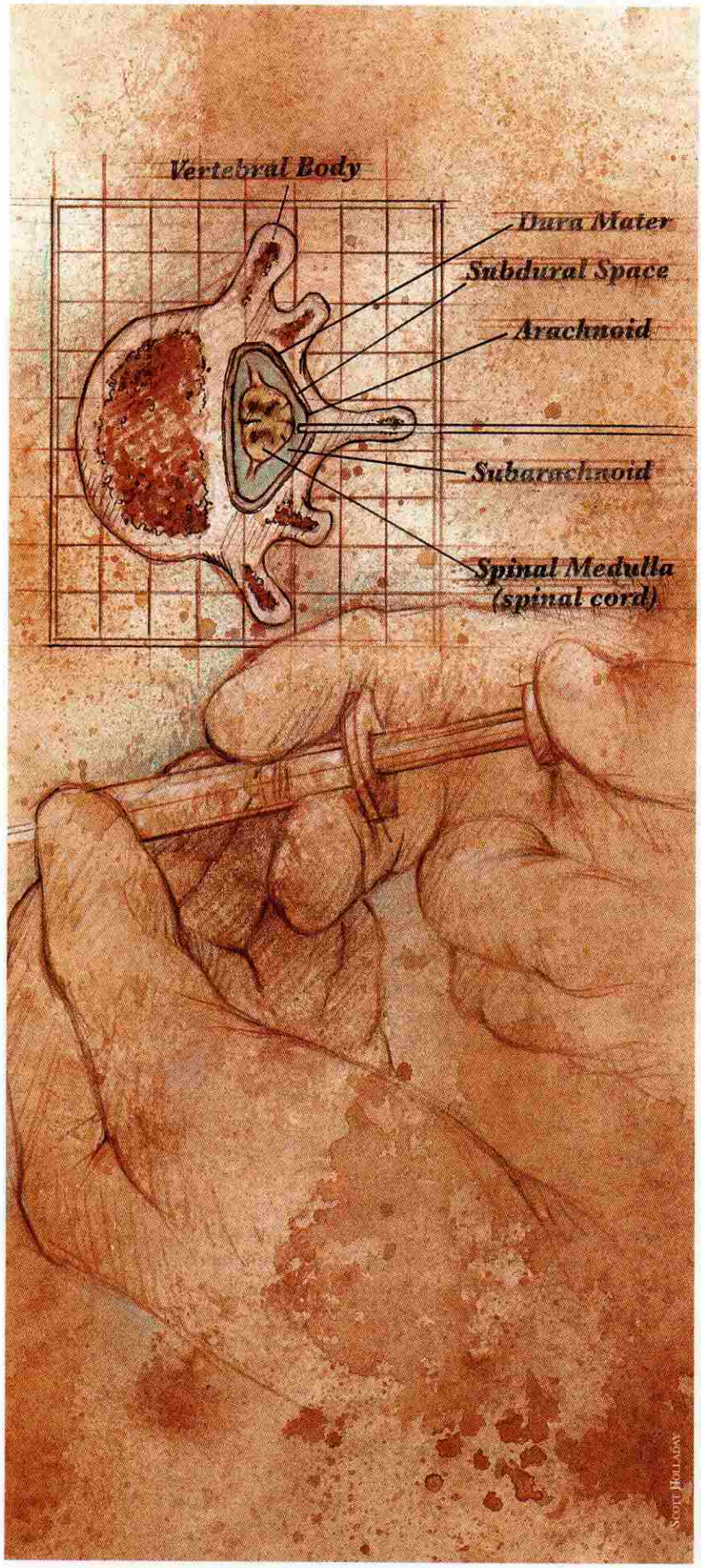
The vertebral column consists of 7 cervical, 12 thoracic, 5 lumbar, 5 fused sacral, and 4 fused coccygeal vertebrae. The spinal cord within the spinal canal is covered by three spinal meninges, which also serve as protection for the brain.

- The dura mater, an expandable sheath of dense fibrous connective tissue, is the outermost and toughest layer.
- The arachnoid mater, which is separated from the dura mater by the subdural space, is a thin membrane covering the brain and spinal cord.
- The pia mater, the most intimate layer, is composed of delicate connective tissue that clings tightly to the brain and spinal cord.

The subarachnoid space between the pia mater and the arachnoid mater contains cerebrospinal fluid (CSF). The total volume of CSF in the brain and spinal cord is approximately 150 ml.

In adults, the spinal cord terminates at the first or second lumbar vertebrae. To administer intrathecal drugs, the anesthesia provider inserts the needle into the subarachnoid space below the termination of the spinal cord at the cauda equina to prevent striking the cord. The L3-4 and L4-5 interspace is the most common site of injection.





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Getting to the root of pain

SPINAL anesthesia and analgesia

Make sure your patient's recovery from spinal blockade is uneventful by following these practical guidelines.

