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# Spine

CORE KNOWLEDGE IN ORTHOPAEDICS

Alexander R. Vaccaro

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# Preface

"The great aim of education is not knowledge but action"
Herbert Spencer

Our understanding of spinal disease is increasing at an expediential rate, in part due to the progress of imaging technology (MRI, CT imaging), diagnostic injections and advances in implant technology. The most learned spinal surgeon is challenged just to keep up with the myriad of published contemporary spine journals and books.

Common to all medical disciplines is a core foundation of knowledge i.e. anatomy, physiology and the nature history of the disorder, which must be understood in order to embark on new frontiers in research and medical treatment. *A Resident and Fellows Guide to the Fundamentals of Spine Surgery* was written to provide a resident, fellow, or even an established spinal surgeon with a simple and general, but complete overview of the basics of spinal surgery. This book is a wonderful asset for a medical student on a spinal surgery rotation or spine fellow at the commencement of their fellowship. The bulleted format of the text and accompanying text boxes and illustrations allow for a rapid review of information in a short period of time providing a foundation for learning that would normally take hours to accomplish with a standard text format. Established spinal surgeons will enjoy an easy to digest and timely review of the basics of spinal surgery which is often necessary on a periodic basis as one moves further from their formal training. Lastly, nurses, physician assistants, spinal care physicians (chiropractors, anesthesiologists, physiatrists) and hospital administrators may also use this book to become familiar with a review of commonly used terminologies and frequently performed spinal procedures.

The overall structure of the book is designed to be a high yield, efficient source of clinical information. The book is organized by medical relevance and conceptual difficulty. Within each chapter are numerous algorithms, pictures, grafts and drawings that highlight the most important clinical pearls of each subject matter and organize the information in a logical way to facilitate learning and recall. The annotated references at the end of each chapter serve as a source for those who would like to expand on the topics found in each chapter.

We hope that you enjoy reading this book as much as we enjoyed editing it and we hope that it serves as a useful tool until the next edited version is available.

Alexander R. Vaccaro, M.D.
Marc Fisicaro

CHAPTER 1

# Basic Anatomy of the Cervical, Thoracic, Lumbar, and Sacral Spine

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## Introduction

- A thorough understanding of spinal anatomy is crucial for a comprehensive evaluation of a patient with spinal disorders (Moore 1999, An 1998, Frymoyer et al. 2001, Rothman et al. 1999, Hoppenfeld et al. 1994).
- The primary roles of the spine are maintaining stability, protecting the neural elements, and allowing range of motion. Specifically adapted anatomic features facilitate these functions.
- The vertebra is the structural building block of the spine, with specific morphologic and functional roles based on the vertebra's position in the spinal column. The intervertebral disks, ligaments, and muscles add stability and control.
- The spinal cord travels within, and is protected by, the spine. Paired nerve roots exit at each spinal level.

## Bony Vertebral Column

- The vertebral column consists of 33 vertebrae—7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal (Fig. 1–1). The 24 cervical through lumbar vertebrae are mobile.
- The vertebral column has four distinct curves—cervical lordosis, lumbar lordosis, thoracic kyphosis, and sacral kyphosis. In stance, the sagittal vertical axis passes through the odontoid, posterior to the cervical vertebrae, through the C7-T1 intervertebral disk, anterior to the thoracic vertebrae, through the T12-L1 intervertebral disk, posterior to the lumbar vertebrae, through the L5-S1 intervertebral disk, and anterior to the sacrum.
- The primary curves are those of the kyphotic thoracic and sacral regions. These form during the fetal period. The secondary curves are those of the lordotic cervical and lumbar regions. These are initiated during the late fetal period but do not become significant until after birth when the spinal column begins to bear the weight of the body and head. Primary curves are caused by the wedge-shaped nature of involved vertebrae, whereas secondary curves are caused by differences in the anterior and posterior dimensions of the intervertebral disks.

# Introduction

This book is designed to function as a pocket aid or reference for medical and graduate students, residents, and those in the beginning of their fellowship training interested in spinal medicine. A general but complete overview of topics commonly encountered in clinical spinal medicine is presented, intended to focus and supplement daily readings and round discussions. Students will find this text useful initially in building a foundation of the core principles of spinal care. Spine fellows and even attending physicians will find this book useful as a quick, on-the-spot review of contemporary treatment principles of commonly encountered spinal disorders.

The design of this text allows you to quickly scan a topic of interest to acquire useful information while on rounds or before entering the operating arena. The book is written in an informal bulleted format with a plethora of outlines, pictures, charts, and graphs. The student or fellow on rounds can refer to any pertinent topic being discussed that day and assimilate the most important facts regarding a particular topic while actively participating in clinical rounds.

The book begins with a basic overview of spinal anatomy, surgical approaches, and physical examination of the spine. As you progress through the book, the topics become more focused on specific but common spinal disorders, such as primary and metastatic tumors of the spine, spinal trauma, and spondylolisthesis. For the seasoned spinal care physician, the book is a wonderful review of specific pathologies that can be read in a short period and can be used for teaching students, residents, ancillary personnel, and spine fellows.

This book is a must for any physician or physician in training who wishes to review on a yearly basis the basics and, if necessary, the details of a particular spinal pathology to maintain a well-rounded understanding of the principles of spinal care.

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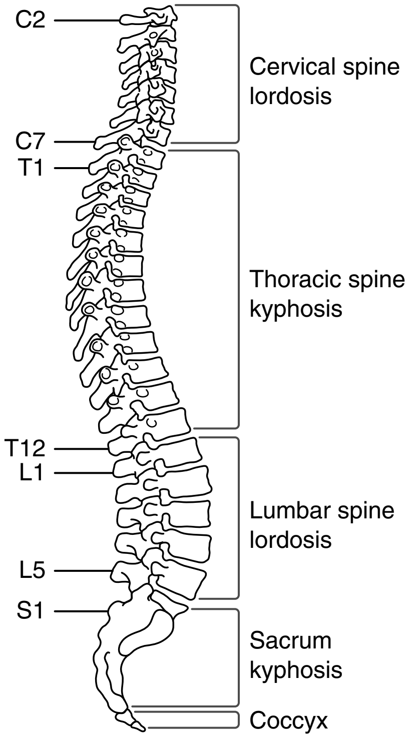



Figure 1–1: Lateral view of the spine demonstrating the normal spinal curvatures.

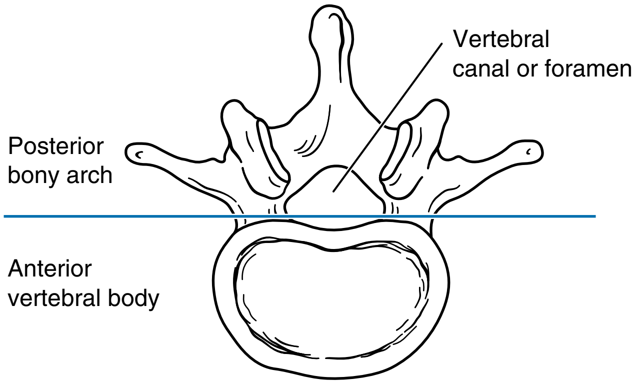



Figure 1–2: Anatomic configuration of a lumbar vertebra.

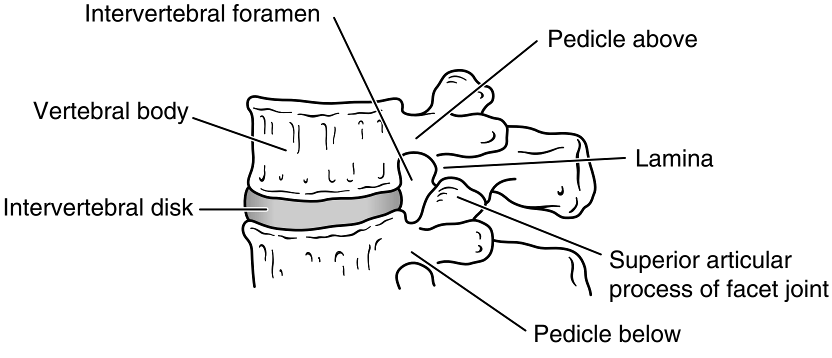
- Each vertebra consists of an anterior body and a posterior bony arch (Fig. 1–2). Together these surround the vertebral canal or foramen. Lateral spaces between the posterior arches of adjacent vertebrae form the foramen through which the spinal nerve roots pass (Fig. 1–3).
- The posterior vertebral arch consists of the pedicles, laminae, spinous processes, facet joints, and transverse processes. The pedicles and laminae form the borders of the vertebral canal with the posterior border of the vertebral body. The spinous and transverse processes are sites of attachment of supporting ligaments and muscles. Of note, the posterior arches include the thickest cortex of the vertebra (Doherty et al. 1994).
- The superior articular process is the portion of the posterior elements that articulates with the supra-adjacent vertebra. The inferior articular process articulates with the subadjacent vertebra. The orientation of the articular processes changes when one moves down the vertebral column. The bony region between the two articular processes of an individual vertebra is termed the pars interarticularis.
- The vertebral bodies of the lumbar spine support an average of 80% of the axial load experienced by the spinal column; the facet joints support the other 20%.

# Specific Vertebral Anatomy

## Atlas (C1)

- The atlas is the first cervical vertebra (Fig. 1–4). This is a ring-like structure that does not have an anterior body or a posterior spinous process. There is an anterior and a much longer posterior arch.
- The posterior arch has a groove along its superior border where the vertebral artery passes in its tortuous path toward the foramen magnum of the skull.
- The superior articular facets are saucer-like and form the atlanto-occipital articulation with the occipital condyles. Because of the orientation of these facets, the majority of cervical flexion and extension of the upper cervical spine is possible in this region.
- The inferior articular facets are flatter, more circular, and contribute to the atlantoaxial articulation with the second cervical vertebra, or axis. The remainder of this articulation is through the unique relationship of the

Figure 1–3: Borders of the intervertebral foramen through which the spinal nerve roots pass.



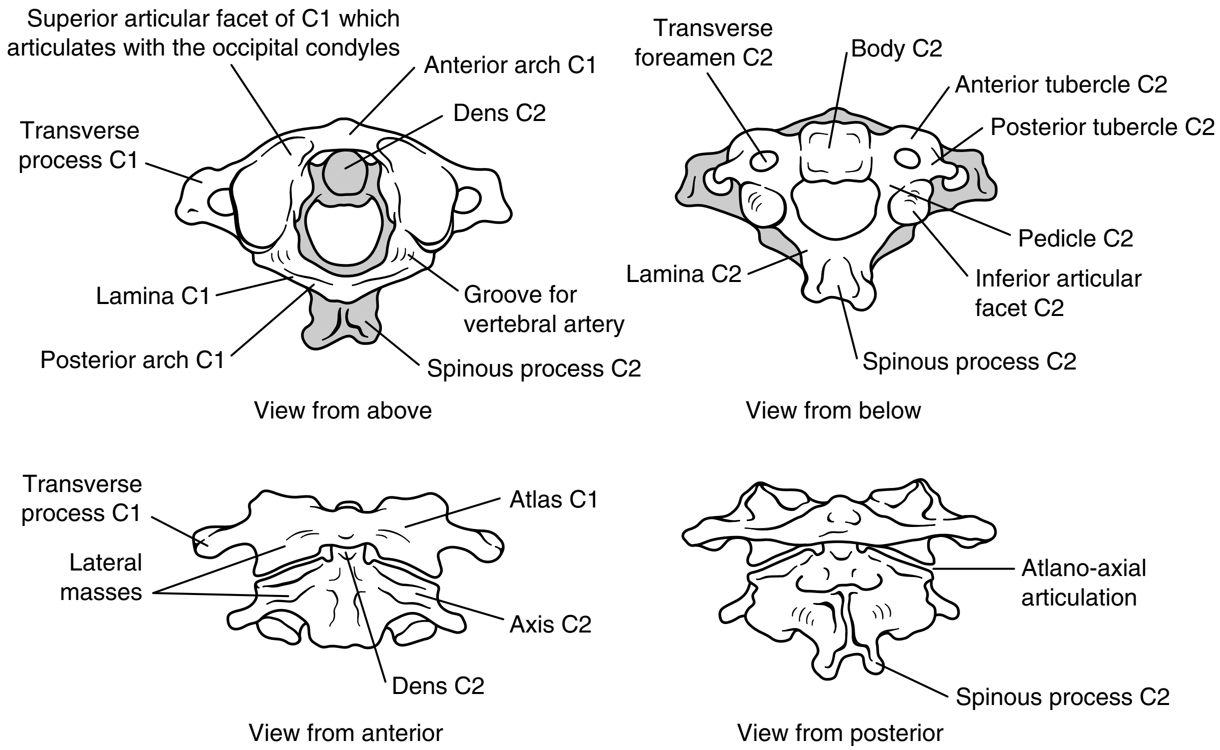



Figure 1–4: C1 and C2 vertebrae.

posterior border of the anterior arch of the atlas and the dens.

- The transverse processes of the atlas are longer and larger than those of the other cervical vertebrae. Within the transverse processes is the transverse foramina through which the vertebral artery passes.

## Axis (C2)

- The axis is the second cervical vertebra (Fig. 1–4). This includes the dens, or odontoid, which projects superiorly from the anterior vertebral body to articulate with the atlas.
- The atlas contacts the axis through the posterior facet joints and the anterior atlantodens articulation. A synovial joint is present between the anterior arch of C1 and the dens and transverse ligament that bonds the odontoid to the anterior C1 arch. The majority of upper cervical rotation occurs at the atlantoaxial joint.
- The transverse ligament is a stout ligament that runs from one side of the atlas to the other and holds the dens against the posterior surface of the anterior C1 arch (Fig. 1–5). Extensions of this ligament superiorly and inferiorly create the cruciform ligament.
- The dens is further stabilized by the alar ligaments that connect the odontoid tip to the occipital condyles. The apical ligament, at the tip of the dens, is a remnant of the notochord.
- The C2-C3 articulation is anatomically similar to the rest of the subaxial cervical levels.
- The C2 pedicle is relatively large and projects 30 degrees medially and 20 degrees superiorly (Xu et al. 1995).
- The C2 spinous process is large, bifid, and often palpable. This serves as the site of attachment for several muscles.
- The transverse processes of this vertebra are similar in morphology, but smaller, than those of the other cervical vertebrae. The vertebral artery passes through the transverse processes in the transverse foramen.

