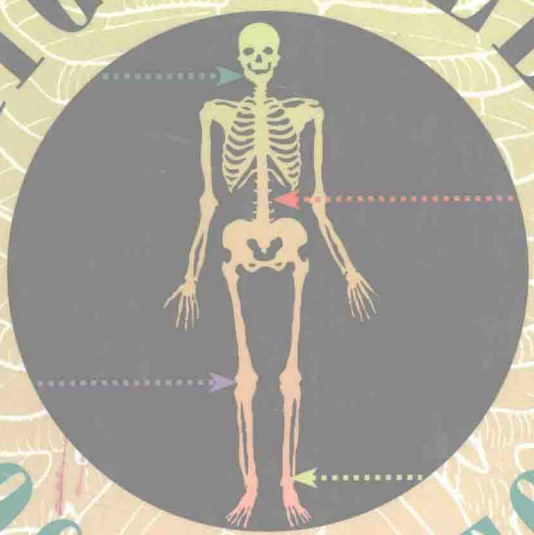
Ronald W. Dudek

High-Yield™ Gross Anatomy



High-Yield™ Gross Anatomy is designed to:

- Provide an uncomplicated review of gross anatomy
- Help equip you for the anatomy questions on the USMLE Step 1
- Clarify difficult concepts

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High-Yield Gross Anatomy

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High-Yield Gross Anatomy

Preface

High-Yield Gross Anatomy is gross anatomy at its irreducible minimum, and contains many of the recurring themes of the USMLE Step 1. The information presented in *High-Yield Gross Anatomy* prepares you to handle not only the clinical vignettes found on the USMLE, but also the questions that test basic gross anatomy concepts. *High-Yield Gross Anatomy* touches on all the major themes and concepts of gross anatomy, which are presented in a regional, rather than systemic, organization.

Like the USMLE Step 1, the discussions are comprehensively illustrated using a combination of artwork, MRIs and x-rays, including cross-sectional anatomy diagrams. In addition, *High-Yield Gross Anatomy* directly addresses the clinical vignettes of the USMLE Step 1 by incorporating relevant clinical issues that require basic gross anatomy to deduce the correct answer. A number of very common clinical techniques (such as liver biopsy, tracheostomy, and lumbar puncture), which all require a knowledge of the accompanying gross anatomy relationships, are included. Also, beginning with this special reprint, some illustrations that were not derived from the original image plates, and were therefore of inferior quality, have been replaced; the superior-quality replacement images that will appear in all subsequent printings of this edition were reproduced with the generous cooperation of both the publisher and the authors from Weir, J and Abrahams, PH: *An Imaging Atlas of Human Anatomy*, 2e, London, UK, Mosby International, 1997.

High-Yield Gross Anatomy, along with *High-Yield Embryology* and *High-Yield Histology*, completes my contribution to the High-Yield series, which is dedicated to improving student performance on the USMLE. In this regard, I would appreciate any comments, suggestions, or additions to any of these review books, especially after you have taken the USMLE. Your input will greatly assist me in future revisions and printings of these titles. You may contact me at dudek@brody.med.ecu.edu.

Contents

1

Vertebral Column and Spinal Cord

I. THE VERTEBRAL COLUMN (Figure 1-1). The vertebral column consists of 33 vertebrae [C1–7, T1–12, L1–5, S1–5 (sacrum), and Co1–4 (coccyx)]. The **vertebral canal** contains the spinal cord, dorsal nerve root, ventral nerve root, and meninges. The spinal nerve is located outside the vertebral canal by exiting through the **intervertebral foramen.**

A. Curves

1. **Primary curves** are thoracic and sacral curvatures that form during the fetal period.

2. **Secondary curves** are cervical and lumbar curvatures that form after birth as a result of lifting the head and walking, respectively.

3. **Kyphosis** is an exaggeration of the thoracic curvature, which can occur in the aged due to osteoporosis or disc degeneration.

4. **Lordosis** is an exaggeration of the lumbar curvature, which can occur as a result of pregnancy, spondylolisthesis, or a potbelly.

5. **Scoliosis** is a complex lateral deviation/torsion that can be caused by poliomyelitis, a short leg, or hip disease.

B. Joints

1. **Atlanto-occipital joints.** Nodding the head (as in indicating "yes") occurs at the **atlanto-occipital joints** between C1 (atlas) and the occipital condyles. These joints are synovial and have **no** intervertebral disc. The **anterior** and **posterior atlanto-occipital membranes** limit excessive movement at this joint.