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Almost a century ago, Dr. August Bier pioneered the use of spinal anesthesia during surgery. Today, because of its many advantages over general anesthesia, spinal anesthesia is increasingly popular for abdominal, genitourinary, orthopedic, vascular, obstetric, and gynecologic surgery. To provide analgesia after surgery, a preservative-free opioid analgesic can be given at the same time as the anesthetic.

Spinal anesthetics and analgesics are administered into the subarachnoid (intrathecal) space at the time of surgery. Epidural analgesia, which is administered into the epidural space

and involves a continuous or an intermittent infusion, is beyond the scope of this article.

Although the spinal route has many advantages, it's not without serious risks. So when you care for a patient who's received drugs intrathecally, you must know how to assess his condition, anticipate and recognize problems, and intervene correctly. In this article, I'll provide assessment and care guidelines for you to follow.

Spinal anesthesia: Block that impulse

Spinal anesthesia is achieved by a single intrathecal injection of local anesthetic into the subarachnoid space to create sensory, motor, and autonomic blockage of the nerve roots and spinal cord. Indicated for surgical procedures below the diaphragm, spinal anesthesia is commonly used for surgeries such as total joint replacement, prostatectomy, and knee arthroscopy. It's especially beneficial for patients with cardiac or respiratory disease because it avoids or lessens the risk of many adverse effects associated with general anesthesia; for example, cardiovascular and respiratory depression, aspiration, incompetent airway, and inadequate ventilatory drive resulting in hypoxemia. Patients with a history of airway problems, difficult intubation, and reactive airway disease also are good candidates for a spinal anesthetic.

Because the patient remains conscious (with the option of sedation) during procedures performed under spinal anesthesia, the anesthesiologist or certified registered nurse anesthetist can monitor his mental status and watch for such problems as chest discomfort or breathing difficulties (with high spinal blockade). If analgesia or muscle relaxation is inadequate, supplementation with general anesthesia is indicated.

Other advantages of spinal anesthesia include a shorter recovery time, minimal drug exposure, and possibly reduced blood loss related to sympathetic blockade, which lowers arterial and venous pressures. In addition, administering a longer-acting anesthetic or an opioid can maintain the sensory block postoperatively, prolonging analgesia.

Disadvantages to spinal anesthesia include the extra time and expertise needed to position the patient and insert the needle, and possible pain from needle placement and medication administration. In some cases, the sensory block may be inadequate because the needle wasn't properly positioned (or it moved during drug injection) or because too little drug was injected.

Contraindications for spinal anesthesia include coagulopathy and uncorrected hypovolemia. A patient with coagulopathy is at risk for developing hematomas that could compress the nerve roots or spinal cord, resulting in neurologic deficit or permanent paralysis. Uncorrected hypovolemia could lead to severe hypotension in a patient who's already at risk for hypotension from the spinal anesthesia. Other absolute contraindications include systemic or localized infection, allergy to the anesthetic, increased intracranial pressure, and acute neurologic disease. Relative contraindications include scoliosis and neurologic abnormality.

Don't let the patient try to stand or walk until all motor functions and sensation have returned—and don't let him stand without assistance.

Choosing a drug

Lidocaine, bupivacaine, and tetracaine are commonly used for spinal anesthesia. The choice is determined by the drug's onset of action and duration and the estimated length of the procedure. The duration of lidocaine and tetracaine may be increased by up to 50% by adding a vasoconstrictive agent such as epinephrine. It also slightly prolongs the duration of bupivacaine, which already has a long duration of action. Constricting blood vessels that supply the spinal cord and dura lessens absorption of the anesthetic into the systemic circulation, prolonging the spinal anesthetic effect.

A radical retropubic prostatectomy, which takes about 3 hours to perform, is one procedure for which spinal anesthesia using tetracaine with epinephrine is indicated. This drug combination provides a prolonged sensory block that also serves to control immediate postoperative pain. For a quick outpatient procedure such as knee arthroscopy, however, short-acting lidocaine would be a better choice.

Assessing your patient

In the postanesthesia care unit immediately after surgery, a patient who's had spinal anesthesia should undergo continuous monitoring of heart rate and rhythm and pulse oximetry. Vital signs should be

monitored every 5 to 15 minutes until they're stable and the patient has an acceptable recovery score according to a standardized scoring system, such as the Modified Aldrete Scoring System. After inpatient surgery, the patient may be transferred to the nursing unit when he can detect stimuli at the hip or move his feet. Before discharge after outpatient surgery, however, a patient must be able to ambulate and void and must meet certain other criteria, such as a mandatory stay time following the last dose of drug received.