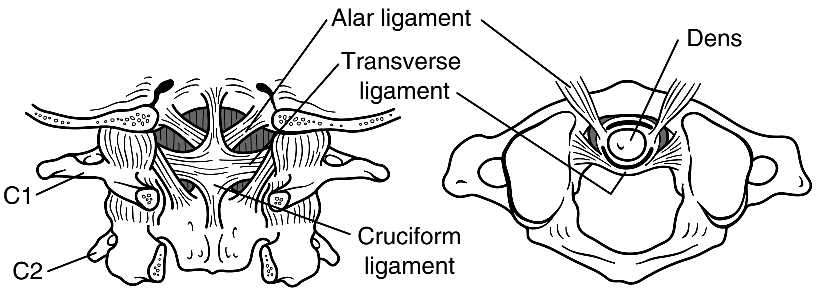



Figure 1–5: Ligaments specific to the atlantoaxial articulation.

## Subaxial Cervical Spine (C3-C7)

- The C3-C6 vertebral bodies are small in relationship to their vertebral canals (Fig. 1–6). The canal, triangular in shape, has the greatest cross-sectional area at C2.
- The superior surfaces, or endplates, of the cervical vertebrae are concave. The inferior endplates are convex. As such, the lateral aspects of the superior endplates curve superiorly to approach the supra-adjacent vertebrae to form what is known as the uncovertebral joints, or the joints of Luschka.
- The facets gradually become steeper and more sagittally oriented as one descends the cervical levels. The bony regions between the cervical facets, called the lateral masses, are just lateral to the laminae.
- The spinous processes are short and bifid.
- Similar to the atlas and axis, the vertebral artery travels within the transverse foramina of the transverse processes. This divides the transverse processes into the anterior and posterior tubercles.
- Between the two tubercles of the transverse processes is the groove on which the exiting nerve roots pass after exiting the intervertebral foramen.
- The seventh cervical vertebra (vertebra prominens) is a transitional vertebra and has several unique characteristics.
- The inferior surface of C7 is larger than its superior surface. The lateral masses of C7 are taller and shallower than those of the other subaxial cervical vertebrae. The pedicles also begin to enlarge as one goes caudally from this level.
- The C7 spinous process is long, nonbifid, and almost horizontal. This serves as a site of attachment for the ligamentum nuchae.
- The transverse processes of C7 do have transverse foramina, but the vertebral arteries rarely (5% of cases) pass through this vertebra. Rather, the vertebral artery usually joins the spinal column at C6.

## Thoracic Spine

- The thoracic vertebrae are intermediate in size between the cervical and lumbar vertebrae (Fig. 1–7). Their size increases as one moves down the spinal column.
- The defining characteristic of thoracic vertebrae is their intimate relationship with the ribs (Vollmer et al. 1997). A rib articulates at the junction of the vertebral body and pedicle (superior costal facet) of its named vertebra and the vertebra above (inferior costal facet). The rib also articulates with the transverse costal facet of the transverse process of its named vertebra. These relations of the rib and the vertebrae are supported by accessory ligaments that make the thoracic spine mechanically stiffer than the cervical and lumbar spine.
- Anteriorly, the thoracic vertebral bodies are relatively heart shaped. Sometimes, the left side of the vertebrae has a depression secondary to the descending aorta.
- The pedicles of the thoracic vertebrae are oval in cross section. These have been reported to be 10 mm in height and 4.5 mm in width at T4 and 14 mm height and 7.8 mm in width at T12 (Vaccaro et al. 1995). As with the pedicles of the lumbar spine, the walls are thicker medially than laterally.
- The spinal canal has less free space for the spinal cord than the cervical and lumbar regions.
- Posteriorly, the thoracic vertebrae have long, slender spinous processes that point downward and overlap the vertebral arches of the inferior vertebra.
- The transverse processes are posteriorly angulated, leaving room for the ribs to pass anterior to them.

## Lumbar Spine

- The lumbar vertebrae are stouter than those of the other spinal regions because they bear the greatest weight (Fig. 1–8).
- Anteriorly, the lumbar vertebral bodies are kidney shaped. Their bodies are wider transversely than they are deep anteroposteriorly, and both of these dimensions exceed their height.

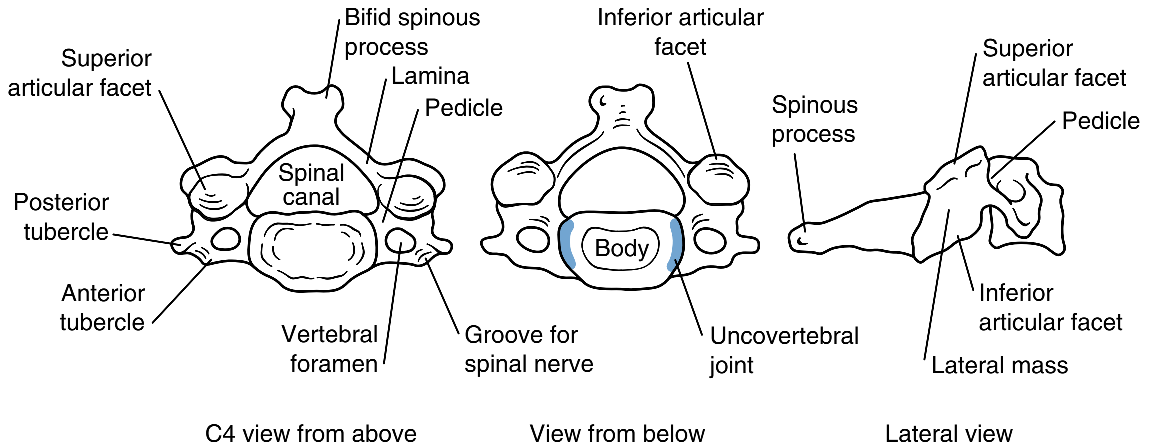



Figure 1–6: C4 as a representative subaxial vertebra.

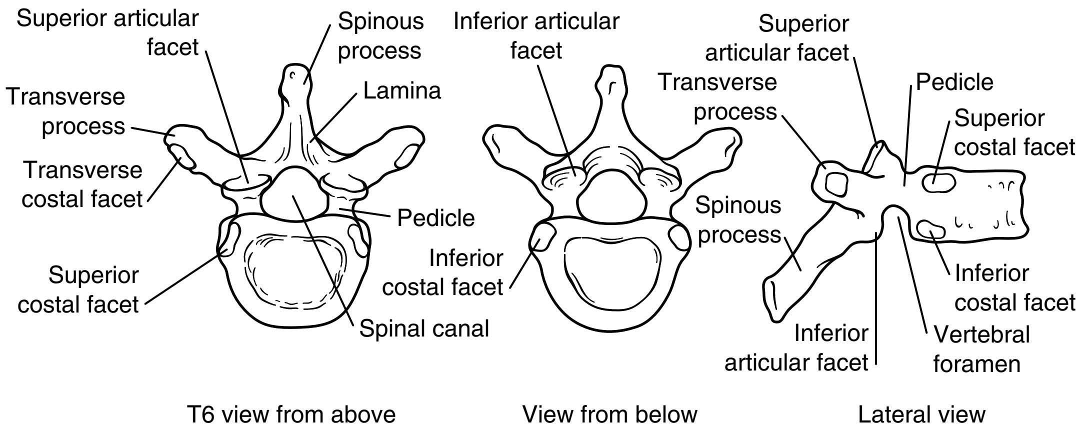



Figure 1–7: T6 as a representative thoracic vertebra.

- The pedicles are short and large and arise from the upper part of the vertebral body. Based on posterior landmarks, a pedicle is located behind the facet of the named vertebra and the supra-adjacent vertebra. In the cephalad–caudad direction, it is in the midline of the associated transverse process. In the medial–lateral direction, the medial aspect of the pedicle is in line with the lateral aspect of the pars interarticularis.
- At L1, the transverse pedicular diameter is approximately 9 mm with a medial angle of 12 degrees (Zindrick et al. 1987). The height-to-width ratio at L1-L4 is approximately1:8, but this decreases to 1:1 at L5 (Panjabi et al. 1992). L1 and L2 are transitional vertebrae similar to the thoracic vertebrae (Panjabi et al. 1992).
- The lumbar facets are in a relative sagittal orientation. As such, axial rotation is limited. The exception is the L5-S1 facet, which is more coronal and resists anteroposterior translation (An 1998). The pars interarticularis is more defined in this region of the spine than in the cervical or thoracic region.
- The nerve roots pass under the lateral recess of the pedicles/articular facets and through the intervertebral foramina. These foramina are bordered by the pedicles above and below, the vertebral body and intervertebral disk anteriorly, and the lamina and facets posteriorly (Fig. 1–3).
- The spinous processes are broad and tall within the lumbar spine.
- The transverse process of L5 is often much smaller than the transverse processes of the other lumbar vertebrae. The L5 transverse process is the site of attachment of the iliolumbar ligament. As with the other lumbar transverse processes, L5 often has an irregular accessory process on the medial aspect of the transverse process near where it joins the rest of the posterior bony arch and a mammillary process at the prominence of the facet joint.

## Sacrum

- The sacrum is composed of five fused vertebrae and is a large, wedge-shaped bone (Fig. 1–9).

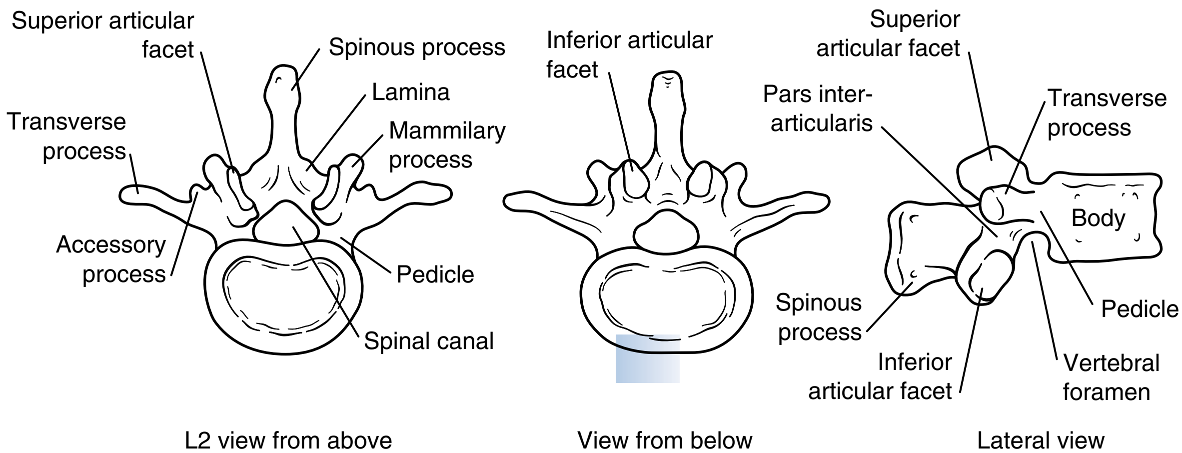



Figure 1–8: L2 as a representative lumbar vertebra.

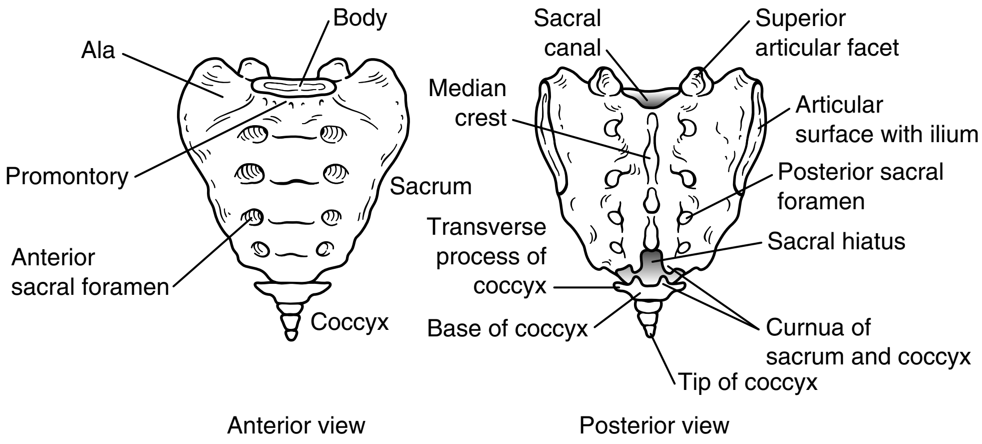



Figure 1–9: Sacrum and coccyx.

- The functions of the sacrum are to provide strength and stability to the pelvis and to transmit the weight of the body from the vertebral column to the pelvic girdle through articulation with the ilea (the sacroiliac joints).
- The spine has an acute angle at L5–S1, which is called the sacrovertebral angle.
- The promontory is the superior flare of the sacrum that articulates with L5. The transverse lines are the residual of the divisions of the sacral vertebrae. The alae are the two lateral wings that extend laterally to the sacroiliac joints. These are derived from fused transverse processes of the sacral vertebrae. The median sacral crest is formed by the fused sacral spinous processes.
- The sacrum has four pairs of anterior and posterior foramina through which the ventral and dorsal primary rami exit. The anterior sacral foramina are larger than the posterior foramina (Esses et al. 1991).
- The sacral hiatus is formed by the absence of the laminae and spinous process of S5. The sacral hiatus is the termination of the sacral canal. This contains the fatty connective tissue, the filum terminale, the S5 nerves, and the coccygeal nerves.
- The sacral cornu is formed by the pedicles of the fifth sacral vertebra. They project inferiorly on each side of the hiatus.

## Coccyx

- The coccyx, colloquially called the "tail bone", is the terminal portion of the spinal column. It consists of four fused rudimentary vertebrae.
- The primary role of the coccyx in the human is to serve as a site of attachment for muscles of the pelvic floor.
- The coccygeal cornua are proximal extensions of the coccyx. The tip of the coccyx is usually flexed forward.

# Intervertebral Disks

- Intervertebral disks are located between the vertebral bodies of C2-C3 through L5-S1. The disks are located between the vertebral endplates covered with hyaline cartilage and supported by subchondral bone.
- Analogous to the menisci of the knee, the intervertebral disk is a relatively avascular structure with only the outermost layers receiving nutrients from peripheral vascularization. The central portions of the disk receive nutrients through diffusion from the vertebral endplates.
- The nucleus pulposus is the inner portion of the disk (Fig. 1–10). This mucoid portion of the disk is

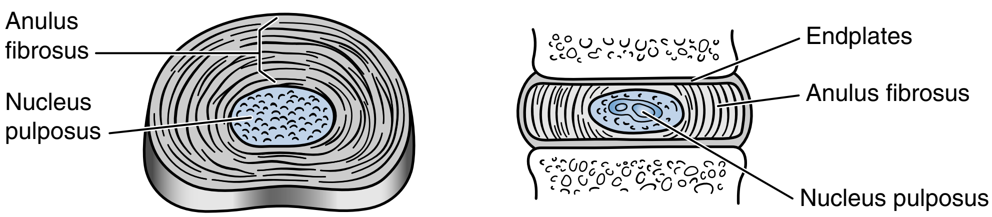



Figure 1–10: Transverse and sagittal images of an intervertebral disk.

predominantly made of type II collagen and is a remnant of the primitive notochord. The nucleus acts at a cushion to axial loads.