2. **Atlantoaxial joints.** Turning the head side to side (as in indicating "no") occurs at the **atlantoaxial joints** between C1 (atlas) and C2 (axis). These are synovial joints and have **no** intervertebral disc. The **alar ligaments** limit excessive movement at this joint.

C. Disorders

1. Atlantoaxial dislocation

a. The **rupture of the cruciform (transverse) ligament** due to trauma or rheumatoid arthritis allows mobility of the **dens** (part of the axis) within the vertebral canal (Figure 1-2). This mobility is called an **atlantoaxial dislocation** and places the cervical spinal cord and medulla at risk.

b. The **dens** is secured in its position by the cruciform, alar, and apical ligaments and by the tectorial membrane, which is a continuation of the posterior longitudinal ligament.

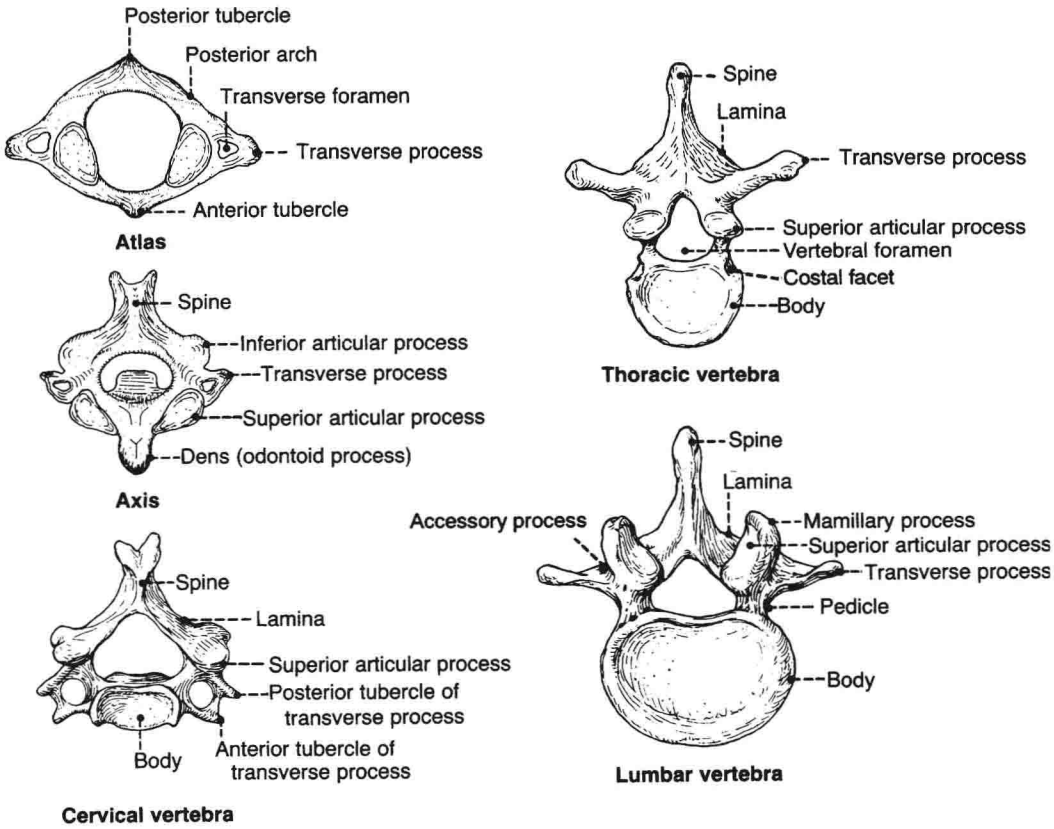

Figure 1-1. Schematic diagram of typical cervical, thoracic, and lumbar vertebrae. Reproduced with permission from Chung, KW: *BRS Gross Anatomy*, 2nd edition, Baltimore, Williams & Wilkins, 1991.

2. **Denervation of facet joints**
   a. **Facet joints** are synovial joints between **inferior** and **superior articular facets.** These joints are **located** near the intervertebral foramen.
   b. If these joints are **traumatized** or **diseased** (e.g., rheumatoid arthritis), a spinal nerve may be impinged and cause severe pain. To relieve the pain, medial branches of the dorsal primary ramus are severed.
3. **Protrusion of the nucleus pulposus**
   a. An intervertebral disc consists of the **annulus fibrosus** (fibrocartilage) and **nucleus pulposus** (remnant of the embryonic notochord). The nucleus pulposus generally herniates in a posterior-lateral direction and compresses a nerve root.
   b. **Important features** of a herniated disc at various vertebral levels are shown in Table 1-1.
4. **Dislocations without fracture** occur only in the cervical region because the articular surfaces are inclined horizontally. Cervical dislocations stretch the posterior longitudinal ligament.
5. **Dislocations with fracture** occur in the thoracic and lumbar region because the articular surfaces are inclined vertically.

