

16

The Vertebral Column, the Spinal Cord, and the Meninges



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VERTEBRAL COLUMN

Examination of the Back

See Chapter 11, CD-ROM.

Abnormal Curves of the Vertebral Column

See Chapter 11, CD-ROM.

Dislocations of the Vertebral Column

See Chapter 12, CD-ROM.

Fractures of the Vertebral Column

See Chapter 12, CD-ROM.

Spinal Nerve Root Pain

Spinal nerve roots exit from the vertebral canal through the intervertebral foramina. Each foramen is bounded superiorly and inferiorly by the pedicles, anteriorly by the intervertebral disc and the vertebral body, and posteriorly by the articular processes and joints (see text Fig. 16-3). In the lumbar region, the largest foramen is between the first and second lumbar vertebrae and the smallest is between the fifth lumbar and first sacral vertebra.

One of the complications of osteoarthritis of the vertebral column is the growth of osteophytes, which commonly encroach on the intervertebral foramina, causing pain along the distribution of the segmental nerve. The fifth lumbar spinal nerve is the largest of the lumbar spinal nerves, and it exits from the vertebral column through the smallest intervertebral foramen. For this reason, it is the most vulnerable.

Osteoarthritis as a cause of root pain is suggested by the patient's age, its insidious onset, and a history of back pain of long duration; this diagnosis is made only when all other causes have been excluded. For example, a prolapsed disc usually occurs in a younger age group and often has an acute onset.

Herniated Intervertebral Discs

The structure and function of the intervertebral disc is described on text page 581. The resistance of these discs to compression forces is substantial, as seen, for example, in circus acrobats who can support four or more of their colleagues on their shoulders. Nevertheless, the discs are vulnerable to sudden shocks, particularly if the vertebral column is flexed and the disc is undergoing degenerative changes, that result in herniation of the nucleus pulposus.

The discs most commonly affected are those in areas where a mobile part of the column joins a relatively immobile part—that is, the cervicothoracic junction and the lumbosacral junction. In these areas, the posterior part of the anulus fibrosus ruptures, and the nucleus pulposus is forced posteriorly like toothpaste out of a tube. This is referred to as a **herniation of the nucleus pulposus**. This herniation can result either in a central protrusion in the midline under the posterior longitudinal ligament of the vertebrae or in a lateral protrusion at the side of the posterior ligament close to the intervertebral foramen (CD Fig. 16-1). The escape of the nucleus pulposus will produce narrowing of the space between the vertebral bodies, which may be visible on radiographs. Slackening of the anterior and posterior longitudinal ligaments results in abnormal mobility of the vertebral bodies, producing local pain and subsequent development of osteoarthritis.

Cervical disc herniations are less common than herniations in the lumbar region (see text Fig. 16-21). The discs most susceptible to this condition are those between the fifth and sixth or sixth and seventh vertebrae. Lateral protrusions cause pressure on a spinal nerve or its roots. Each spinal nerve emerges above the corresponding vertebra; thus, protrusion of the disc between the fifth and sixth cervical vertebrae can cause compression of the C6 spinal nerve or its roots (see CD Fig. 16-1). Pain is felt near the lower part of the back of the neck and shoulder and along the area in the distribution of the spinal nerve involved. Central protrusions may press on the spinal cord and the anterior spinal artery and involve the various nerve tracts of the spinal cord.

Lumbar disc herniations are more common than cervical disc herniations (see CD Fig. 16-1). The discs usually affected are those between the fourth and fifth lumbar vertebrae and between the fifth lumbar vertebra and the sacrum. In the lumbar region the roots of the cauda equina run posteriorly over several intervertebral discs (see CD Fig. 16-1B).

A lateral herniation may press on one or two roots and often involves the nerve root going to the intervertebral foramen just below. However, because C8 nerve roots exist and an eighth cervical vertebral body does not, the thoracic and lumbar roots exit below the vertebra of the corresponding number. Thus, the L5 nerve root exits between the fifth lumbar and first sacral vertebrae. Moreover, because the nerve roots move laterally as they pass toward their exit, the root corresponding to that disc space (L4 in the case of the L4–5 disc) is already too lateral to be pressed on by the herniated disc. Herniation of the L4–5 disc usually gives rise to symptoms referable to the L5 nerve roots, even though the L5 root exits between L5 and S1 vertebrae. The nucleus pulposus occasionally herniates directly backward, and if it is a large herniation, the whole cauda equina may be compressed, producing paraplegia.

An initial period of back pain is usually caused by the injury to the disc. The back muscles show spasm, especially on the side of the herniation, because of pressure on the spinal nerve root. As a consequence, the vertebral column shows a scoliosis, with its concavity on the side of the lesion. Pain is referred down the leg and foot in the distribution of the affected nerve. Since the sensory posterior roots most commonly pressed on are the fifth lumbar and the first sacral, pain is usually felt down the back and lateral side of the leg, radiating to the sole of the foot. This condition is often called **sciatica**. In severe cases paresthesia or actual sensory loss may be present.