- The anulus fibrosus is the outer portion of the disk. This multilayered, fibrocartilaginous structure is predominantly made of type I collagen. A lattice is made with overlapping sheets running in opposite directions to give the anulus increased strength, especially in rotation. The anulus is thickest anteriorly and thinnest posterolaterally.
- The anulus absorbs the radially directed forces from the nucleus and converts these to hoop stresses at the periphery of the disk, where they are firmly attached to the vertebral endplates.
- The outermost portions of the anulus are continuous with the anterior and posterior longitudinal ligaments.
- The intervertebral disks contribute {1/4} of the length to the spinal column, but this is a dynamic measure. When in the horizontal position, nutrients and fluid enter the disk, increasing height. With prolonged stance, nutrients and fluids exit the disk, decreasing height.

# Ligaments of the Vertebral Column

## Anterior Longitudinal Ligament

- The anterior longitudinal ligament runs along the anterior aspect of the vertebral column (Fig. 1–11). It begins at the anterior border of the anterior margin of the foramen magnum (basion) as the anterior occipital membrane and ends on the anterior surface of the sacrum.
- As the ligament descends, it widens, and it is thickest opposite the disk spaces. The deepest fibers of this ligament are found at only one level. The intermediate fibers span two or three levels. The most superficial fibers span four or five levels.
- The functions of the anterior longitudinal ligament are to prevent hyperextension and to support the anulus fibrosus anteriorly.

## Posterior Longitudinal Ligament

- The posterior longitudinal ligament runs along the posterior aspect of the vertebral column (Fig. 1–11). It begins along the posterior border of the basion as the tectorial membrane, continues within the spinal canal, and ends on the posterior surface of the sacrum.
- The posterior longitudinal ligament is narrow over the middle of the vertebral bodies and expands over the disks and vertebral endplates (Fig. 1–12). The lateral expansions are thin, and the central portion of the ligament is thick.
- The posterior longitudinal ligament is double layered—its superficial layer is adjacent to the dura and contributes to the enveloping connective tissue underlying neural elements. The deep layers connect to the anulus fibrosus centrally and blend into the intervertebral foramen laterally.
- The functions of the posterior longitudinal ligament are to prevent hyperflexion and to support the posterior aspects of the anterior vertebral column.

## Ligamentum Flavum

- The ligamentum flavum, or the yellow ligament, is a thick, segmental ligament that runs between the lamina of adjacent vertebrae (Fig. 1–11). It begins on the undersurface of the inferior border of the lamina and courses down to the leading superior edge of the lamina (Fig. 1–12).
- There are gaps at the midline of the ligamentum flavum to allow the veins to exit.

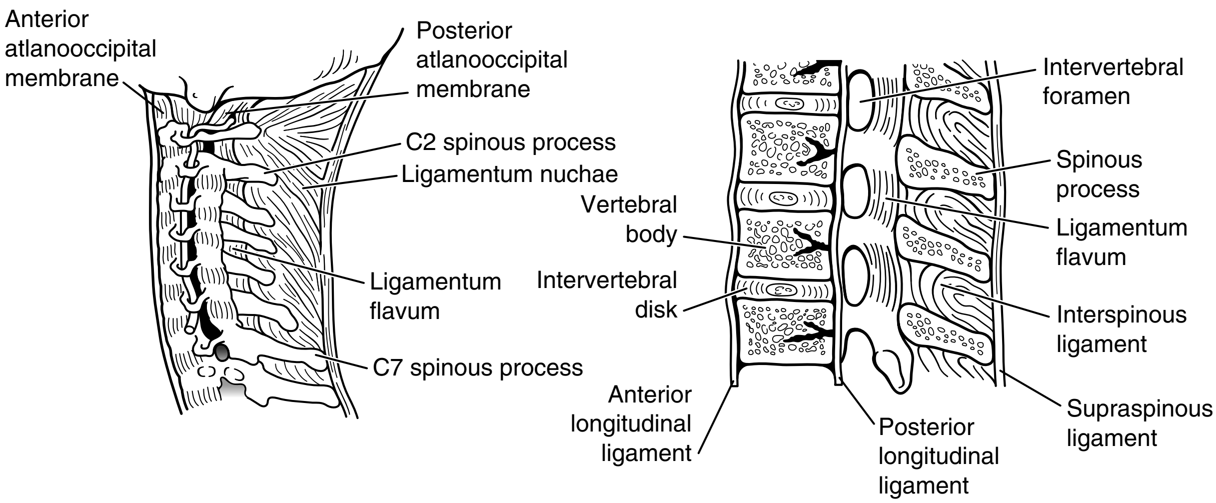



Figure 1–11: Ligaments of the spinal column.

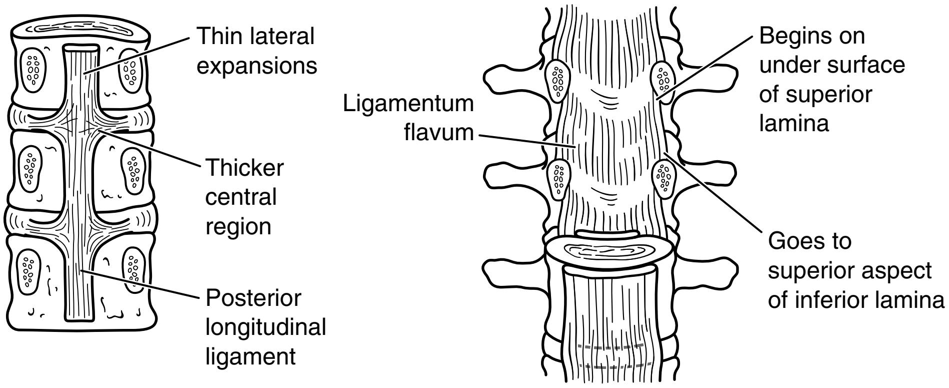



**Figure 1–12: Posterior longitudinal ligament and ligamentum flavum.**

- The function of the ligamentum flavum is to maintain upright posture. It helps to preserve the normal curvature of the spine and to straighten the column after it has been flexed. However, the elasticity of the ligamentum flavum decreases with age, and this may be associated with hypertrophy and buckling.

## Supraspinous Ligament

- The supraspinous ligament is a midline structure that runs over the posterior aspect of the spinous processes (Fig. 1–11). The cervical expansion of this ligament is called the ligamentum nuchae.
- The nuchal portion of this ligament extends from the seventh cervical spinous process to the external occipital protuberance. It is attached to the posterior tubercle of the atlas and to the spinous processes of the other cervical vertebrae.
- The primary purpose of this ligament is to act as a tension band in preventing hyperflexion. It also acts as a site of attachment for the fascial coverings of the medial spinal muscles.

## Additional Spinal Ligaments

- The interspinous ligaments connect adjacent spinous processes. As with the supraspinous ligament, this contributes to the posterior tension band preventing hyperflexion.
- Intertransverse ligaments connect adjacent transverse processes. These help to limit lateral bending and act as a border between anterior and posterior structures, particularly in the lumbar spine.
- Denticulate ligaments are fine intradural ligaments that attach neural elements to overlying covering membranes.

# Muscles of the Vertebral Column

## Posterior Muscles

- The extrinsic posterior muscles of the back include the trapezius and latissimus dorsi, the serratus posterior superior, and the serratus posterior inferior.
- The intrinsic posterior spinal muscles are located under the more superficial extrinsic musculature. The intrinsic spinal muscles extend, rotate, and laterally bend the vertebral column. As a rule, superficial spinal muscles are longer than deeper spinal muscles. Many of these muscles are named in subdivisions based on the site of insertion of portions of the muscle.
- The intrinsic posterior muscles are divided into superficial, intermediate, and deep layers (Fig. 1–13, Table 1–1). These are innervated by the dorsal ramus of the spinal nerves.
- The superficial layer consists of the splenius capitis and the splenius cervicis muscles.
- The muscles of the intermediate layer are also known as the erector spinae muscles. This layer is composed of: (1) the iliocostalis, subdivided into the cervicis, thoracis, and lumborum portions; (2) the longissimus, subdivided into the capitis, cervicis, and thoracic portions; and (3) the smaller spinalis muscle group, subdivided into the capitis, cervicis, and thoracis portions.
- The muscles of the deep layer are also known as the transversospinalis muscles. This layer is composed of: (1) the semispinalis, subdivided into the capitis, cervicis, and thoracis portions; (2) the multifidus; (3) the rotators; and (4) the short rotators (the interspinales and intertransversarii muscles).
- The muscles of the upper cervical spine make up the suboccipital triangle (Fig. 1–13, Table 1–1). The suboccipital triangle is bound medially by the rectus capitis posterior, laterally by the obliquus capitis superior, and inferiorly by the obliquus capitis inferior. The roof is formed by the semispinalis capitis and longissimus capitis. The posterior arch of the atlas and posterior atlanto-occipital membrane form the floor of the triangle. Within the triangle are the vertebral artery and suboccipital nerve and vessels. All of the muscles are innervated by the suboccipital nerve.

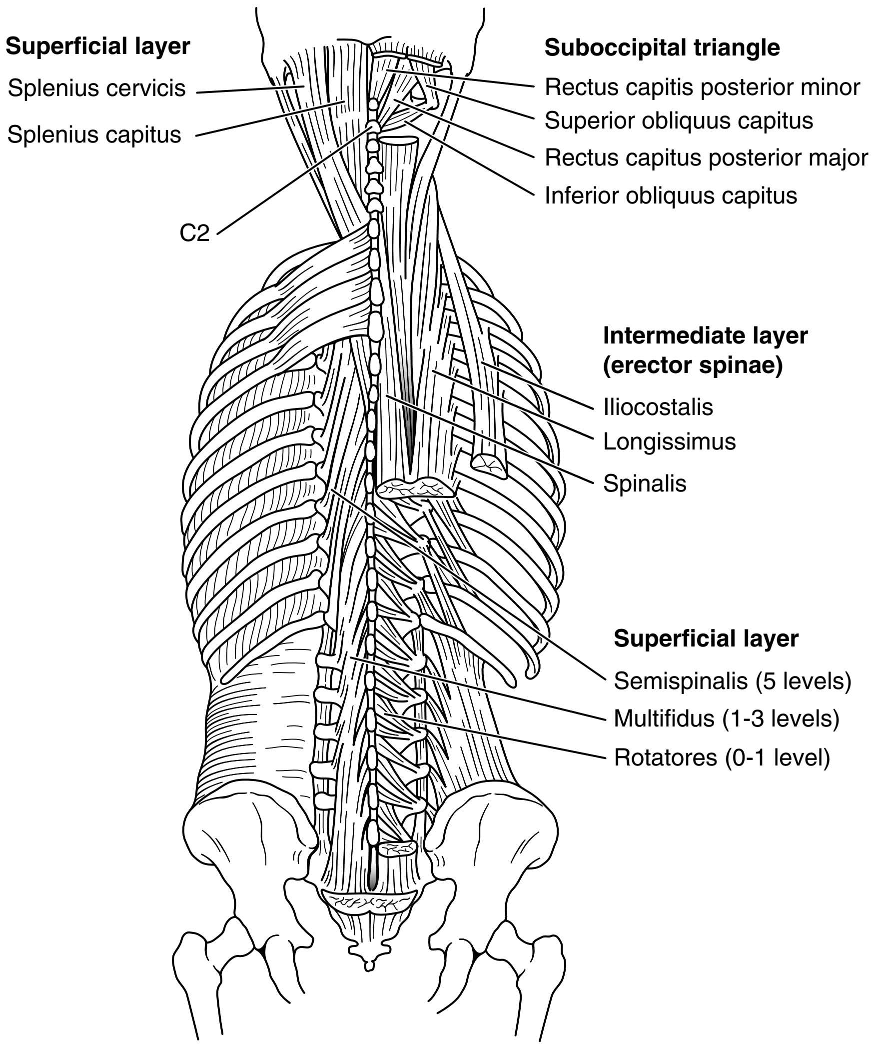



**Figure 1–13: Posterior intrinsic spinal muscles.**

## Anterior Spinal Muscles

- Anterior muscles that flex, laterally bend, and rotate the spine generally act a greater distance from the vertebral column than the posterior muscles.
- The sternocleidomastoid, scalene muscles, longus colli, and longus capitis act on the cervical spine.
- The abdominal, psoas, and quadratus lumorum muscles act on the thoracolumbar spine.

# Blood Supply and Venous Drainage

- The arterial blood supply of the spine is predominantly from segmental vessels that originate from the vertebral arteries, aorta, and iliac vessels (Fig. 1–14). Not only are these important for the bony spine, but they also are crucial for the functioning of the spinal cord.
- Segmental vessels have dorsal branches that divide into anterior and posterior radicular arteries when they enter the intervertebral foramen. These form a single anterior spinal artery and a pair of posterior spinal arteries, respectively.
- The artery of Adamkiewicz is a particularly large radicular vessel that generally arises in the left thoracolumbar region and is considered to contribute significantly to the anterior vascular supply of the spinal cord at this level.
- The vertebral artery deserves specific mention. This is a branch off the subclavian artery that, as discussed in preceding sections, usually enters the transverse foramen of the cervical vertebra at C6, gives off segmental branches when it ascends the cervical spine, and then curves medially, after passing through C1, to within 1.5 cm of midline in the adult before entering the foramen magnum.