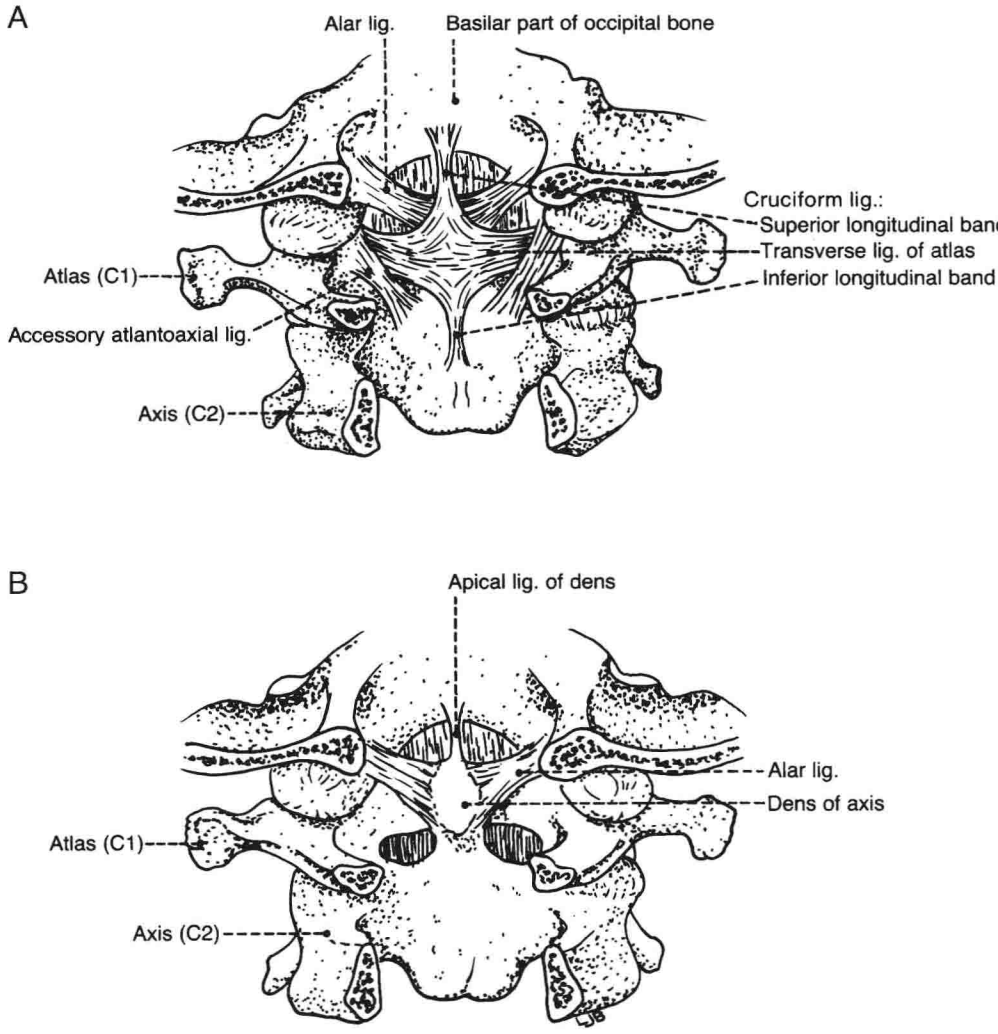

Figure 1-2. A posterior view of the ligaments of the atlas and axis at a superficial level (*A*) and deeper level (*B*). The posterior arch and lamina of the atlas and axis have been removed. Reproduced with permission from Chung, KW: *BRS Gross Anatomy*, 2nd edition, Baltimore, Williams & Wilkins, 1991.