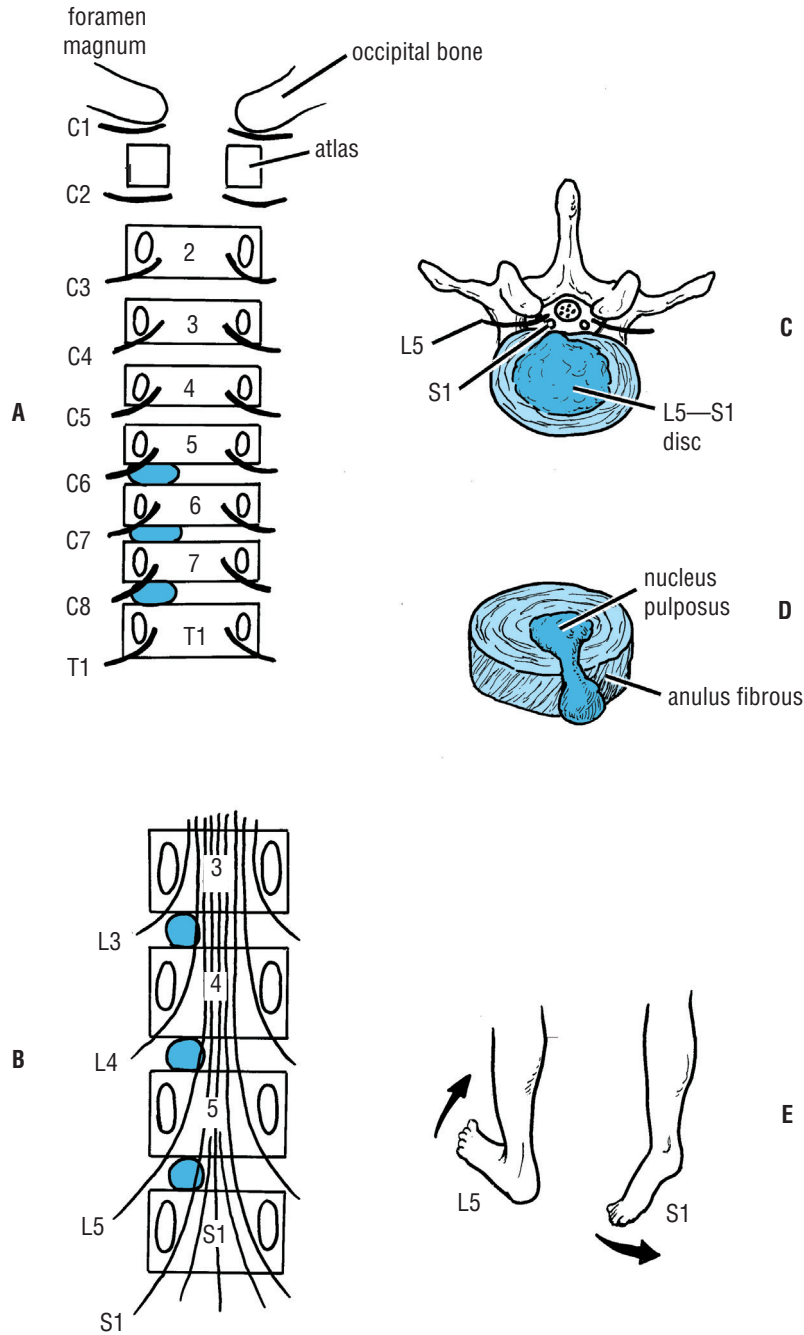
Pressure on the anterior motor roots causes muscle weakness. Involvement of the fifth lumbar motor root produces weakness of dorsiflexion of the ankle, whereas pressure on the first sacral motor root causes weakness of plantar flexion, and the ankle jerk may be diminished or absent (see CD Fig. 16-1).

A large, centrally placed protrusion may give rise to bilateral pain and muscle weakness in both legs. Acute retention of urine may also occur.

A correlation between the disc lesion, the nerve roots involved, the pain dermatome, the muscle weakness, and the missing or diminished reflex is shown in CD Table 16-1.

Disease and the Intervertebral Foramina

The intervertebral foramina (see text Fig. 16-3) transmit the spinal nerves and the small segmental arteries and veins, all of which are embedded in areolar tissue. Each foramen is bounded above and below by the pedicles of adjacent vertebrae, in front by the lower part of the vertebral body and by the intervertebral disc, and behind by the articular processes and the joint between them. In this situation, the spinal nerve is vulnerable and may be pressed on or irritated by disease of the surrounding structures. Her-



CD Figure 16-1 **A** and **B**. Posterior views of vertebral bodies in the cervical and lumbar regions showing the relationship that might exist between the herniated nucleus pulposus and the spinal nerve roots. Note that there are eight cervical spinal nerves but only seven cervical vertebrae. In the lumbar region, for example, the emerging L4 nerve roots pass out laterally close to the pedicle of the fourth lumbar vertebra and are not related to the intervertebral disc between the fourth and fifth lumbar vertebrae. **C**. Posterolateral herniation of the nucleus pulposus of the intervertebral disc between the fifth lumbar vertebra and the first sacral vertebra showing pressure on the S1 nerve root. **D**. An intervertebral disc that has herniated its nucleus pulposus posteriorly. **E**. Pressure on the L5 motor nerve root produces weakness of dorsiflexion of the ankle; pressure on the S1 motor nerve root produces weakness of plantar flexion of the ankle joint.

CD Table 16-1 Summary of Important Features Found in Cervical and Lumbosacral Root Syndromes

Root Injury	Dermatome Pain	Muscle Supplied	Movement Weakness	Reflex Involved
C5	Lower lateral aspect of upper arm	Deltoid and biceps	Shoulder abduction, elbow flexion	Biceps
C6	Lateral aspect of forearm	Extensor carpi radialis longus and brevis	Wrist extensors	Brachioradialis
C7	Middle finger	Triceps and flexor carpi radialis	Extension of elbow and flexion of wrist	Triceps
C8	Medial aspect of forearm	Flexor digitorum superficialis and profundus	Finger flexion	None
L1	Groin	Iliopsoas	Hip flexion	Cremaster
L2	Anterior aspect of thigh	Iliopsoas, sartorius, hip adductors	Hip flexion, hip adduction	Cremaster
L3	Medial aspect of knee	Iliopsoas, sartorius, quadriceps, hip adductors	Hip flexion, knee extension, hip adduction	Patellar
L4	Medial aspect of calf	Tibialis anterior, quadriceps	Foot inversion, knee extension	Patellar
L5	Lateral part of lower leg and dorsum of foot	Extensor hallucis longus, extensor digitorum longus	Toe extension, ankle dorsiflexion	None
S1	Lateral edge of foot	Gastrocnemius, soleus	Ankle plantar flexion	Ankle jerk
S2	Posterior part of thigh	Flexor digitorum longus, flexor hallucis longus	Ankle plantar flexion, toe flexion	None

niation of the intervertebral disc, fractures of the vertebral bodies, and osteoarthritis involving the joints of the articular processes or the joints between the vertebral bodies can all result in pressure, stretching, or edema of the emerging spinal nerve. Such pressure would give rise to dermatomal pain, muscle weakness, and diminished or absent reflexes.

Narrowing of the Spinal Canal

After about the fourth decade of life the spinal canal becomes narrowed by aging. Osteoarthritic changes in the joints of the articular processes with the formation of osteophytes, together with degenerative changes in the intervertebral discs and the formation of large osteophytes between the vertebral bodies, can lead to narrowing of the spinal canal and intervertebral foramina. In persons in whom the spinal canal was originally small, significant

stenosis in the cauda equina area can lead to neurologic compression. Symptoms vary from mild discomfort in the lower back to severe pain radiating down the leg with the inability to walk.