**Table 1–1: Posterior Spine Muscles**

| | MUSCLE | ORIGIN | INSERTION | PRIMARY FUNCTIONS |
|---|---|---|---|---|
| **Superficial** | Splenius capitis | Ligamentum nuchae, spinous processes | Mastoid process, occipital nuchal line | Extension, lateral bending, rotation |
| | Splenius cervicis | Same | Posterior tubercles C1-C3 | Same |
| **Intermediate** | Iliocostalis | Iliac crests, sacrum, spinous processes | Ribs, cervical transverse processes | Extension, lateral bending |
| (erector spinae) | Longissimus | Same | Ribs, transverse processes, mastoid process | Same |
| | Spinalis | Same | Spinous processes, skull | Same |
| **Deep layer** (transversospinalis and short rotators) | Semispinalis | Transverse processes | Spinous processes of vertebrae 5-6 levels above | Extension, rotation |
| | Multifidus | Sacrum, ilium, transverse processes | Spinous processes of vertebrae 1-3 levels above | Stabilizing effect |
| | Rotators | Transverse processes | Spinous processes of vertebrae 1-2 levels above | Extension, rotation |
| | Interspinales | Spinous processes | Spinous process of adjacent vertebra | Extension |
| | Intertransversarii | Transverse process | Transverse process of adjacent vertebrae | Lateral bending |
| **Suboccipital muscles** | Rectus capitis posterior major | C2 spinous process | Lateral portion of nuchal line of skull | Extension, rotation of head |
| | Rectus capitis posterior minor | Posterior tubercle of atlas | Medial portion of nuchal line of skull | Same |
| | Superior obliquus capitis | Transverse process of C1 | Lateral portion of nuchal line of skull | Same |
| | Inferior obliquus capitis | Spinous process of C2 | Transverse process of C1 | Same |

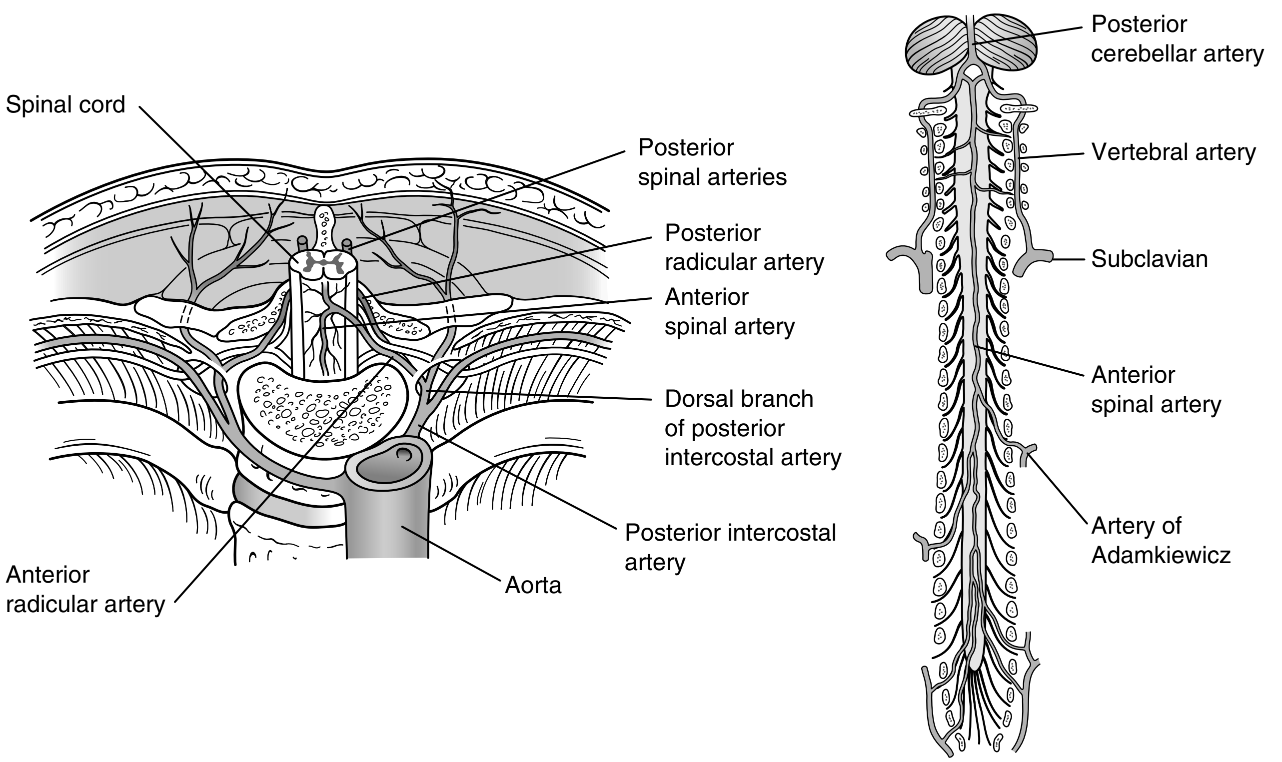



Figure 1–14: Arterial blood supply to the spine.

- The spinal veins form plexuses within the vertebral bodies and around the epidural space (Fig. 1–15).

## Neuroanatomy

- There are 31 pairs of spinal nerves—8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal (Fig. 1–16). The first seven cervical nerves leave the vertebral canal above their named vertebrae. The eighth cervical and the remainder of the spinal nerves exit the vertebral canal below their named vertebrae.
- The dorsal and ventral rootlets coalesce to form the dorsal and ventral roots, respectively (Fig. 1–17). The dorsal root has the cell bodies of the entering sensory neurons (dorsal root ganglion) medial to its union with the motor neurons of the ventral root. The dorsal and ventral roots form the spinal nerve that divides into the dorsal and ventral primary rami after developing sympathetic branches.
- The dorsal primary ramus innervates the skin and deep muscles of the back. The ventral primary ramus forms the plexi, intercostals, and subcostal nerves.
- The spinal cord is shorter than the vertebral column; it usually ends at L1 or L2. The spinal cord has cervical and lumbar enlargements because the nerves branch out to the upper and lower extremities, and it terminates in the conus medullaris. Nerve roots continue more distally in the cauda equine until the thecal sac terminates in the filum terminale (Fig. 1–16).
- The spinal cord is covered by three layers of meninges—the dura, the arachnoid, and the pia mater, from peripheral to central (Figs. 1–17 and 1–18). Together these form the thecal sac.
- The pia is closely related to the spinal cord and therefore cannot be dissected from it. It is relatively thick and gives rise to a longitudinal projection on each side called the denticulate ligament. These ligaments anchor the spinal cord to the arachnoid and, through it, to the dura.
- The arachnoid is a transparent layer that connects to the pia by web-like trabeculations. Under it is the subarachnoid space, which is filled with cerebrospinal fluid. This space extends down to S2. There is a large subarachnoid space between L1 and S2 called the lumbar cistern.
- The dura is the tough, fibrous, outer covering of the spinal cord. Between the dura and the arachnoid is a potential space, called the subdural space, that also extends to S2. The epidural space is outside the dura and contains the internal venous plexus and epidural fat.
- The internal morphology of the spinal cord consists of central gray matter, which is predominantly cell bodies, surrounded by peripheral white matter, which is predominantly axons that make up specific neural tracts (Fig. 1–17 and Table 1–2).

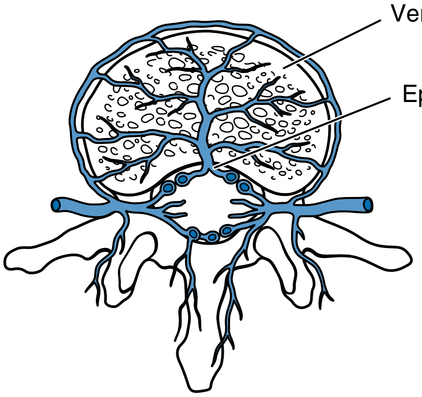



Figure 1–15: Venous drainage of the spine.

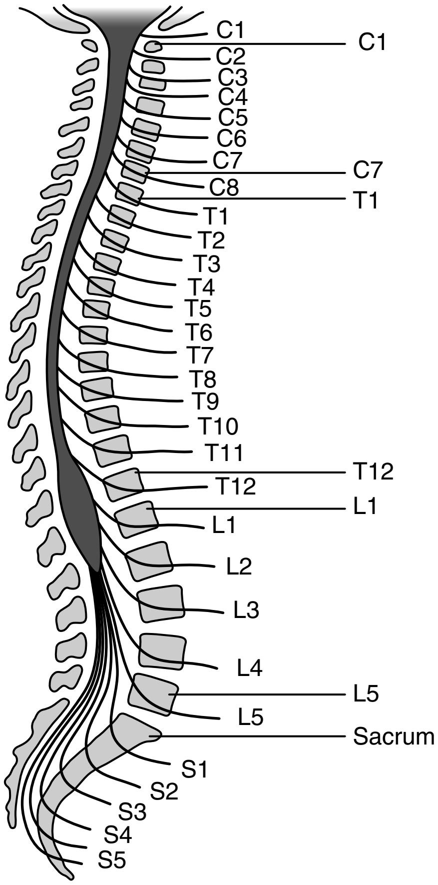



Figure 1–16: Diagram of the spinal nerves when they exit the vertebral column.

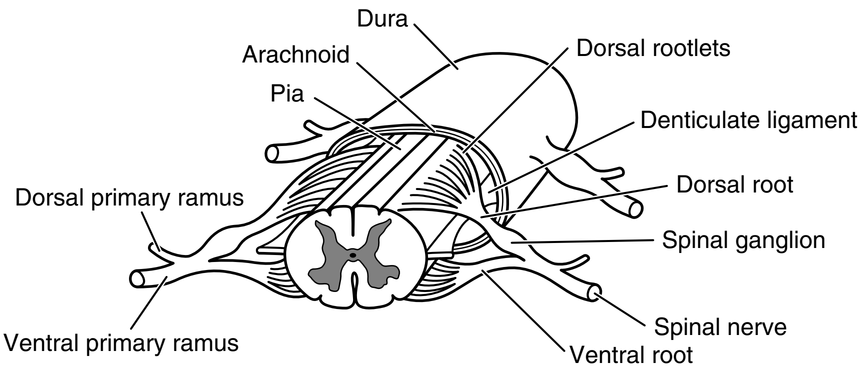



Figure 1–17: Spinal root and nerve anatomy.

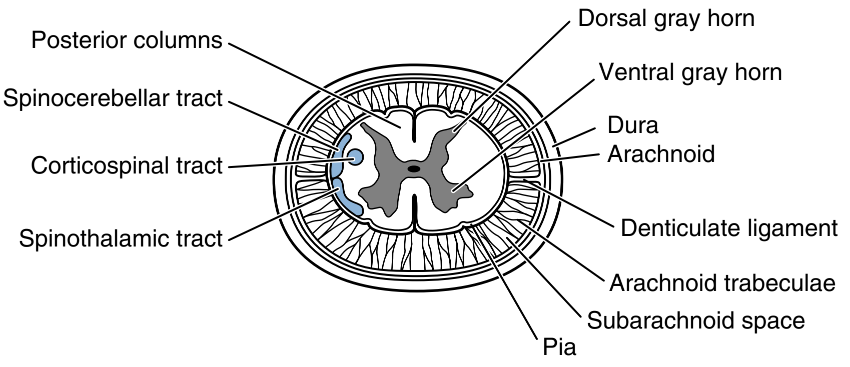



Figure 1–18: Spinal supra-adjacent cord anatomy.

**Table 1–2: Spinal Tracts**

| NAME OF TRACT | INFORMATION TRANSMITTED | DECUSSATION |
|---|---|---|
| Posterior columns | Light touch, vibration, proprioception | Caudal medulla |
| Spinocerebellar | Unconscious proprioception | No decussation |
| Corticospinal | Voluntary movement | Caudal medulla |
| Spinothalamic | Pain, temperature | At level of spinal cord entry |

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CHAPTER 2

# Physical Examination of the Spine

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## Introduction

- The spine is a complex biomechanical structure that does the following:
  - Protects the neural structures
  - Allows an upright posture
  - Aids in respiration and ambulation
- Unfortunately, these requirements place a great strain on the spine and may promote accelerated aging or symptomatic degeneration.

## Anatomy of the Spinal Column

- The vertebral spinal column does the following:
  - Supports the cranium and trunk
  - Allows movement
  - Protects the spinal cord
  - Absorbs stresses produced by walking, running, and lifting
- The vertebral spinal column consists of 33 vertebrae with 23 intervening fibrocartilage intervertebral disks supported by numerous ligaments and paraspinal muscles.
- The spinal column is divided into five regions consisting of the following:
  - 7 cervical vertebrae
  - 12 thoracic vertebrae
  - 5 lumbar vertebrae
  - 5 sacral vertebrae
  - 3 to 4 coccygeal vertebrae
- Spinal ligaments include the following:
  - The anterior longitudinal ligament
  - The posterior longitudinal ligament
  - The ligamentum flavum
  - Interspinous ligaments
  - Numerous smaller ligaments

### Muscles of the Back

#### Superficial Extrinsic Back Muscles

- The following muscles connect the upper limbs to the trunk and control limb movements:
  - Trapezius
  - Latissimus dorsi
  - Levator scapulae
  - Rhomboid major
  - Rhomboid minor

#### Intermediate Extrinsic Back Muscles

- The following superficial respiratory muscles are deep to the rhomboids and latissimus:
  - Serratus posterior superior
  - Serratus posterior inferior

## Superficial Intrinsic Back Muscles (Fig. 2–1)

- Splenius capitis
- Splenius cervicis

## Intermediate Intrinsic Back Muscles—The Erector Spinae (Fig. 2–1)

- The following muscles are massive and strong and function as the chief extensors of the vertebral column:
  - Iliocostalis—Lateral column
  - Longissimus—Intermediate column
  - Spinalis—Medial column

## Deep Intrinsic Back Muscles—The Transversospinal Muscle Group (Fig. 2–1)

- The following muscles are deep to the erector spinae and obliquely disposed:
  - Semispinalis—Superficial layer
  - Multifidus—Intermediate layer
  - Rotators—Deepest layer

## Minor Deep Intrinsic Back Muscles

- Interspinales
- Intertransversarii
- Levatores costarum

## Prevertebral (Deep) Muscles of the Neck (Fig. 2–2)

### Anterior Vertebral Muscles

- The following muscles are deep to the anterior cervical triangle and are anterior flexors of the head and neck:
  - Longus colli
  - Longus capitis
  - Rectus capitis anterior
  - Rectus capitis lateralis