6. **Hyperextension of the neck (whiplash)** stretches the anterior longitudinal ligament.
7. A route of **metastasis** for breast, lung, and prostate cancer to the brain exists because the **internal** and **external vertebral venous plexuses** communicate with the cranial dural sinuses and veins of the thorax, abdomen, and pelvis.
8. **Spina bifida occulta** is a common congenital malformation where the **vertebral arch** is absent. The defect is covered by skin and usually is marked by a tuft of hair. This condition is not associated with any neurological deficit.
9. **Hemivertebrae** occurs when a portion of the **vertebral body** fails to develop and can lead to scoliosis.
10. **Sickle cell anemia** is associated with "H-type vertebra" (as observed radiographically) in which central depressions occur in the **vertebral body.**

Table 1-1

Vertebral Levels of a Herniated Disc*

Herniated Disc Between	Compressed Nerve Root	Dermatome Affected	Muscles Affected	Movement Weakness	Reflex Involved
C4 and C5	C5	C5 Shoulder and lateral aspect of arm	Deltoid Biceps	Abduction of arm Flexion of forearm	Biceps jerk
C5 and C6	C6	C6 Lateral arm forearm, and thumb	Extensor carpi radialis longus	Extension of wrist	Biceps jerk
C6 and C7	C7	C7 Posterior arm, forearm, and middle finger	Flexor carpi radialis Triceps	Flexion of wrist Extension of elbow	Triceps jerk
L4 and L5	L5	L5 Lateral thigh, leg, and dorsum of foot	Tibialis anterior Extensor hallucis longus Extensor digitorum longus	Dorsiflexion of ankle (cannot stand on heels) Extension of toes	None
L5 and S1	S1	S1 Posterior thigh, leg and lateral part of foot	Gastrocnemius Soleus	Plantar flexion of ankle (cannot stand on heels	Ankle jerk

* This table is not intended to portray real-life clinical situations. Because of the overlap of nerve root contributions to spinal nerves, real-life clinical situations may not be as clear-cut as this table indicates. This table is intended for USMLE review where you are asked to choose the "most likely" answer.

11. **Spondylolisthesis** occurs when the **pedicles** of a lumbar vertebra fail to develop properly. This malformation allows the body of the lumbar vertebra to move anterior with respect to the vertebrae below it, causing a lordosis.

12. **Spondylolysis** is a fracture of the lamina between the inferior and superior articular processes (**pars interarticularis**) within a lumbar vertebra.

13. **Ankylosing spondylitis** is an inflammatory arthritis generally affecting the lumbar vertebrae and sacroiliac joint. The **annulus fibrosus** of the intervertebral discs may become ossified. The ossification bridges the discs at various levels forming a "bamboo spine." A majority of these patients are positive for histocompatibility antigen HLA-B27.

14. **Osteomyelitis** is a bacterial infection that may occur within vertebrae. Tuberculosis and *Staphylococcus aureus* may be causative agents.

D. **Reference points**

1. **Sacral promontory** is the projecting anterior edge of the S1 vertebral body. It is an important obstetrical landmark.

2. **Vertebral levels** are used to reference location of important anatomical structures as shown in Table 1-2. Knowledge of these vertebral levels helps when deciphering clinical vignette questions.

II. SPINAL CORD (Figure 1-3)

A. Denticulate ligaments are lateral extensions of **pia mater,** which attach to the dura mater and thereby suspend the spinal cord within the dural sac.

B. Vascular supply (Figure 1-4)

Table 1-2

Vertebral Levels for Reference

Anatomical Structure	Vertebral Level
Hyoid bone Bifurcation of common carotid artery	C4
Thyroid cartilage	C5
Cricoid cartilage Start of trachea Start of esophagus	C6
Sternal notch	T2
Sternal angle Junction of superior and inferior mediastinum Bifurcation of trachea	T4
Pulmonary hilum	T5-T7
IVC hiatus	T8
Xiphisternal joint	T9
Esophageal hiatus	T10
Aortic hiatus	T12
Duodenum	T12-L1
Kidneys	T12-L3
Celiac artery	T12
Superior mesenteric artery Renal artery	L1
End of spinal cord in adult (conus medullaris), pia	L1 or L2
End of spinal cord in new born Inferior mesenteric artery Umbilicus	L3
Iliac crest Bifurcation of aorta	L4
Sacral promontory	S1
End of dural sac, dura, arachnoid, subarachnoid space, and CSF	S2
End of sigmoid colon	S3