If you care for an inpatient after he's transferred to your unit, you need to continue assessing his level of anesthesia and evaluate the return of motor function and sensation according to facility policy. Because larger nerve fibers recover quicker than smaller ones, motor function (which is conducted by the largest nerve fibers) returns before other functions. As sensation returns, the patient will detect light touch and pressure before temperature and pain. Motor function and sensation generally return from the hip to the feet, with higher dermatome levels recovering first. (See *Using a Dermatome Chart.*)

Assess motor function by asking the patient to wiggle his toes or flex and extend his foot. The ability to raise the leg indicates a good return of motor function. Document the level of blockade according to a dermatome chart.

To evaluate the level of sensory blockade, you can use a cold object, such as an alcohol swab, and a sharp object, such as the end of a paper clip. (Avoid using pins, which can injure the skin.) Apply the object bilaterally and ask the patient to report where he feels sensation. Then use the dermatome chart to document your findings.

Sensation may return faster on one side than the other, depending on the patient's position when the block was administered. For example, if he was lying on his right side, more of the drug may have migrated there, extending the life of the block on his right.

Your patient may believe that his legs are flexed or elevated when they are actually lying flat. This is known as the loss of proprioception: His brain is remembering the last leg position before the block took effect. Proprioception returns with the return of sensation.

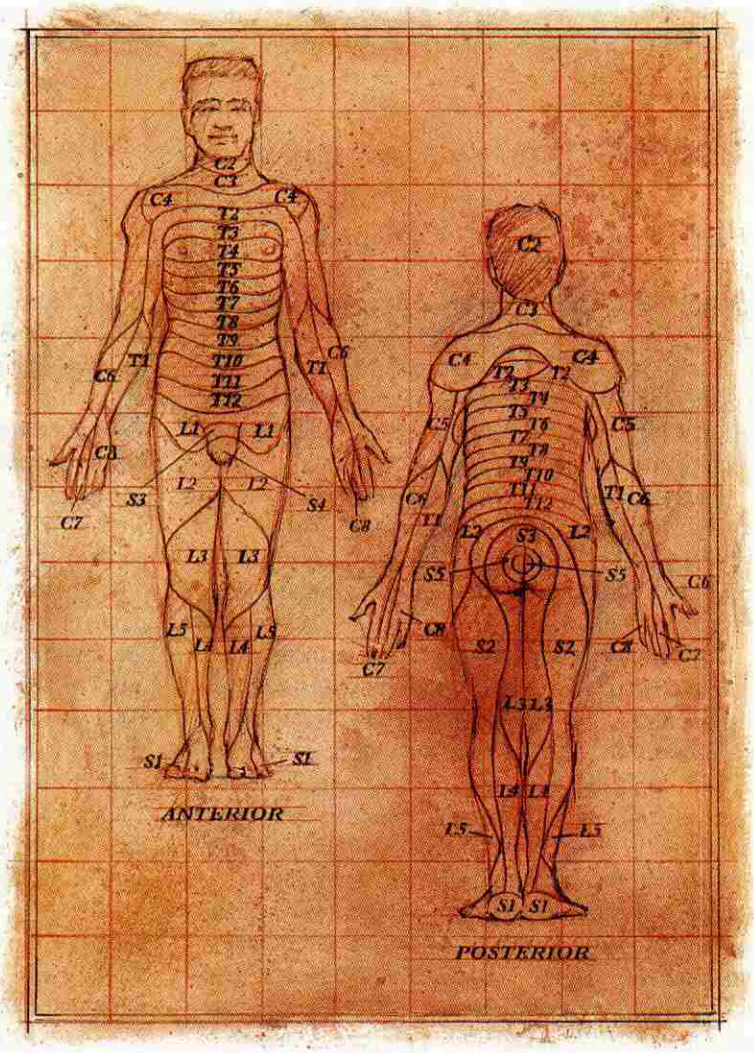
Important: Don't let the patient try to stand or walk until all motor function and sensation have returned—and don't let him stand without assistance.

Using a dermatome chart

Document your findings according to the level of sensation the patient reports. For example, if he can feel sensation on his right hip and left thigh, you'd document the return of sensation at L1 on the right side and L2-L3 on the left side.

Common landmarks

- T4, nipple line
- T6, xiphoid process
- T10, umbilicus
- L1, hip
- L2 and L3, thigh
- L4 and L5, calf
- S1, toes



Complications and interventions

As your patient recovers, monitor him for the following

complications and intervene appropriately:

• *hypotension,* which results from autonomic blockade and venous pooling. Hypotension may be accompanied by nausea and vomiting. Administer intravenous (I.V.) fluids, elevate his legs, and closely monitor blood pressure (BP).

If these methods don't work, the physician may order a vasopressor such as ephedrine or phenylephrine (Neo-Synephrine). An indirect alpha$_1$-agonist with a beta$_1$ component, ephedrine raises BP by stimulating norepinephrine release. The indirect alpha$_1$ action is vasoconstriction of smooth muscle, which increases preload. Its beta$_1$ effect is to stimulate receptors in the myocardium, which increases heart rate and improves contractility and nerve conduction. In combination, these effects raise BP.