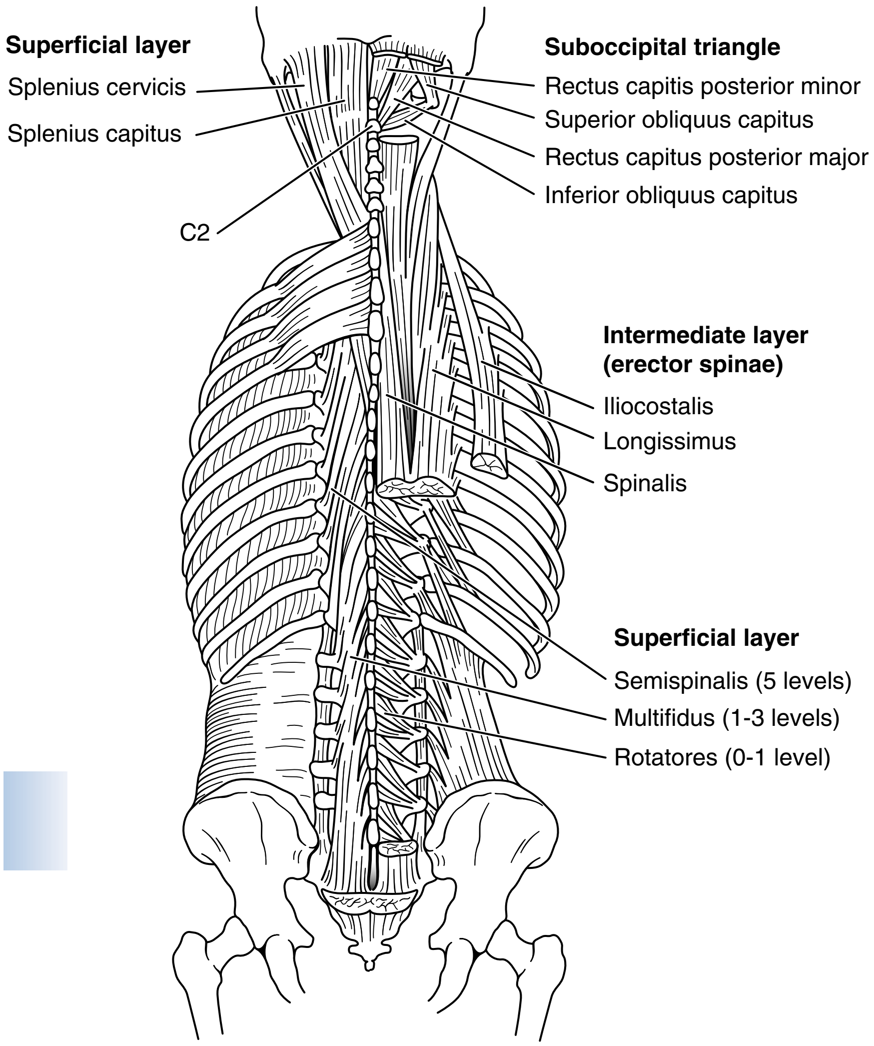



Figure 2–1: Superficial, intermediate, and deep back musculature.

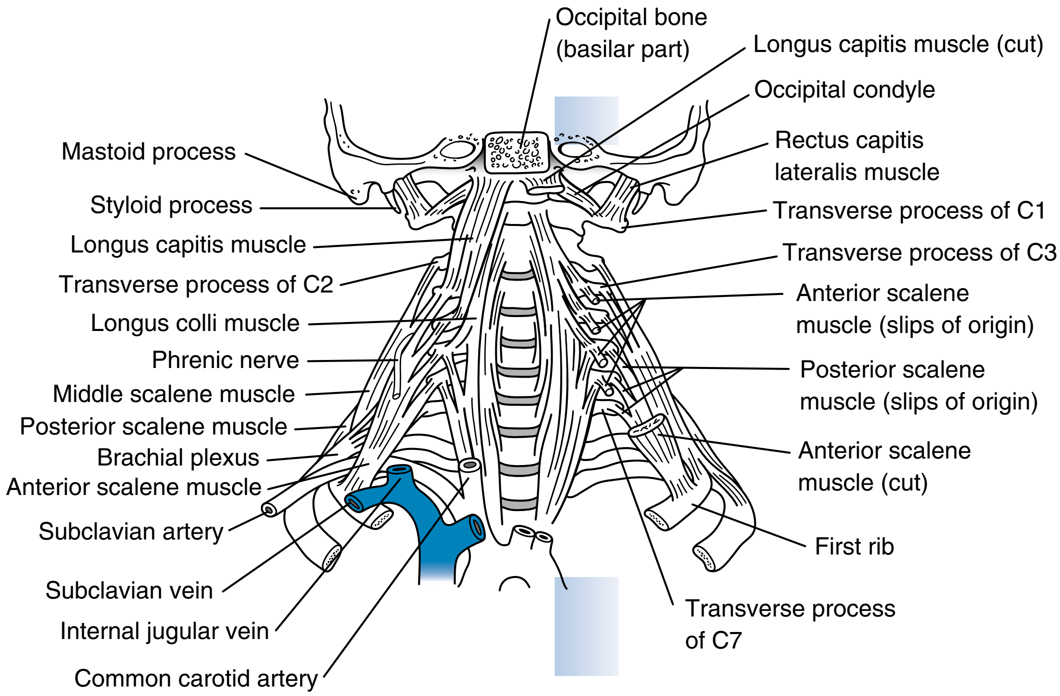



Figure 2–2: Prevertebral musculature of the neck.

### Lateral Vertebral Group

- The muscles of this group are deep to the posterior cervical triangle and are rotators and lateral flexors of the neck:
  - Splenius capitis
  - Posterior scalene
  - Middle scalene
  - Anterior scalene

## Coronal and Sagittal Spinal Alignment

- The vertebral column has four major curves (Fig. 2–3):
  - Cervical
  - Thoracic
  - Lumbar
  - Sacrococcygeal or pelvic
- The thoracic and sacrococcygeal curves are referred to as primary curves because they retain the kyphotic curvature from embryogenesis, as seen in the fetus.
- The cervical and lumbar spines are secondary curves. They develop or adapt a lordotic structure as a result of postural changes to accommodate sitting and ambulation.
- There is a large degree of variability in what is considered the "normal" sagittal curvature of the cervical, thoracic, and lumbar spine. (Table 2–1)

**Table 2–1: Curvature of the Spine**

| CURVATURE | NORMAL CURVATURE |
|---|---|
| Cervical lordosis | 20 to 40 degrees |
| Thoracic kyphosis | 20 to 45 degrees |
| Lumbar lordosis | 40 to 60 degrees |
| Sacral kyphosis | Sacrum fused in a kyphotic curve |

- Overall, the spine should support the head over the pelvis, a state referred to as being in coronal and sagittal balance or alignment.
- The length of the cervical spinal canal measured in the sagittal plane during flexion (kyphotic posture) is greater than the length during extension (lordotic posture).
- The normal cervical lordosis allows the neural elements to traverse the spinal canal through a shorter course without ventral compression.
- The lordotic cervical curvature might also protect against neural injury because axial loads are dispersed dorsally onto the facet joints and large articular pillars rather than onto the vertebral body.
- The flexibility of the cervical spine allows it to compensate for misalignment of the thoracic and lumbar spine.
- An increased lordotic cervical posture is observed in the setting of exaggerated thoracic kyphosis.

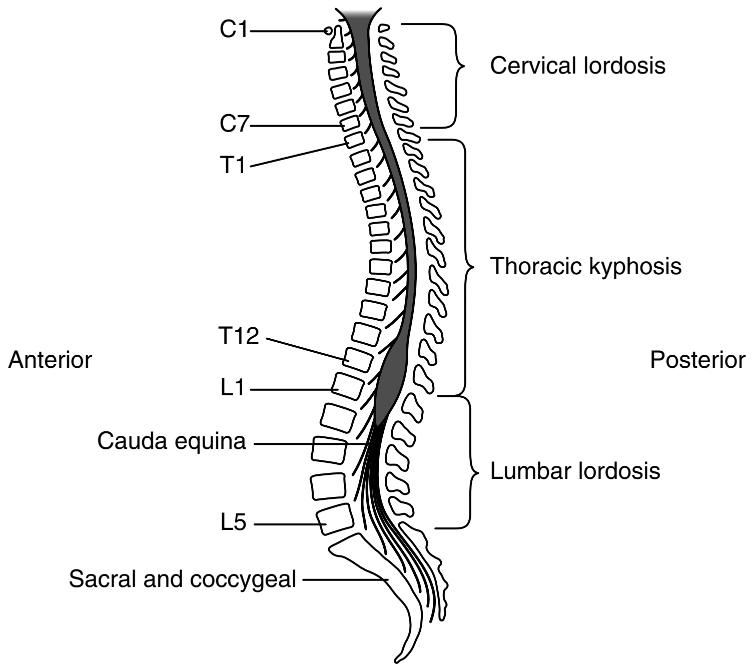



Figure 2–3: Spinal cord (lateral view).

- A plumb line dropped from C7 should fall and cross the posterior vertebra line or body walls at the L5-S1 interspace.
- Variability in sagittal alignment is influenced by age and gender; females have a greater degree of thoracic kyphosis than males, and older people have a greater degree of thoracic kyphosis than younger people.
- There is also a significant degree of variability in spinal alignment on a segmental basis, particularly at the transitional regions of the lordotic cervical and lumbar spine.
- Normal thoracic kyphosis has been reported to be between 20 and 45 degrees.

## Spinal Curvatures

### Flattening of the Lumbar Curve (Fig. 2–4)

- The most common cause of loss of lumbar lordosis is degenerative disk disease.
- Secondary causes include lumbar compression fractures or iatrogenic flatback posture from distraction instrumentation placed in the posterior lumbar spine.
- Younger patients may assume a flattened lumbar posture in the setting of an acute muscle spasm or a symptomatic acute herniated disk.

### Exaggerated Lumbar Lordosis

- An exaggeration of the normal lumbar lordotic curve can develop to compensate for the protuberant abdomen of pregnancy or marked obesity.
- It may also develop as a compensation for exaggerated thoracic kyphosis or contractures of the hips.
- Superficially, a deep midline furrow may be seen between the lumbar paravertebral muscles on a posterior examination of a patient with increased lumbar lordosis.

### Thoracic Kyphosis (Fig. 2–5)

- An increase in thoracic kyphosis is seen with aging and in the setting of multiple thoracic vertebral compression fractures.
- In adolescent patients, thoracic kyphosis may be secondary to Scheuermann's disease.

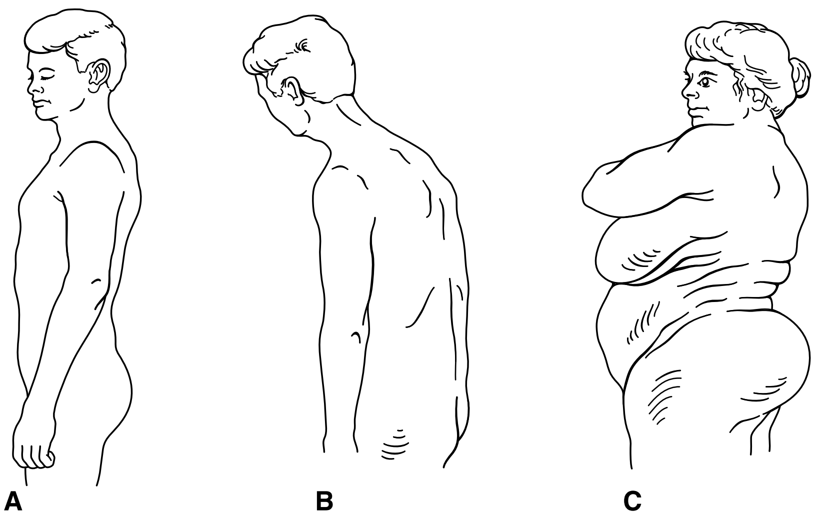


Figure 2–4: Spinal curvatures. Normal spinal curvature (A), flattening of the lumbar curve (B), and lumbar lordosis (C).

## Gibbus (Fig. 2–5)

- A gibbus is a prominent thoracic bony ridge caused by a severe kyphotic angle.
- It most often occurs as a result of an angular deformity caused by a collapsed vertebra.

## Scoliosis

- Scoliosis is a lateral curvature of the spine (Fig. 2–6).
- The body normally attempts to compensate for coronal plane curves by developing secondary coronal curves. A plumb line dropped from C7 or T1 should pass through the gluteal cleft.
- Scoliosis may be structural or functional.

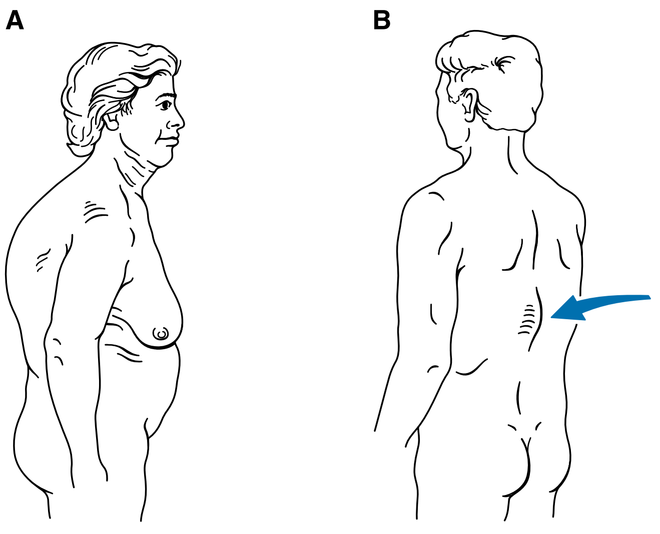


Figure 2–5: Thoracic kyphosis (A) and gibbus deformity (B).

## Structural Scoliosis

- Structural scoliosis typically is associated with a rotation of the vertebrae upon each other, and the rib cage is accordingly deformed.
- This deformity is best seen when the patient flexes forward.
- On the side of the thoracic convexity, the ribs bulge posteriorly and are widely separated.
- On the opposite side (concavity), they are displaced anteriorly and are close together.

## Functional Scoliosis

- Functional scoliosis compensates for other abnormalities such as unequal leg lengths.
- It involves neither fixed vertebral rotation nor fixed thoracic deformity.
- The scoliosis resolves with correction of the primary process.

## List (Fig. 2–6)

- List is a lateral tilt of the spine.
- A plumb line dropped from the spinous process of T1 falls to one side of the gluteal cleft.
- Causes include a symptomatic herniated disk and painful spasms of the paravertebral muscles.

# Surface Landmarks

- Surface landmarks help orient the examiner to certain vertebral levels.
- The spinous processes of C7 and T1 are typically large and prominent, making them readily palpable at the base of the neck.
- The interspace between T7 and T8 is typically at the level of the inferior angle of the scapula.