IVC = inferior vena cava

CSF = cerebrospinal fluid

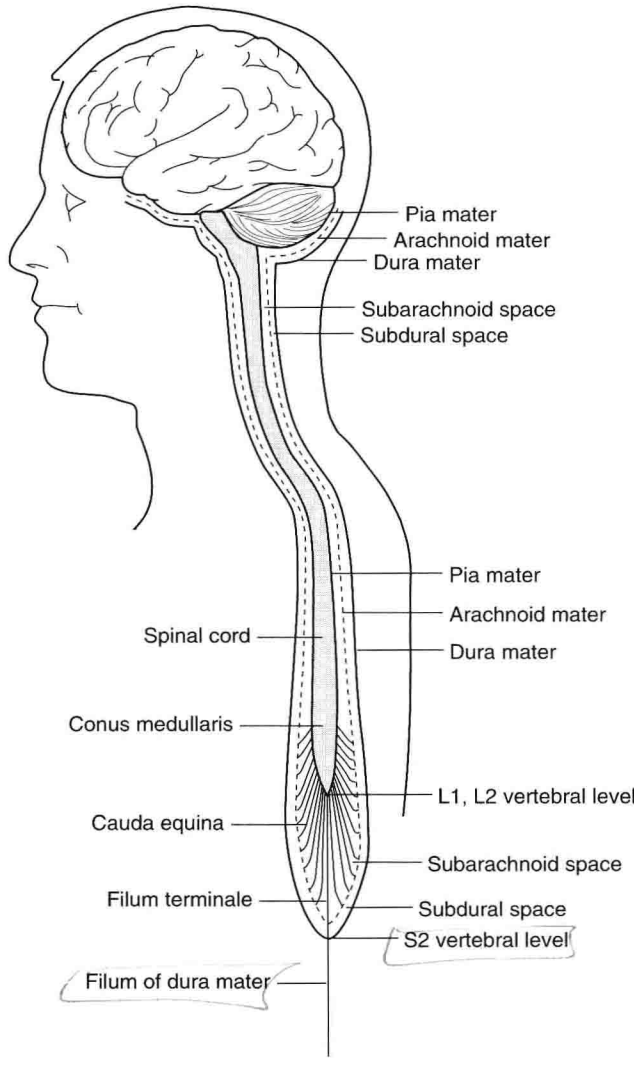

Figure 1-3. A schematic diagram of the spinal cord and meninges. The **subarachnoid space** lies between the pia and arachnoid and contains cerebrospinal fluid (CSF). The **subdural space** is a potential space that lies between the arachnoid and dura. The **epidural space** lies between the bony vertebrae and dura. The epidural space (not shown) contains fat, connective tissue, and the internal vertebral venous plexus. The **cauda equina** is a bundle of nerve roots of lumbar and sacral spinal nerves below the level of termination of the spinal cord. The pia mater as an investing sheet of the spinal cord ends at the conus medullaris. However, the pia mater is reflected onto a fibrous strand called the **filum terminale,** which extends to the end of the dural sac at S2. The filum terminale blends into the **filum of dura mater,** which passes through the sacral canal, exits through the sacral hiatus, and inserts onto the dorsum of the coccyx. Adapted with permission from Chung, KW: *BRS Gross Anatomy*, 2nd edition, Baltimore, Williams & Wilkins, 1991.