Sacroiliac Joint Disease

The clinical aspects of this joint are referred to again because disease of this joint can cause low back pain and may be confused with disease of the lumbosacral joints. Essentially, the sacroiliac joint is a synovial joint that has irregular elevations on one articular surface that fit into corresponding depressions on the other articular surface. It is a strong joint and is responsible for the transfer of weight from the vertebral column to the hip bones. The joint is innervated by the lower lumbar and sacral nerves so that disease in the joint may produce low back pain and sciatica.

The sacroiliac joint is inaccessible to clinical examination. However, a small area located just medial to and below the posterosuperior iliac spine is where the joint comes closest to the surface. In disease of the lumbosacral region, movements of the vertebral column in any direction cause pain in the lumbosacral part of the column. In sacroiliac disease, pain is extreme on rotation of the vertebral column and is worst at the end of forward flexion. The latter movement causes pain because the hamstring muscles hold the hip bones in position while the sacrum is rotating forward as the vertebral column is flexed.



SPINAL CORD

Spinal Cord Ischemia

The blood supply to the spinal cord is surprisingly meager, considering the importance of this nervous tissue. The longitudinally running anterior and posterior spinal arteries are of small and variable diameter, and the reinforcing segmental arteries vary in number and in size. Ischemia of the spinal cord can easily follow minor damage to the arterial supply as a result of regional anesthesia, pain block procedures, or aortic surgery.

Spinal Cord Injuries

The degree of spinal cord injury at different vertebral levels is largely governed by anatomic factors. In the cervical region, dislocation or fracture dislocation is common, but the large size of the vertebral canal often results in the spinal cord escaping severe injury. However, when considerable displacement occurs, the cord is sectioned and death occurs immediately. Respiration ceases if the lesion occurs above the segmental origin of the phrenic nerves (C3, 4, and 5).

In fracture dislocations of the thoracic region, displacement is often considerable, and the small size of the vertebral canal results in severe injury to the spinal cord.

In fracture dislocations of the lumbar region, two anatomic facts aid the patient. First, the spinal cord in the adult extends only down as far as the level of the lower border of the first lumbar vertebra. Second, the large size of the vertebral foramen in this region gives the roots of the cauda equina ample room. Nerve injury may therefore be minimal in this region.

Injury to the spinal cord can produce partial or complete loss of function at the level of the lesion and partial or complete loss of function of afferent and efferent nerve tracts

below the level of the lesion. The symptoms and signs of spinal shock and paraplegia in flexion and extension are beyond the scope of this book. For further information, a textbook of neurology should be consulted.

Relationships of Spinal Cord Segments to Vertebral Numbers

Because the spinal cord is shorter than the vertebral column, the spinal cord segments do not correspond numerically with the vertebrae that lie at the same level (CD Fig. 16-2). The following list helps determine which spinal segment is contiguous with a given vertebral body:

Vertebrae	Spinal Segment
Cervical	Add 1
Upper thoracic	Add 2
Lower thoracic (T7–9)	Add 3
Tenth thoracic	L1 and 2 cord segments
Eleventh thoracic	L3 and 4 cord segments
Twelfth thoracic	L5 cord segment
First lumbar	Sacral and coccygeal cord segments