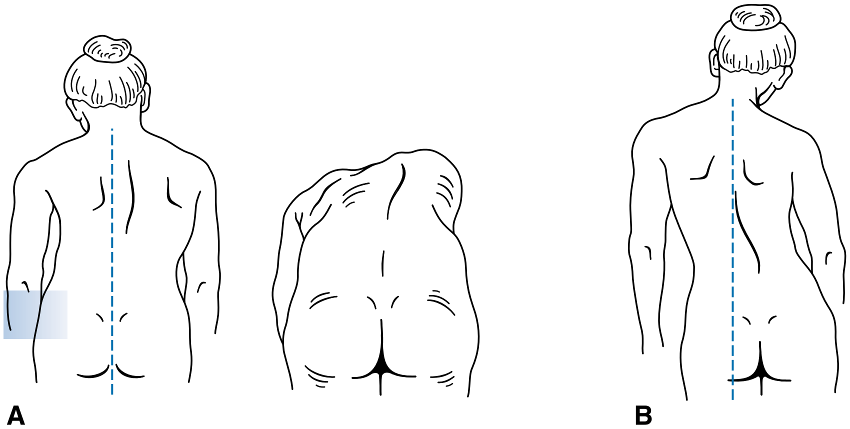



Figure 2–6: Scoliosis (A) and list (B).

- An imaginary line connecting the highest point on each iliac crest crosses the L4 body.
- An imaginary line connecting the two dimples found over the posterior superior iliac spine indicates the level of S1.

## Techniques of Examination—Inspection

- Examination of the spine begins with inspecting and observing the patient's static and dynamic posture and gait when they enter the room.
  - Drape or gown patients to expose the entire neck and back for complete inspection.
  - Patients should be observed in their natural standing position with the feet together and the arms hanging at the sides. The head should be midline in the same plane as the sacrum, and the shoulders and pelvis should be level.
  - Neck stiffness, the splinting of an extremity, or an uncomfortable writhing in the sitting position all may reveal underlying spinal pathology.
- Examination of the skin should be performed to observe any pigmented or raised lesions. The presence of cafe-au-lait spots or neurofibromas may suggest a neurocutaneous syndrome such as neurofibromatosis.
- The posterior midline should be examined to evaluate cutaneous midline rosy spots, tufts of hair, or dimples. These observations may indicate a failure of midline skeletal fusion during embryogenesis and possibly may suggest an occult spinal dysraphism.
- Gait is a complex process relying on the input and output of information from all aspects of the neuraxis; it is also dependent on the structural properties of the spinal column.
  - Examination of gait involves observation of cadence, ease of movement, arm swing, and overall steadiness.
  - Patients are asked to walk at their usual pace across the room or down the hall, turn, and return to the starting position.
  - The examiner should observe posture, balance, swinging of the arms, and movements of the legs.

1. Balance should be easily maintained.
2. The arms should freely swing at the patient's sides.
3. Turns should be accomplished smoothly and without difficulty.

  - A gait that lacks coordination, with reeling and instability, is referred to as ataxic and may be caused by cerebellar disease or loss of proprioception.
  - Patients are asked to walk heel-to-toe in a straight line (also called tandem walking).

### Range of Motion of the Spine (Figs. 2–7 and 2–8)

- Range of motion consists of the following:
  - Flexion
  - Extension
  - Lateral bending to the right and left
  - Rotation to the right and left
- Approximately 50% of cervical flexion and extension occurs between the occiput and C1, and 50% of rotation occurs between C1 and C2.

### Atrophy

- Atrophy is the loss of the muscle bulk or mass and definition.
- It has multiple etiologies.
- It is most commonly caused by a loss of anterior horn cells from neural compression.
- Myopathies are typically present with proximal muscle wasting.
- Fasciculations are spontaneous discharges of individual muscles fibers and are seen as twitches under the skin.

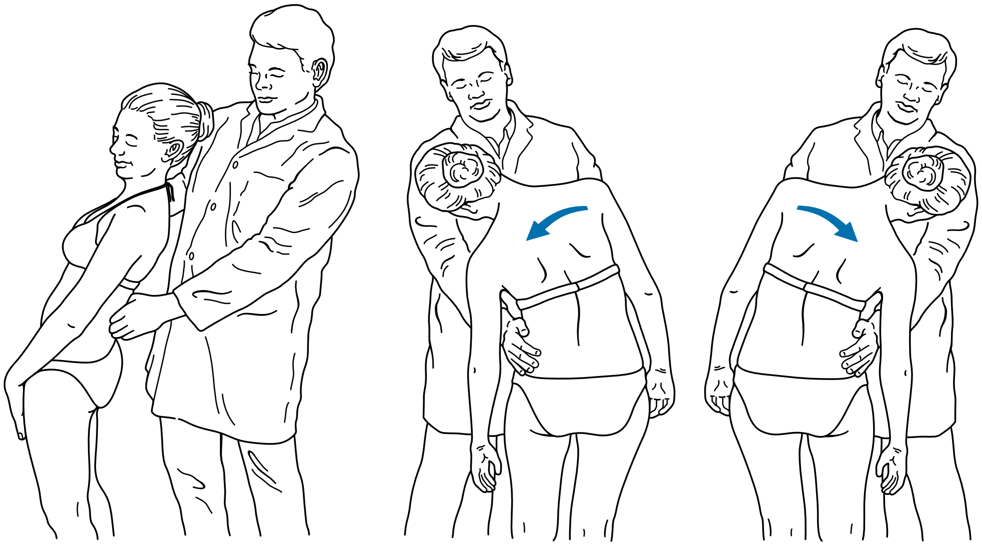


Figure 2–7: Range of motion of the spine. Extension and lateral bending.

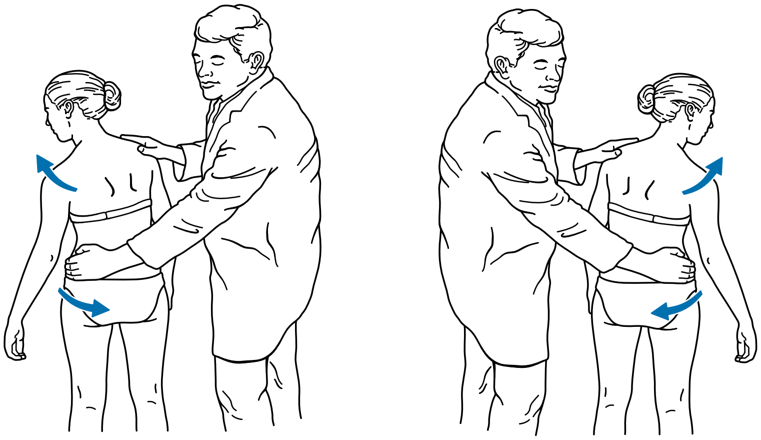
## Techniques of Examination—Palpation

- Palpation of each spinal vertebra and muscle follows inspection.
- Tenderness may suggest a bruise, a fracture, or a dislocation if preceded by trauma; the presence of an underlying infection; or arthritis.
- In the cervical spine, palpation may elicit discomfort from the posterior facet joints, located about one inch lateral to the spinous processes of C2-C7. These joints lie deep to the trapezius muscle and may not be palpable unless the neck muscles are relaxed.
- In the lumbar spine, the examiner may palpate for any vertebral "step-offs" to determine the presence of vertebral translocation or spondylolisthesis. Working caudally, palpation over the sacroiliac joint—often identified by the dimple overlying the posterior superior iliac spine—may reveal tenderness resulting from sacroiliac joint pathology, a common cause of low back pain.
- Palpation of the paravertebral musculature is essential. Muscles in spasm may feel firm and knotted. Spasms may be the result of bony, ligamentous, or muscle sprain or injury and are not necessarily helpful in the localization of a causative process.

## Motor Examination

- The motor examination begins proximally and proceeds distally.

Figure 2–8: Rotation.



## Motor Examination of the Upper Extremities (Fig. 2–9)

- The deltoid muscles should be examined with the arms held at a 90-degree angle to the torso.
- The biceps muscles are tested by flexion at the elbows with the hands fully supinated.
- The wrist extensors are tested by applying tension to the wrist while the patient attempts to extend the wrist.
- The triceps muscles are tested with the arms held against the body with the elbows flexed. The patient then attempts to extend at the elbows against resistance.
- The intrinsic hand muscles are tested with finger flexion or by spreading of the fingers.

## Motor Examination of the Lower Extremities (Fig. 2–10)

- The iliopsoas muscle is tested by applying downward force against hip flexion.
- The quadriceps muscles are tested by applying force against knee extension.
- The anterior tibialis muscles are tested by applying force against active ankle dorsiflexion.
- The extensor hallucis longus muscles are tested by applying force against active toe dorsiflexion.
- The gastrocnemii muscles are tested by applying force against active ankle plantar flexion.

## Muscle Tests

- The motor examination is designed to detect muscle weakness in a pattern that localizes the level of pathology or dysfunction (central nervous system, spinal cord, peripheral nerve, or muscle) and provides a reproducible means of assessing strength (Tables 2–2 and 2–3).
  - The tone of the muscle is defined as the degree of tension of the muscle at rest.
  - Spasticity is increased muscle tone or a resistance to motion.
  - Muscles should be noted for stiffness, elasticity, rigidity, cogwheeling, and the presence of postural tremor.

# Sensory Examination

- The sensory examination is the most subjective portion of the neurologic or spinal evaluation (Table 2–4). There are four distinct sensations with defined anatomic pathways in the spinal cord.
  - Pain perception may be tested with the sharp portion of a safety pin.
  - Light touch may be tested with a cotton swab.
  - Temperature may be tested with two test tubes containing either a hot or a cold solution.
  - Proprioception examination begins distally at the distal phalanx or great toe and proceeds proximally to each larger joint. Testing is specifically conducted to assess

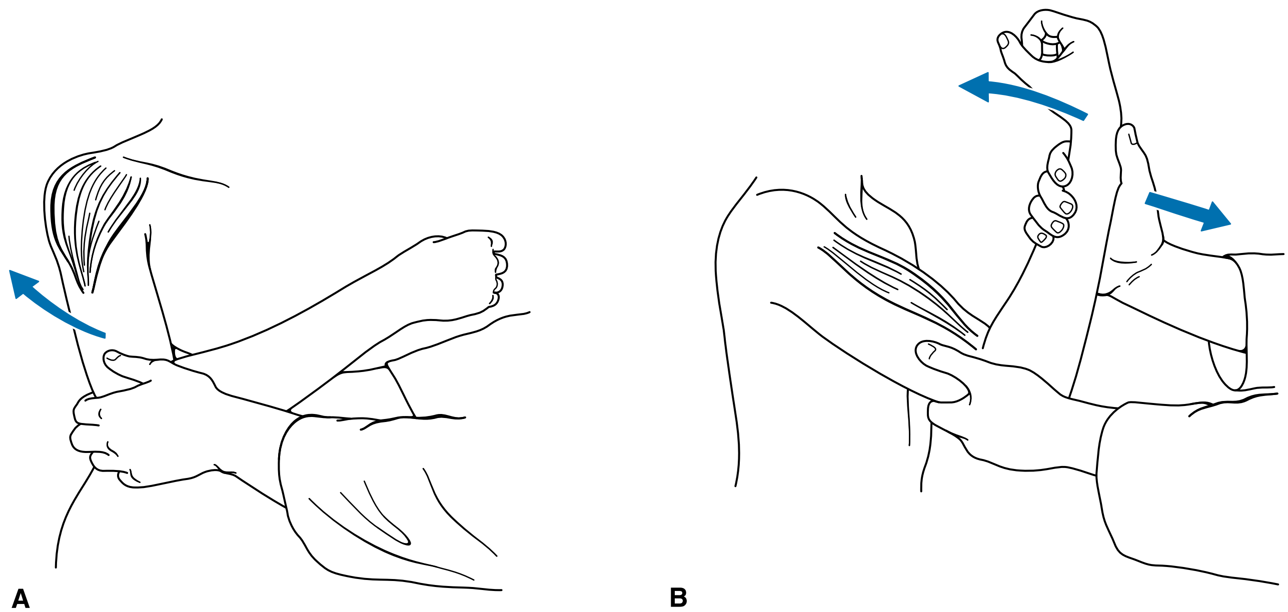



Figure 2–9: Muscle tests of the upper extremities. A, Shoulder abduction, deltoid—C5. B, Biceps—C5, C6.

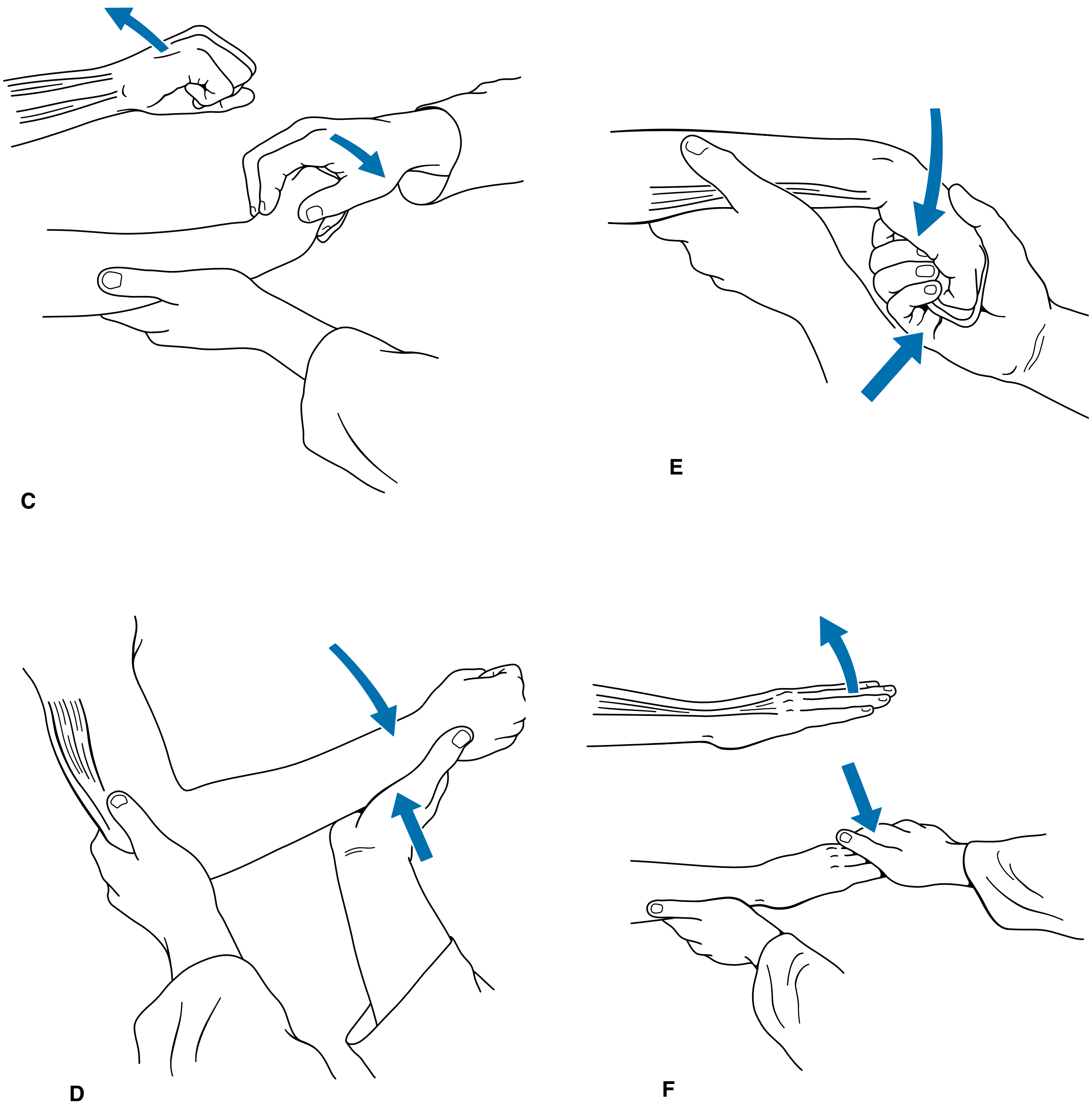



Figure 2–9: Cont'd C, Wrist extension—C6. D, Triceps—C7. E, Wrist flexion—C7, C8. F, Finger extension—C7.