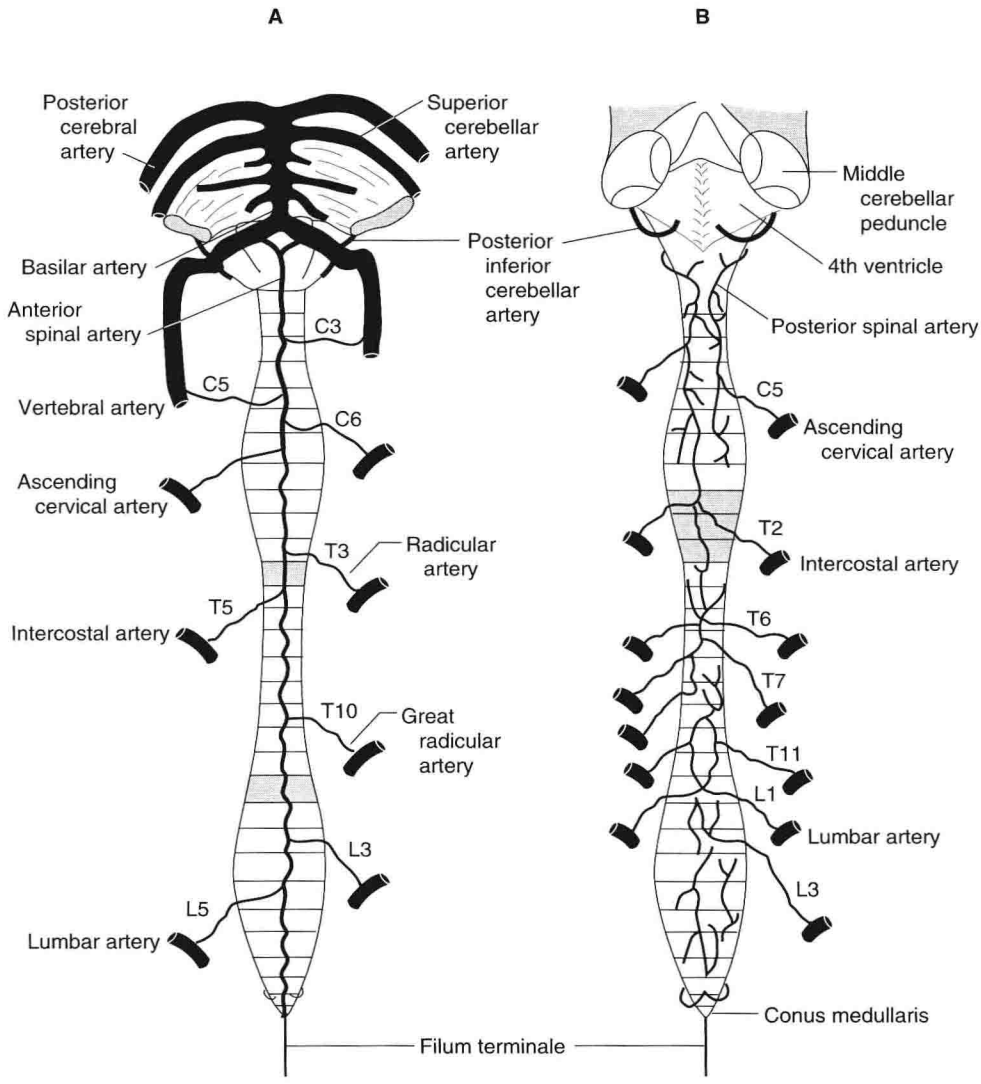

Figure 1-4. A schematic diagram of the arteries that supply the spinal cord from anterior (*A*) and posterior (*B*) views. Radicular arteries are shown at various levels. The great radicular artery is shown branching from a posterior intercostal artery at T10. The shaded areas indicate regions of the spinal cord most vulnerable to arterial blood deprivation. Adapted with permission from Moore, KL: *Clinically Oriented Anatomy*, 3rd edition, Baltimore, Williams & Wilkins, 1992.

1. **Anterior spinal artery** arises from the vertebral arteries and supplies the ventral two thirds of the spinal cord.
2. **Posterior spinal arteries** arise from the vertebral arteries or the posterior inferior cerebellar arteries and supply the dorsal one third of the spinal cord.
3. **Radicular arteries** arise from the vertebral, deep cervical, ascending cervical, posterior intercostal, lumbar, and lateral sacral arteries. The radicular arteries enter the ver-

tebral canal through the intervertebral foramina and branch into the anterior and posterior radicular arteries.

4. **Great radicular artery** generally arises on the left side from a posterior intercostal artery or a lumbar artery. The great radicular artery is clinically important because it makes a major contribution to the anterior spinal artery and is the main blood supply to the lower part of the spinal cord. If the great radicular artery is ligated during resection of an **aortic aneurysm,** the patient may become paraplegic, impotent, and lose voluntary control of the bladder and bowel.

C. Epidural (caudal) anesthesia is used to relieve pain during childbirth labor. An anesthetic is injected into the **sacral canal** via the **sacral hiatus,** which is marked by the **sacral cornua** (two bony landmarks). The anesthetic diffuses through the dura mater and arachnoid to enter the cerebrospinal fluid (CSF) where it bathes the cauda equina.

D. Lumbar puncture (Figure 1-5) can be done to either withdraw CSF or inject an anesthetic (**spinal block**). A needle is inserted above or below the **spinous process** of the **L4 vertebra.** The needle passes through the following structures:

1. Skin
2. Superficial fascia
3. Supraspinous ligament
4. Interspinous ligament
5. Ligamentum flavum
6. Epidural space containing the internal vertebral venous plexus
7. Dura mater
8. Arachnoid

E. Transection of the spinal cord results in loss of sensation and motor function below the lesion.

1. **Paraplegia** occurs if the transection occurs anywhere between the cervical and lumbar enlargements of the spinal cord.
2. **Quadriplegia** occurs if the transection occurs above C3. These individuals may die quickly due to respiratory failure if the phrenic nerve is compromised.