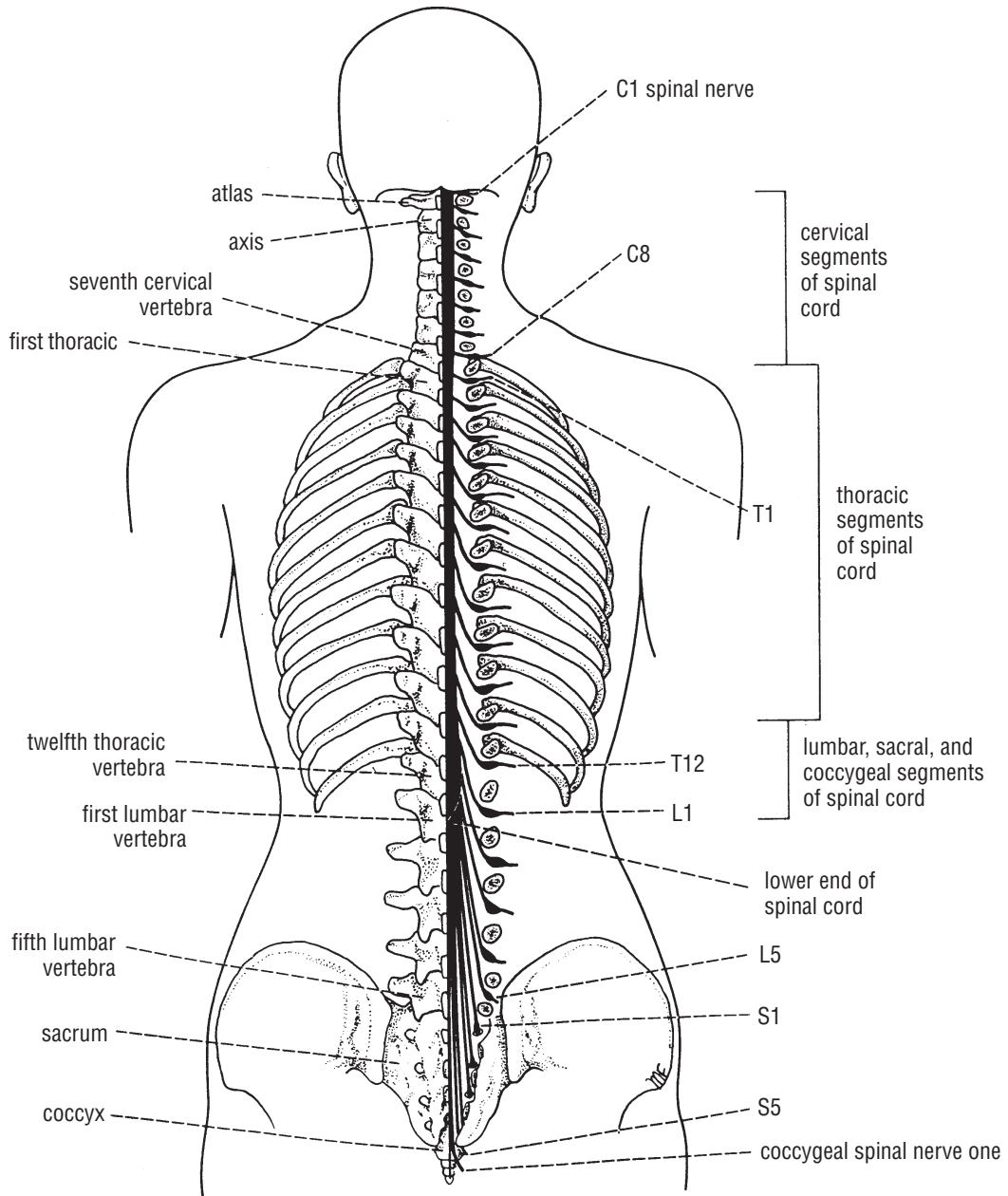


SUBARACHNOID SPACE

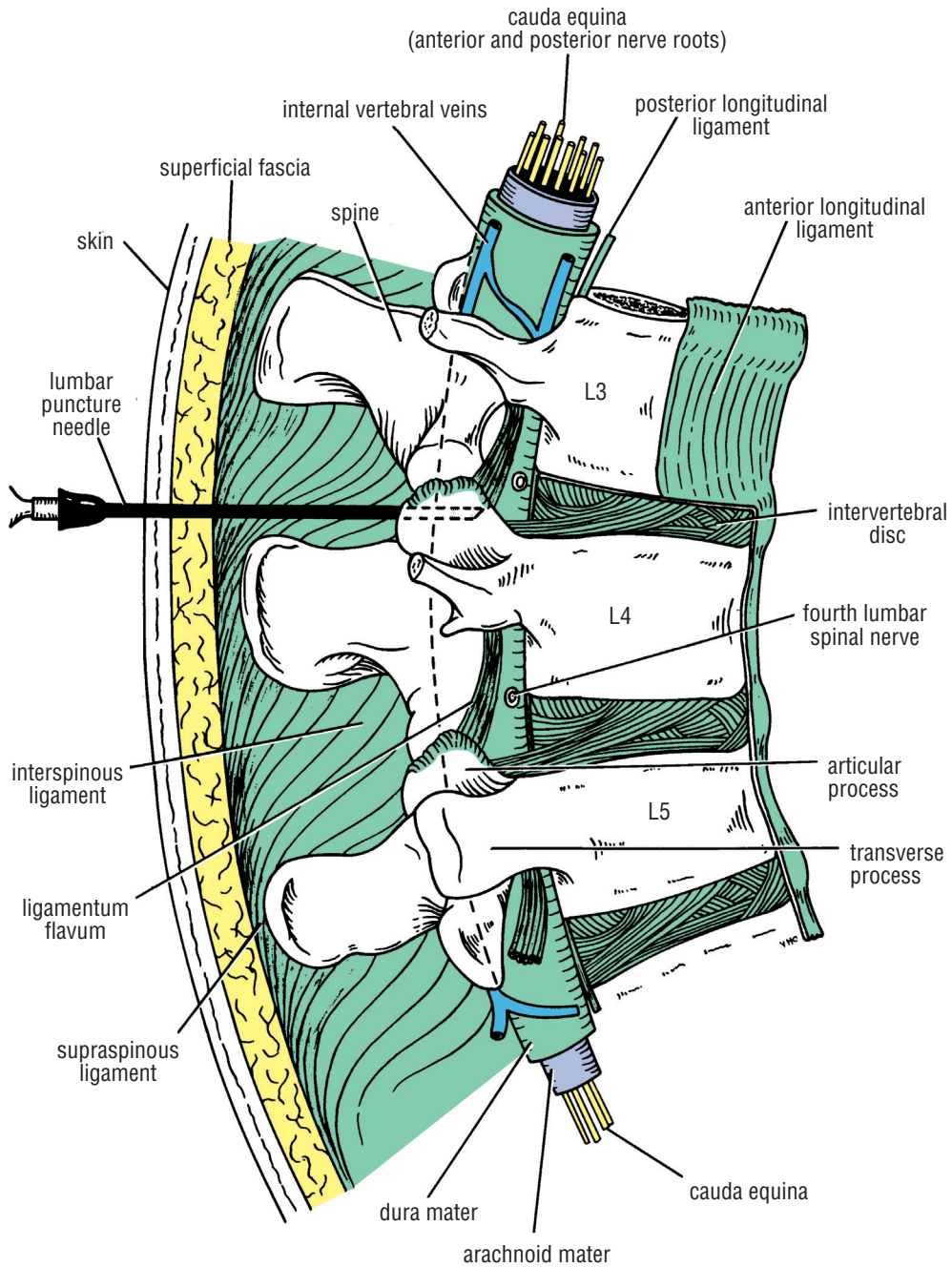
Spinal Tap (Lumbar Puncture)

Lumbar puncture may be performed to withdraw a sample of cerebrospinal fluid for examination. Fortunately, the spinal cord terminates below at the level of the lower border of the first lumbar vertebra in the adult. (In the infant, it may reach as low as the third lumbar vertebra.) The subarachnoid space extends down as far as the lower border of the second sacral vertebra. The lower lumbar part of the vertebral canal is thus occupied by the subarachnoid space, which contains the cauda equina—that is, the lumbar and sacral nerve roots and the filum terminale. A needle introduced into the subarachnoid space in this region usually pushes the nerve roots to one side without causing damage.

With the patient lying on the side with the vertebral column well flexed, the space between adjoining laminae in the lumbar region is opened to a maximum (CD Fig. 16-3). An imaginary line joining the highest points on the iliac crests passes over the fourth lumbar spine (see text Fig. 16-22). With a careful aseptic technique and under local anesthesia, the lumbar puncture needle, fitted with a stylet, is



CD Figure 16-2 Posterior view of the spinal cord showing the origins of the roots of the spinal nerves and their relationship to the different vertebrae. On the right, the laminae have been removed to expose the right half of the spinal cord and the nerve roots.



CD Figure 16-3 Sagittal section through the lumbar part of the vertebral column in flexion. Note that the spines and laminae are well separated in this position, enabling one to introduce a lumbar puncture needle into the subarachnoid space.

passed into the vertebral canal above or below the fourth lumbar spine (see CD Fig. 16-3). The needle will pass through the following anatomic structures before it enters the subarachnoid space: skin, superficial fascia, supraspinous ligament, interspinous ligament, ligamentum flavum, areolar tissue (containing the internal vertebral venous plexus in the epidural space), dura mater, and arachnoid mater. The depth to which the needle will have to pass varies from 1 in. (2.5 cm) or less in a child to as much as 4 in. (10 cm) in obese adults.