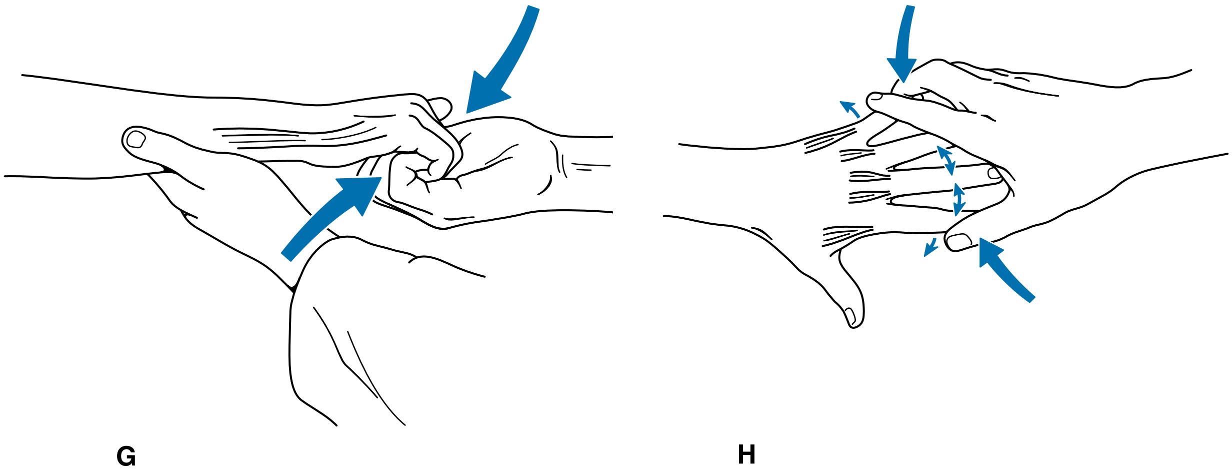



Figure 2–9: Cont'd G, Finger flexion—C8. H, Finger abduction—adduction, T1.

whether the patient can reliably detect excursion of the joint and position sense.

- The aim of sensory testing is to identify whether there is a dermatomal pattern of sensory dysfunction, which would suggest spinal root pathology; a peripheral nerve disorder; or possibly a glove or stocking distribution deficit, which would suggest a neuropathy.

## Localizing Dermatomes (Fig. 2–11)

C6—Thumb
C7—Middle digit
C8—Fifth digit
T4—Nipple
T10—Umbilicus
L1—Inguinal ligament

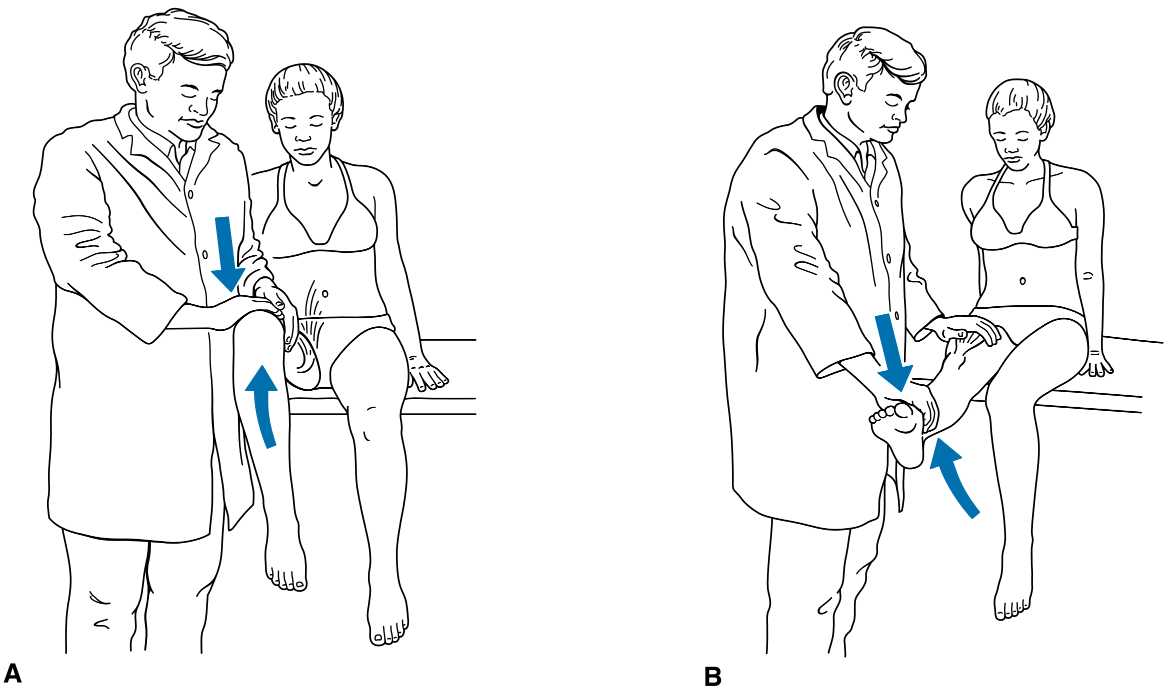



Figure 2–10: Muscle tests of the lower extremities. A, Iliopsoas—L2, L3. B, Quadriceps—L3, L4.

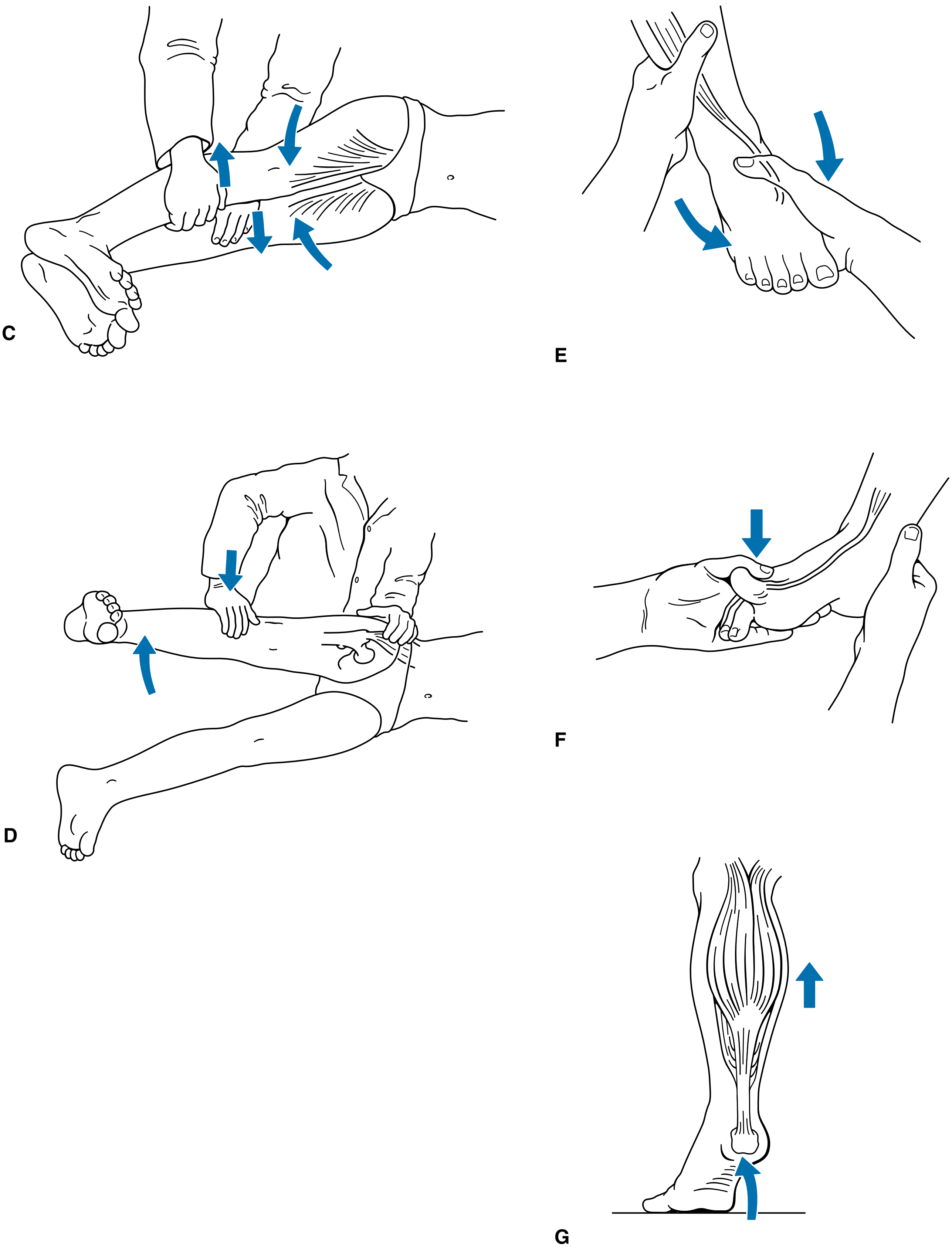



Figure 2–10: Cont'd C, Hip adductors—L2, L3. D, Hip abductors—L4, L5, S1. E, Tibialis anterior—L4. F, Extensor hallucis longus—L5. G, Gastrocnemius or soleus—L5, S1.

**Table 2–2: Motor Function Grading**

| MOTOR FUNCTION | DESCRIPTION | GRADE |
|---|---|---|
| Absent | Total paralysis | 0 |
| Trace | Palpable or visible contraction | 1 |
| Poor | Active movement through the range of motion with gravity eliminated | 2 |
| Fair | Active movement through the range of motion against gravity | 3 |
| Good | Active movement through the range of motion against resistance | 4 |
| Normal | Normal strength | 5 |

**Table 2–3: Spinal Nerve Innervation**

| SPINAL SEGMENT | MUSCLE | FUNCTION |
|---|---|---|
| C3-C5 | Diaphragm | Inspiration |
| C5, C6 | Biceps brachii brachialis | Elbow flexors |
| C6, C7 | Extensor carpi radialis longus and brevis | Wrist extensors |
| C7, C8 | Triceps brachii | Elbow extensors |
| C8, T1 | Interossei thenar group | Hand intrinsics |
| L2, L3 | Iliopsoas | Hip flexion |
| L2, L3 | Adductor longus and brevis | Hip adductors |
| L3, L4 | Quadriceps | Knee extensors |
| L4, L5 | Tibialis anterior | Ankle dorsiflexors |
| L4-S1 | Gluteus medius | Hip abductors |
| L5-S1 | Extensor hallucis longus | Great toe extensor |
| S1, S2 | Gastrocnemius soleus | Ankle plantarflexors |
| S2-S4 | Sphincter ani externus | Anal sphincter |

**Table 2–4: Spinal Nerve Innervation**

| ROOT | MUSCLES | REFLEX | SENSATION |
|---|---|---|---|
| C5 | Deltoid, biceps | Biceps | Lateral arm<br>*Axillary nerve* |
| C6 | Biceps, wrist extensors | Brachioradialis | Lateral forearm<br>*Musculocutaneous nerve* |
| C7 | Triceps, wrist extensors, finger extensors | Triceps | Middle finger<br>*Median nerve* |
| C8 | Hand intrinsics, finger flexors | | Medial forearm<br>*Median antebrachial cutaneous nerve* |
| T1, T2 | Hand intrinsics | | Medial arm<br>*Median brachial cutaneous nerve* |
| T2-T12 | Intercostals, rectus abdominus | Beevor's sign—Abnormal | T2—Clavicle, axilla<br>T3—Axilla<br>T4-T6—Nipple line to inferior xiphoid process<br>T7-T9—Xiphoid process to inferior umbilicus<br>*Ventral and lateral cutaneous branches of intercostal nerves*<br>*Upper lateral cutaneous nerve of arms*<br>T10, T11—Umbilicus<br>T12—Groin<br>*Lateral cutaneous branches of subcostal and iliohypogastric nerves*<br>*Femoral branch of the genitofemoral nerve*<br>*Ilioinguinal nerve* |
| T12, L1-L3 | Iliopsoas (hip flexion) | Patellar tendon reflex (supplied by L2-L4) | T12—Groin<br>L1-L3—Anterior thigh between the inguinal ligament and the knee<br>*Ilioinguinal nerve*<br>*Lateral, anterior, medial femoral cutaneous nerves of the thigh*<br>*Obturator nerve* |
| L4 | Tibialis anterior | Patellar tendon | Medial leg<br>*Saphenous nerve* |
| L5 | Extensor hallucis longus | | Lateral leg and dorsum of the foot<br>*Lateral cutaneous nerve of the calf*<br>*Medial plantar nerve* |
| S1 | Peroneus longus and brevis | Achilles tendon | Lateral foot<br>*Lateral plantar nerve* |