F. Dermatomes (Figure 1-6) are strips of skin extending from the posterior midline to the anterior midline that are supplied by cutaneous branches of dorsal and ventral rami of spinal nerves. A clinical finding of **sensory deficit** in a dermatome is important in order to assess which spinal nerve, nerve root, or spinal cord segment may be damaged. Some dermatomes that are helpful in answering clinical vignette questions are given in Table 1-3.

III. RADIOLOGY

A. Midsagittal section through the cadaver and MRI image of the cervical region (Figure 1-7)

B. Lateral radiograph of the cervical region (Figure 1-8)

C. AP radiograph of the lumbar region (Figure 1-9)

D. Oblique radiograph of the lumbar region (Figure 1-10)

E. Sagittal MRI of the lumbosacral region (Figure 1-11)

F. Lateral radiograph of the lumbosacral region (Figure 1-12)

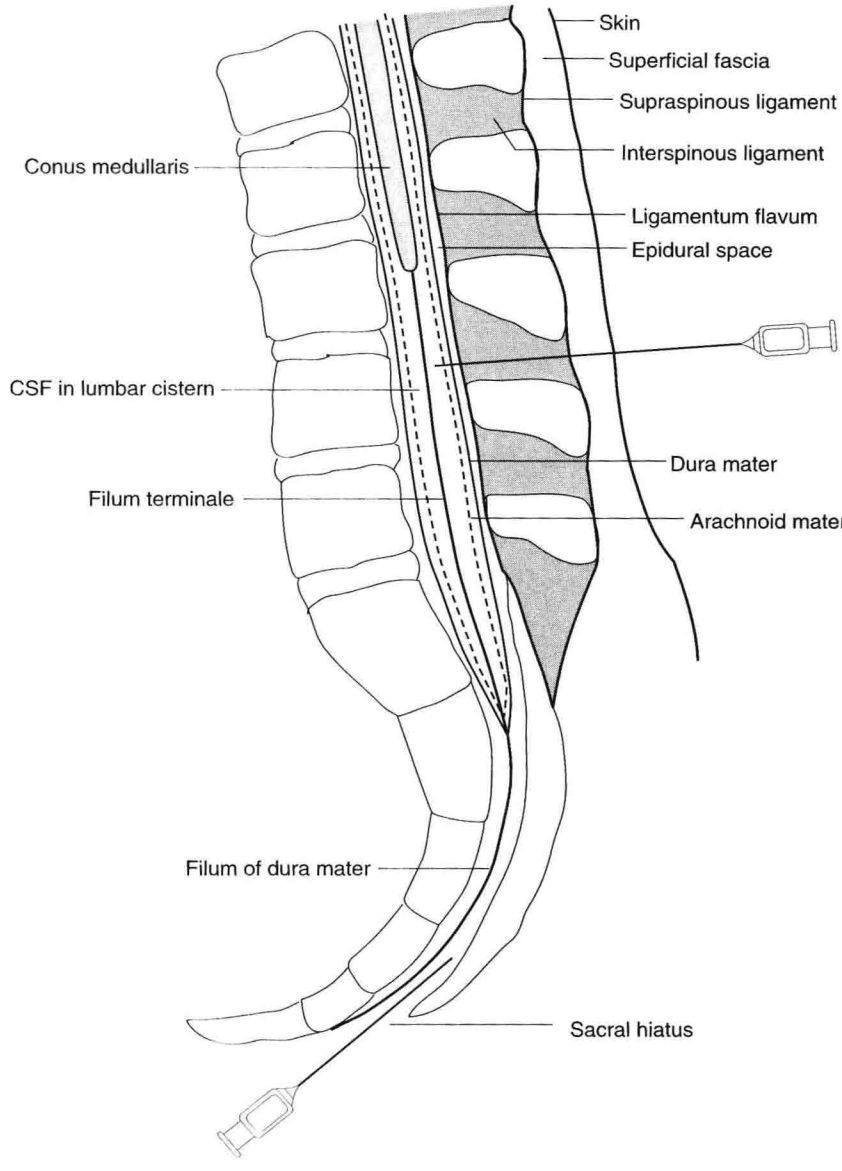

Figure 1-5. A schematic diagram of the lumbar vertebral column and spinal cord. A lumbar puncture needle has been inserted above the spinous process of L4 to withdraw cerebrospinal fluid (CSF). Note the layers the needle must penetrate. Another needle is shown inserted into the sacral canal through the sacral hiatus. This is the site for delivery of an epidural anesthetic. Adapted with permission from Moore, KL: *Clinically Oriented Anatomy*, 3rd edition, Baltimore, Williams & Wilkins, 1992.