As the stylet is withdrawn, a few drops of blood commonly escape. This usually indicates that the point of the needle is situated in one of the veins of the internal vertebral plexus and has not yet reached the subarachnoid space. If the entering needle should stimulate one of the nerve roots of the cauda equina, the patient will experience a fleeting discomfort in one of the dermatomes, or a muscle will twitch, depending on whether a sensory or a motor root was impaled. If the needle is pushed too far anteriorly, it may hit the body of the third or fourth lumbar vertebra (see CD Fig. 16-3).

The cerebrospinal fluid pressure can be measured by attaching a manometer to the needle. In the recumbent position, the normal pressure is about 60–150 mm H₂O. It is interesting to note that the cerebrospinal fluid pressure normally fluctuates slightly with the heart beat and with each phase of respiration.

Anatomy of “Not Getting In”

If bone is encountered, the needle should be withdrawn as far as the subcutaneous tissue, and the angle of insertion should be changed. The most common bone encountered is the spinous process of the vertebra above or below the path of insertion. If the needle is directed laterally rather than in the midline, it may hit the lamina or an articular process.

Anatomy of Complications of Lumbar Puncture

- **Postlumbar puncture headache:** This headache starts after the procedure and lasts 24 to 48 hours. The cause is a leak of cerebrospinal fluid through the dural puncture, and it usually follows the use of a wide-bore needle. The leak reduces the volume of cerebrospinal fluid, which, in turn, causes a downward displacement of the brain and stretches the nerve-sensitive meninges—a headache follows. The headache is relieved by assuming the recumbent position. Using small-gauge stylet needles and avoiding multiple dural holes reduce the incidence of headache.
- **Brain herniation:** Lumbar puncture is contraindicated in cases in which intracranial pressure is significantly raised. A large tumor, for example, above the tentorium cerebelli with a high intracranial pressure may result in a

caudal displacement of the uncus through the tentorial notch or a dangerous displacement of the medulla through the foramen magnum, when the lumbar cerebrospinal fluid pressure is reduced.

Block of the Subarachnoid Space

A block of the subarachnoid space in the vertebral canal, which may be caused by a tumor of the spinal cord or the meninges, can be detected by compressing the internal jugular veins in the neck. This raises the cerebral venous pressure and inhibits the absorption of cerebrospinal fluid in the arachnoid granulations, thus producing a rise in the manometric reading of the cerebrospinal fluid pressure. If this rise fails to occur, the subarachnoid space is blocked and the patient is said to exhibit a positive Queckenstedt’s sign.



CAUDAL ANESTHESIA

Solutions of anesthetics may be injected into the sacral canal through the sacral hiatus. The solutions pass upward in the loose connective tissue and bathe the spinal nerves as they emerge from the dural sheath. Caudal anesthesia is used in operations in the sacral region, including anorectal surgery and culdoscopy. Obstetricians use this method of nerve block to relieve the pains during the first and second stages of labor. Its advantage is that, administered by this method, the anesthetic does not affect the infant.

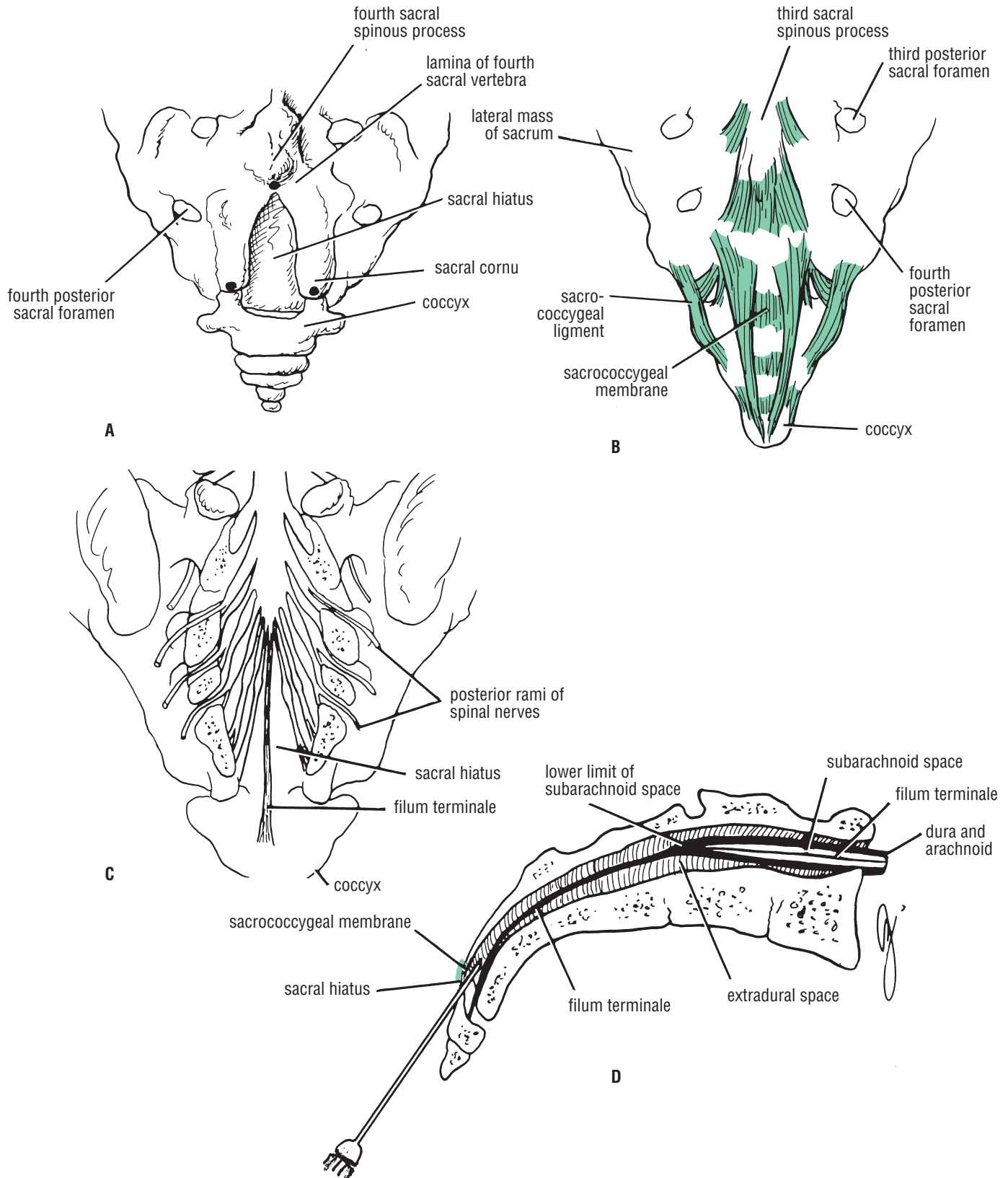
The sacral hiatus is palpated as a distinct depression in the midline about 1.6 in. (4 cm) above the tip of the coccyx in the upper part of the cleft between the buttocks. The hiatus is triangular or U shaped and is bounded laterally by the sacral cornua (CD Fig. 16-4).