Phenylephrine is a direct alpha$_1$-agonist that raises BP by constricting peripheral veins and arteries, which increases systemic vascular resistance. It has little direct effect on heart rate or myocardial contractility.

The duration of pressor and cardiac effects for ephedrine is up to 1 hour after I.V. administration. Phenylephrine's effects last only 15 to 20 minutes.

• *bradycardia*, which occurs when the level of spinal block is high enough to affect the nerve fibers that innervate the heart. This bradycardia may be sinus or junctional in origin. If necessary, administer an anticholinergic, such as atropine or glycopyrrolate.

• *urine retention,* which occurs because of persistent sensory and autonomic blockade of the fibers that innervate the bladder. These are among the last autonomic fibers to regain function. If the patient experiences persistent urine retention, prepare to insert a urinary catheter.

• *postdural puncture headache,* also known as spinal headache, indicating a leak of cerebrospinal fluid (CSF) through the opening in the dural sheath. Signs and symptoms of leakage, which may occur from 6 to 12 hours after the spinal anesthesia to the second postoperative day, include frontal or occipital head pain, tinnitus, double vision, nausea, and photophobia. The headache is position-dependent and worsens when the patient's head is elevated. Keep him supine, provide large amounts of oral or I.V. fluids (possibly both), and administer analgesics if needed.

If the headache persists, the physician may perform an autologous blood patch, which involves placing 10 to 20 ml of the patient's blood into the epidural space. The clot serves as a hemostatic plug, closing the dural tear and preventing further CSF leakage. Keep the patient supine for 20 to 30 minutes after the procedure.

• *back pain* secondary to needle placement, local tissue irritation, reflex muscle spasm, or positioning during surgery. Treat discomfort with analgesics, application of heat to the site, patient positioning, and bed rest. The soreness usually passes in 10 to 14 days.

Because a drug given intrathecally comes into direct contact with the spinal cord, it's effective at a fraction of the dose you'd give via the epidural route.

Spinal analgesia: Keeping pain at bay after surgery

Spinal analgesia is commonly used to control postoperative pain from major surgeries that are known to be painful; for example, large abdominal surgeries or total joint replacements. The analgesic, usually morphine or fentanyl, is administered at the same time as the spinal anesthetic. The opioid both hastens the onset of analgesia and prolongs analgesic effects. Because a drug given intrathecally comes into direct contact with the spinal cord, it's effective at a fraction of the dose you'd give via the epidural route.

Opioid selection depends on the type of procedure, the expected length of time needed for pain control, and the drug's lipophilic or hydrophilic characteristics. Lipid-soluble drugs such as fentanyl and sufentanil penetrate the dura mater faster than water-soluble opioids, providing a faster onset of action but a shorter duration of action. Preservative-free morphine, which is water-soluble, has a slower onset of action and longer duration of action (12 to 24 hours). For these reasons, fentanyl typically is given for immediate pain control in same-day surgery patients; morphine is a better choice for patients who need more prolonged analgesia.

Monitoring your patient's recovery

Throughout your patient's recovery, regularly assess and document his report of pain on a 0-to-10 pain scale or other standard pain-assessment tool. Notify the physician or anesthesia provider if the patient needs additional

pain control. As a rule, a patient shouldn't receive an additional opioid within 24 hours of the spinal injection unless cleared by the anesthesia provider.

Also monitor for adverse reactions, including:

• *respiratory depression,* defined as less than 8 breaths/minute. The peak time for respiratory depression from morphine is 8 to 10 hours after the dose. Treat respiratory depression with 0.1 to 0.2 mg of I.V. naloxone at 2- to 3-minute intervals until the desired degree of reversal is achieved. Because naloxone's half-life is shorter than morphine's, you may have to give another dose.

Remember, naloxone reverses all opioid effects, including analgesia. Closely monitor the patient's response to treatment, including the return of pain and the return of autonomic responses. Treat pain as ordered.

• *urine retention.* Assess the patient's urine output and, if he doesn't have an indwelling catheter, palpate the bladder for distension. If urine output is low or the bladder is distended, prepare to insert a catheter if indicated.

• *pruritus.* Among the opioids, morphine is especially likely to produce this adverse effect because of the activation of mast cells and subsequent histamine release. Treatment ranges from applying ordinary lotion or a cool cloth to administering small, incremental doses of diphenhydramine HCl (Benadryl) or nalbuphine (Nubain).

• *nausea and vomiting.* Administer antiemetics, as indicated.

Back on his feet

As you monitor your patient's recovery from a spinal block, you're in the best position to prevent problems and help get your patient back on his feet.

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