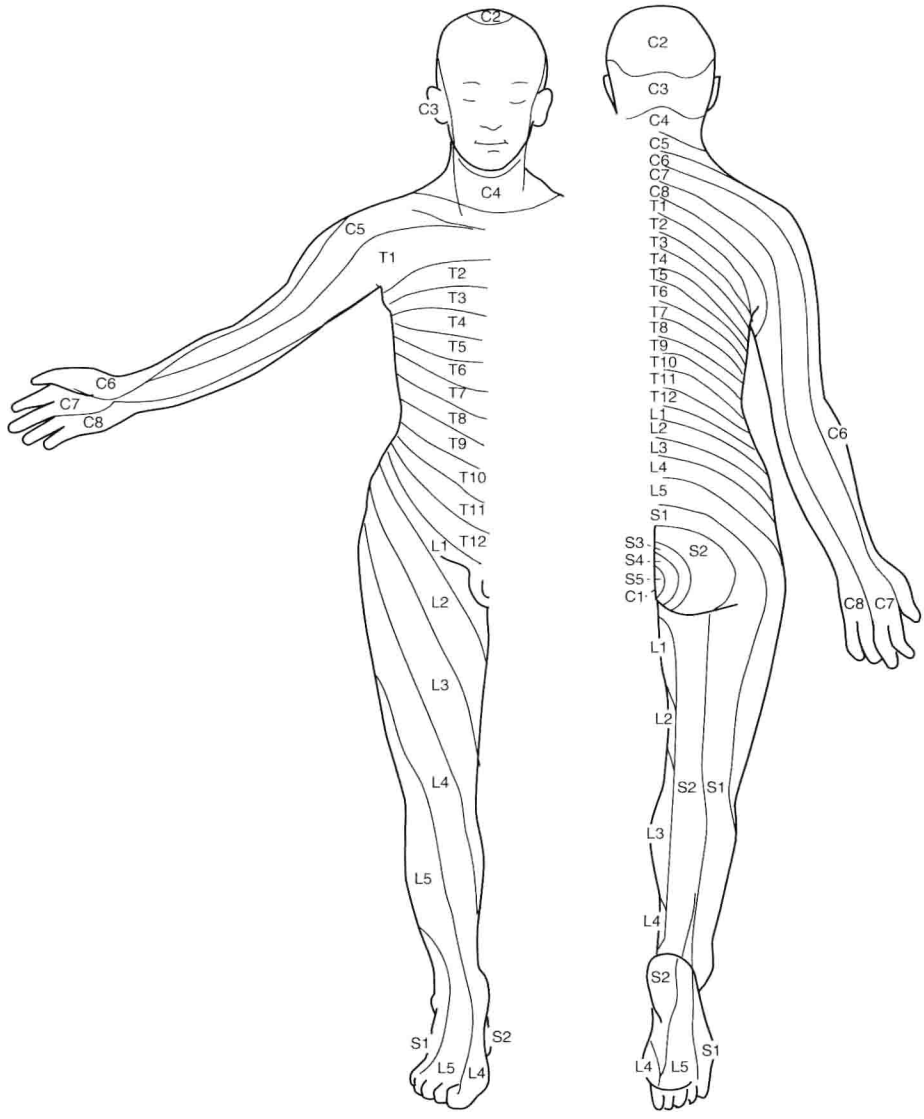

Figure 1-6. Anterior and posterior views of the dermatomes of the body. Although dermatomes are shown as distinct segments, in reality, there is overlap between any two adjacent dermatomes. Adapted with permission from Chung, KW: *BRS Gross Anatomy*, 2nd edition, Baltimore, Williams & Wilkins, 1991.

Table 1-3

Dermatomes

Structure	Dermatome
Clavicle	C5
Thumb	C6
Middle and index fingers	C7
Ring and little fingers	C8
Nipples	T4
Umbilicus	T10
Inguinal region	T12
Anterior and medial surface of lower limb	L1, L2, L3, L4
Big toe	L4
Dorsum of foot	L5
Lateral surface of foot and little toe	S1
Perineum	S2, S3, S4