The size and shape of the hiatus depend on the number of laminae that fail to fuse in the midline posteriorly. The common arrangement is for the hiatus to be formed by the nonfusion of the fifth and sometimes the fourth sacral vertebrae.

With a careful aseptic technique and under local anesthesia, the needle, fitted with a stylet, is passed into the vertebral (sacral) canal through the sacral hiatus.

The needle pierces the skin and fascia and the sacrococcygeal membrane that fills in the sacral hiatus (see CD Fig. 16-4). The membrane is formed of dense fibrous tissue and represents the fused supraspinous and interspinous ligaments as well as the ligamentum flavum. A distinct feeling of “give” is felt when the ligament is penetrated.

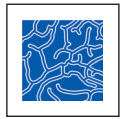
Note that the sacral canal is curved and follows the general curve of the sacrum (see CD Fig. 16-4). The anterior



CD Figure 16-4 **A.** The sacral hiatus. *Black dots* indicate the position of important bony landmarks. **B.** Posterior surface of the lower end of the sacrum and the coccyx showing the sacrococcygeal membrane covering the sacral hiatus. **C.** The dural sheath (thecal sac) around the lower end of the spinal cord and spinal nerves in the sacral canal; the laminae have been removed. **D.** Longitudinal section through the sacrum showing the anatomy of caudal anesthesia.

wall, formed by the fusion of the bodies of the sacral vertebrae, is rough and ridged. The posterior wall, formed by the fusion of the laminae, is smooth. The average distance between the sacral hiatus and the lower end of the subarachnoid space at the second sacral vertebra is about 2 in. (5 cm) in adults.

Note also that the sacral canal contains the dural sac (containing the cauda equina), which is tethered to the coccyx by the filum terminale; the sacral and coccygeal nerves as they emerge from the dural sac surrounded by their dural sheath; and the thin-walled veins of the internal vertebral venous plexus.



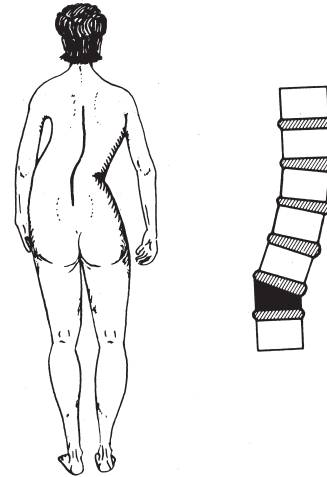
CONGENITAL ANOMALIES

Scoliosis

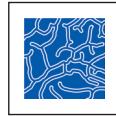
Scoliosis results from a congenital hemivertebra. A hemivertebra is caused by a failure in development of one of the two ossification centers that appear in the centrum of the body of each vertebra (CD Fig. 16-5).

Spina Bifida

In spina bifida, the spines and arches of one or more adjacent vertebrae fail to develop. The condition occurs most frequently in the lower thoracic, lumbar, and sacral regions. Beneath this defect, the meninges and spinal cord may or may not be involved in varying degrees. This condition is a result of failure of the mesenchyme, which grows in between the neural tube and the surface ectoderm, to form the vertebral arches in the affected region. The types of spina bifida are shown in CD Figs. 16-6 and 16-7.

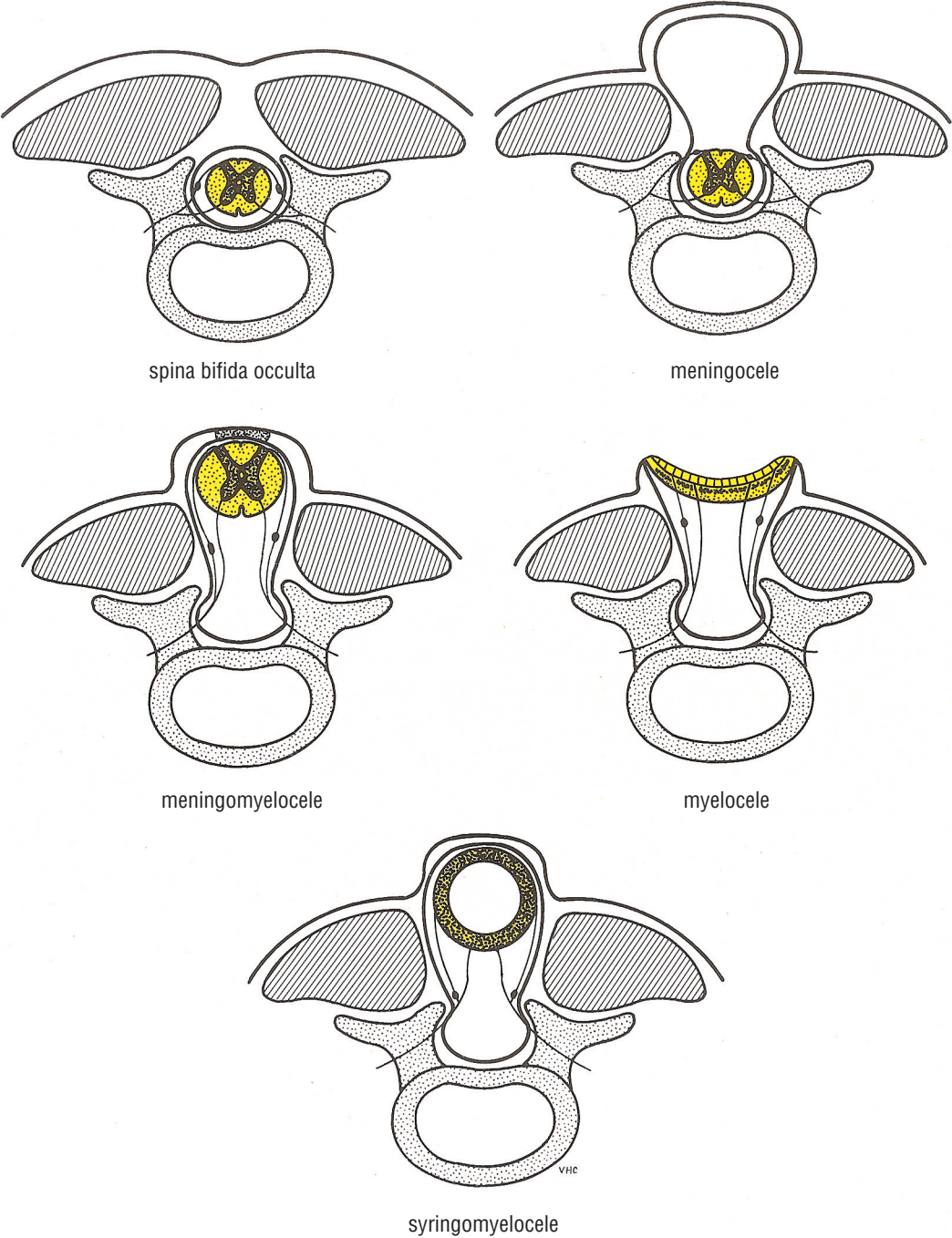


CD Figure 16-5 Posterior view of a woman with scoliosis resulting from a congenital hemivertebra in the lower thoracic region.

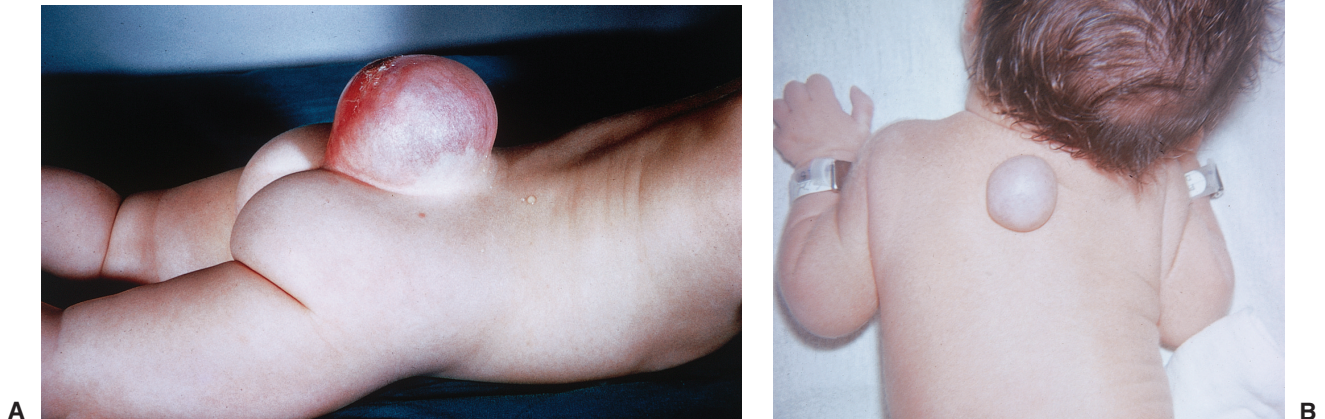


RELATIONSHIP OF THE VERTEBRAL BODY TO THE SPINAL NERVE

Since the fully developed vertebral body is intersegmental in position, each spinal nerve leaves the vertebral canal through the intervertebral foramen and is closely related to the intervertebral disc. This fact is of great clinical significance in cases with prolapse of an intervertebral disc (see CD Fig. 16-1).



CD Figure 16-6 Different types of spina bifida.



CD Figure 16-7 A. Meningocele in the lumbosacral region. (Courtesy of L. Thompson.)
B. Meningomyelocele in the upper thoracic region. (Courtesy of G. Avery.)

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

An 11-year-old boy was showing off in front of friends by diving into the shallow end of a swimming pool. After one particularly daring dive, he surfaced quickly and climbed out of the pool, holding his head between his hands. He said that he had hit the bottom of the pool with his head and now had severe pain in the root of the neck, which was made worse when he tried to move his neck. A lateral radiograph revealed that the right inferior articular process of the fifth cervical vertebra was forced over the anterior margin of the right superior articular process of the sixth cervical vertebra, producing a unilateral dislocation with nipping of the right sixth cervical nerve.

- The following symptoms and signs confirmed the diagnosis **except** which?
 - The head was rotated to the right.
 - There was spasm of the deep neck muscles on the right side of the neck, which were tender to touch.
 - The patient complained of severe pain in the region of the back of the neck and right shoulder.
 - The slightest movement produced severe pain in the right sixth cervical dermatome.
 - The large size of the vertebral canal in the cervical region permitted the spinal cord to escape injury.

A 50-year-old coal miner was crouching at the mine face when a large rock suddenly became dislodged from the roof of the mine shaft and struck him on the upper part of his back. The emergency department

physician suspected a displacement of the upper thoracic spines on the sixth thoracic spine.

- The following physical signs confirmed a diagnosis of fracture dislocation between the fifth and sixth thoracic vertebrae **except** which?
 - A lateral radiograph revealed fractures involving the superior articular processes of the sixth thoracic vertebra and the inferior articular processes of the fifth thoracic vertebra.
 - Considerable forward displacement of the body of the fifth thoracic vertebra on the sixth thoracic vertebra occurred.
 - The patient had signs and symptoms of spinal shock.
 - The large size of the vertebral canal in the thoracic region leaves plenty of space around the spinal cord for bony displacement.
 - The patient later showed signs and symptoms of paraplegia.

A 66-year-old woman was seen in the emergency department complaining of a burning pain over the upper part of her right arm. The pain had started 2 days previously and had progressively worsened. Physical examination revealed weakness and wasting of the right deltoid and biceps brachii muscles. The patient also had hyperesthesia in the skin over the lower part of the right deltoid and down the lateral side of the arm. Radiologic examination showed extensive spur formation on the bodies of the fourth, fifth, and sixth cervical vertebrae. These signs and symptoms suggested severe osteoarthritis of the cervical vertebral column.

3. This disease produced the following changes in the vertebrae and related structures **except** which?
- Repeated trauma and aging had resulted in degenerative changes at the articulating surfaces of the fourth, fifth, and sixth cervical vertebrae.
 - Extensive spur formation resulted in narrowing of the intervertebral foramina with pressure on the nerve roots.
 - The burning pain and hyperesthesia were caused by pressure on the third and fourth cervical posterior roots.
 - The weakness and wasting of the deltoid and biceps brachii muscles were caused by pressure on the fifth and sixth cervical anterior roots.
 - Movements of the neck intensified the symptoms by exerting further pressure on the nerve roots.
 - Coughing or sneezing raised the pressure within the vertebral canal and resulted in further pressure on the roots.

A medical student offered to move a grand piano for his landlady. He had just finished his final examinations in anatomy and was in poor physical shape. He struggled with the antique monstrosity and suddenly experienced an acute pain in the back, which extended down the back and outer side of his left leg. On examination in the emergency department, he was found to have a slight scoliosis with the convexity on the right side. The deep muscles of the back in the left lumbar region felt firmer than normal. No evidence of muscle weakness was present, but the left ankle jerk was diminished.

4. The symptoms and signs of this patient strongly suggest a diagnosis of prolapsed intervertebral disc **except** which?
- The pain was the worst over the left lumbar region opposite the fifth lumbar spine.
 - The pain was accentuated by coughing.
 - With the patient supine, flexing the left hip joint with the knee extended caused a marked increase in the pain.
 - A lateral radiograph of the lumbar vertebral column revealed nothing abnormal.
 - A magnetic resonance imaging study revealed the presence of small fragments of the nucleus pulposus that had herniated outside the anulus in the disc between the fifth lumbar vertebra and the sacrum.
 - The pain occurred in the dermatomes of the third and fourth lumbar segments on the left side.
5. When performing a lumbar puncture (spinal tap) on an adult, the following anatomic facts have to be taken into consideration **except** which?
- With the patient in the lateral prone or upright sitting position, the vertebral column should be well flexed to separate the spines and laminae of adjacent vertebrae.

- An imaginary line joining the anterior superior iliac spines passes over the fourth lumbar spine.
- The needle should be inserted above or below the fourth lumbar spine.
- To enter the subarachnoid space, the needle will pass through the skin, superficial fascia, supraspinous ligament, interspinous ligament, ligamentum flavum, areolar tissue (containing the internal vertebral venous plexus), dura mater, and arachnoid mater.
- The spinal cord ends below in the adult at the level of the lower border of the first lumbar vertebra.
- With the patient in the lateral prone position, the normal cerebrospinal fluid pressure is about 60–150 mm H₂O.

A 22-year-old student was driving home from a party and crashed his car head on into a brick wall. On examination in the emergency department, he was found to have a fracture dislocation of the seventh thoracic vertebra, with signs and symptoms of severe damage to the spinal cord.

6. On recovery from spinal shock he was found to have the following signs and symptoms **except** which?
- Upper motor neuron paralysis of his left leg
 - A band of cutaneous hyperesthesia extending around the abdominal wall on the left side at the level of the umbilicus, which was caused by the irritation of the cord immediately above the site of the lesion
 - On the right side, total analgesia, thermoanesthesia, and partial loss of tactile sense of the skin of the abdominal wall below the level of the umbilicus involving the whole of the right leg
 - Fracture dislocation of the seventh thoracic vertebra, which would result in severe damage to the seventh thoracic segment of the spinal cord
 - Unequal sensory and motor losses on the two sides, which indicate a left hemisection of the spinal cord

A 45-year-old woman visited her physician because of a low back pain of 3 months' duration. She was otherwise very fit. On examination of her back, nothing abnormal was discovered. The physician then listened to her chest, examined her thyroid gland, and finally examined both breasts. A large, hard mass was found in the left breast.

7. The following facts support the diagnosis of carcinoma of the left breast with secondaries in the vertebral column **except** which?
- The lump in the breast was painless and the patient had noticed it while showering 6 months previously.
 - Several large, hard, pectoral lymph nodes were found in the left axilla.
 - A lateral radiograph of the lumbar vertebral column showed extensive metastases in the bodies of the second and third lumbar vertebrae.
 - The lump was situated in the upper outer quadrant of the left breast and was fixed to surrounding tissues.

E. Although the cancer had spread by the lymph vessels, no evidence of spread via the bloodstream was present.

A 75-year-old woman was dusting the top of a high closet while balanced on a chair. She lost her balance and fell to the floor, catching her right lumbar region on the edge of the chair.

8. The following statements about this patient are correct **except** which?
- A. Examination of the back revealed a large bruised area in the right lumbar region, which was extremely tender to touch.

B. Anteroposterior and lateral radiographs exclude the presence of a fracture, especially of a transverse process.

C. A 24-hour specimen of urine should be examined for blood to exclude or confirm injury to the right kidney.

D. Careful examination of the erector spinae muscles or quadratus lumborum muscle may reveal extreme tenderness and therefore injury to these muscles.

E. A lumbar puncture (spinal tap) should always be performed in back injuries to exclude damage to the spinal cord.

Answers and Explanations

- A** is the correct answer. The right inferior articular process of the fifth cervical vertebra was forced over the anterior margin of the right superior articular process of the sixth cervical vertebra, causing the head of the patient to be rotated to the left.
- D** is the correct answer. The vertebral canal in the thoracic region is small and round and little space is around the spinal cord for bony displacement to occur without causing severe damage to the cord.
- C** is the correct answer. The burning pain and hyperesthesia were caused by pressure on the fifth and sixth cervical posterior roots.
- F** is the correct answer. The pain occurred in the dermatomes of the fifth lumbar and first sacral segments on the left side.
- B** is the correct answer. An imaginary line joining the highest points of the iliac crests passes over the fourth lumbar spine.
- D** is the correct answer. Fracture dislocation of the seventh thoracic vertebra would result in severe damage to the tenth thoracic segment of the spinal cord.
- E** is the correct answer. The carcinoma of the left breast was in an advanced stage and had spread by way of the lymph vessels to the axillary lymph nodes and by the bloodstream to the bodies of the second and third lumbar vertebrae. Carcinoma of the thyroid, bronchus, breast, kidney, and prostate tend to metastasize via the bloodstream to bones.
- E** is the correct answer. A lumbar puncture (spinal tap) is not required in cases of simple trauma to the back.