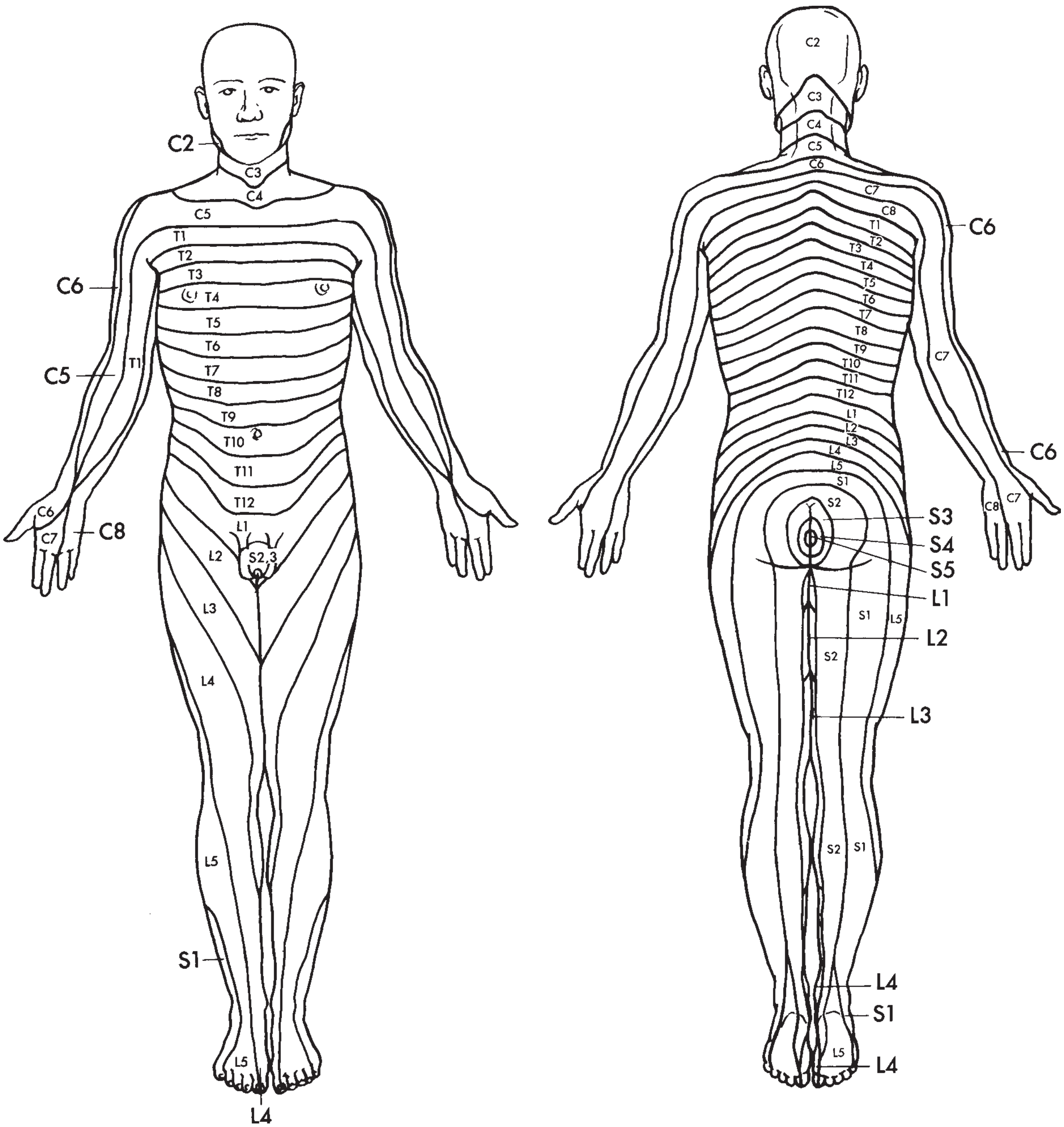



**Figure 2–11: Sensory examination points.** (Leventhal 2003.)

## Reflexes

- Reflex testing is an essential part of the examination and provides a means of differentiating between spinal cord and peripheral pathology.
- A simple monosynaptic reflex consists of an afferent input that synapses in the spinal cord and returns to the extremity through an efferent output (Fig. 2–12). Upper motor neurons inhibit the output of the efferent signal; therefore, if reflexes are increased, the examiner should suspect a decrease in upper motor influence.
- Decreased reflexes may imply the loss either of sensory input or of motor neuron or muscle integration.
- Reflexes are graded from 0 to 4. Hyperactive reflexes are graded 3 or 4 and suggest the presence of spinal cord pathology or upper motor nerve dysfunction.
  - Reflex grading is as follows:

  0—Absence
  1—Diminished
  2—Normal reflex
  3—Hyperactive reflex
  4—Clonus present
- Distracting patients may help elicit reflexes through techniques such as the Jendrassik maneuver (having patients pull their hands apart while the stimulus is being applied).

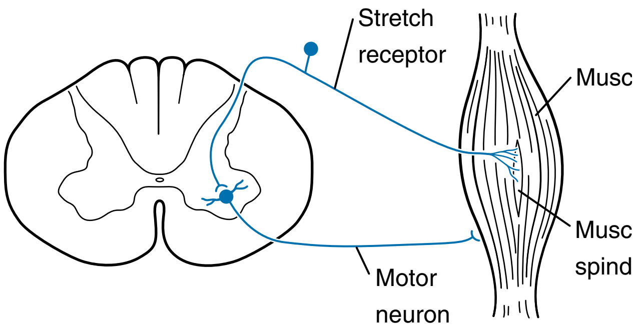



Figure 2–12: A simple monosynaptic reflex.

- The examination of the upper extremity deep tendon reflexes includes tests of the biceps tendon, the brachioradialis, and the triceps tendon reflexes. Reflexes in the lower extremities include the quadriceps reflex (knee jerk) and the gastrocnemius reflex (ankle jerk). In addition, reflexes of the hamstring muscles (biceps femoris) can be tested.

## Upper Extremity

- Triceps reflex—Forearm extension
- Biceps reflex—Elbow flexion
- Brachioradialis reflex
  - Tap distal radius → Lateral wrist flexion and partial supination of the forearm

## Lower Extremity

- Patellar reflex—Contraction of quadriceps (strongest muscles in body) and extension of the leg
- Suprapatellar reflex—Above the knee; same response
- Achilles reflex—Causes plantar-flexion of foot

## Upper Extremity Long Tract Reflexes

- Hoffman's reflex—Triggered by taking the middle finger, flicking the distal phalanx from the palm, and observing a pincer movement between the thumb and the index finger (Fig. 2–13).
- Trömner sign—Elicited by elevating the middle finger from the rest of the hand and flicking the distal phalanx toward the palm, again looking for the pincher movement between the thumb and the index finger.
- These two reflexes may not necessarily be signs of pathology; rather, they may be indications of brisk muscle stretch reflexes. Asymmetry may be significant and may herald the presence of a central nervous dysfunction or a significant cervical cord compression, especially in an elderly patient.

# Nerve Root Tension Signs

- Spurling's sign—This extends the neck with concurrent lateral bending and an axial load on the head. This is a positive sign if the maneuver reproduces the patient's pain in a radicular nature; this is suggestive of a cervical radiculopathy (Fig. 2–14).
- Lasègue's sign (straight leg raise)—Flexing the leg at the hip reproduces the patient's radicular pain in the leg and not the back. Pain should be reproduced with less than 60 degrees of flexion to be positive. This is highly suggestive of nerve root irritation, typically by a herniated lumbar disk (Fig. 2–15).
- Bowstring sign—After reproducing the patient's pain and obtaining a positive Lasègue's sign, the knee is flexed. This is positive if the patient's pain resolves with flexion at the knee. If the pain persists, this is suggestive of hip pathology.
- Cram test—The cram test is similar to the Lasègue's sign. The patient is supine; the leg is flexed at the hip and then

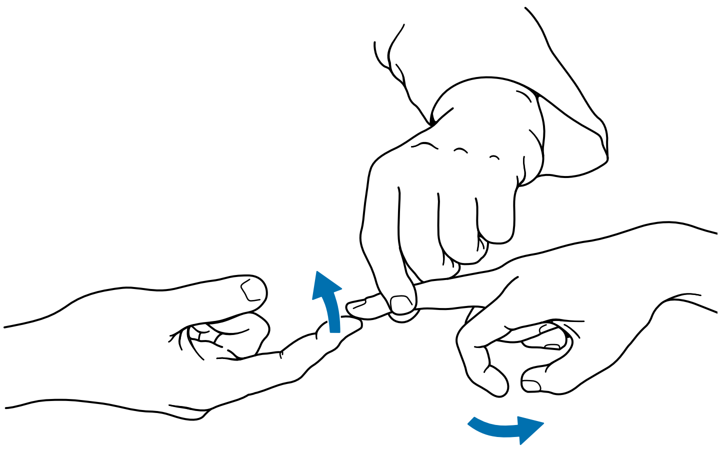


Figure 2–13: Hoffmann's reflex.

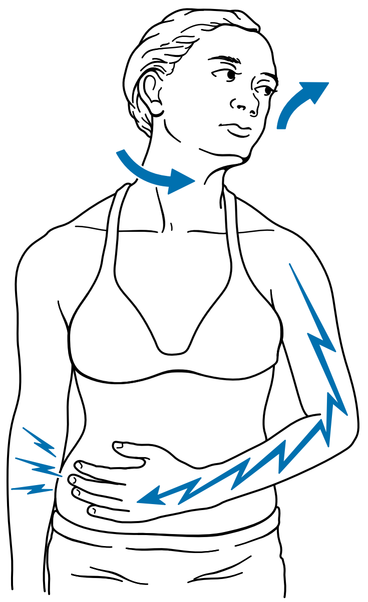


Figure 2–14: Spurling's sign.

extended at the knee. It is positive if it reproduces the patient's pain.

- Frajersztajn's sign (contralateral straight leg raise)—flexing the leg at the hip with an extended knee of the asymptomatic leg reproduces the pain in the contralateral leg (Fig. 2–16).
- Femoral stretch sign—The patient is placed prone and the leg is straightened and extended at the hip. This places tension on the femoral nerve (L2-L4) and may suggest an upper lumbar radiculopathy.

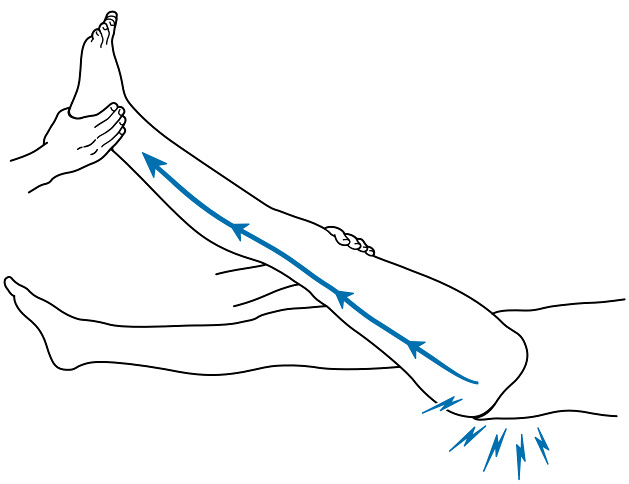
## Pathologic Long Tract Signs

- Babinski's sign (extensor plantar reflex)—This is elicited by applying a gentle stimulus to the lateral aspect of the sole starting over the heel and extending toward the base of the little toe. A positive Babinski's sign refers to the initial dorsiflexion of the great toe upward and the spreading of the other toes; it is indicative of corticospinal tract dysfunction (Fig. 2–17).
- Crossed adductor's sign—This stimulates the patellar reflex and causes the contralateral thigh adductors to contract. This is suggestive of an upper motor lesion.
- Chaddock's sign—This is tested by laterally abducting the little toe briskly and allowing it to slap back against the other toes, looking for dorsiflexion of the great toe, or flicking the third or fourth toe down rapidly, again looking for great toe dorsiflexion.
- Clonus—This is a rhythmic, nonvoluntary movement of muscle with stimulation.
- Lhermitte's sign—Flexion of the neck causes an electric shock-like sensation to shoot down the spine. This originally was described with multiple sclerosis and believed to be the result of posterior column dysfunction. It may be seen in patients with severe cervical cord compression from stenosis or a disk herniation (Fig. 2–18).

## Superficial Reflexes

- The following are cutaneous abdominal reflexes:
  - Superficial abdominal reflex—This reflex is elicited by scratching from the abdominal margins toward the umbilicus and observing a quivering motion of the abdominal muscles.

Figure 2–15: Lasègue's sign.



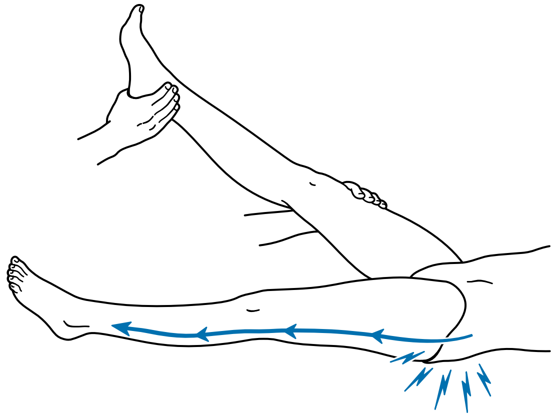


Figure 2–16: Frajersztajn's sign.

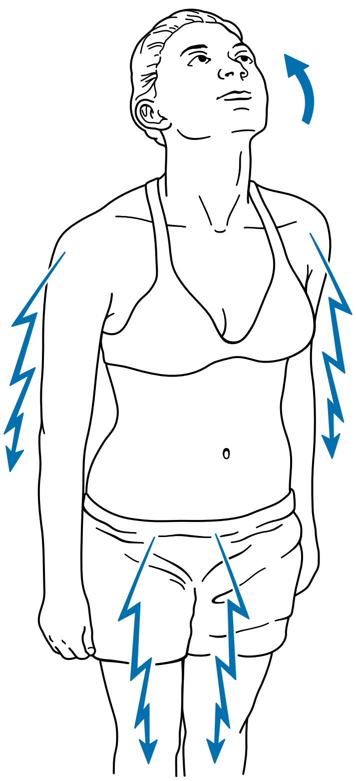


Figure 2–18: Lhermitte's sign.

- Deep abdominal reflex—This is elicited by tapping over the anterior rectus abdominal muscle sheath and observing a contraction of the abdominal muscles.
- Beevor's sign—Patients perform a quarter sit-up with the arms crossed behind the head. The examiner should be watching the navel. Beevor's sign is considered positive if the navel moves up, down, or to either side. A positive Beevor's sign occurs if the lower abdominal musculature (controlled by the spinal cord below T9) is weaker than the upper abdominal musculature (Fig. 2–19).
- Cremasteric reflex (in males)—This is elicited by stroking the thigh (the genitofemoral nerve) and observing the ascent of the ipsilateral testicle (Fig. 2–20).
- Anal wink reflex—Contraction of the external anal sphincter follows application of a sharp stimulus. This test is used to determine the end of spinal shock in the context of spinal cord injury (Fig. 2–21).

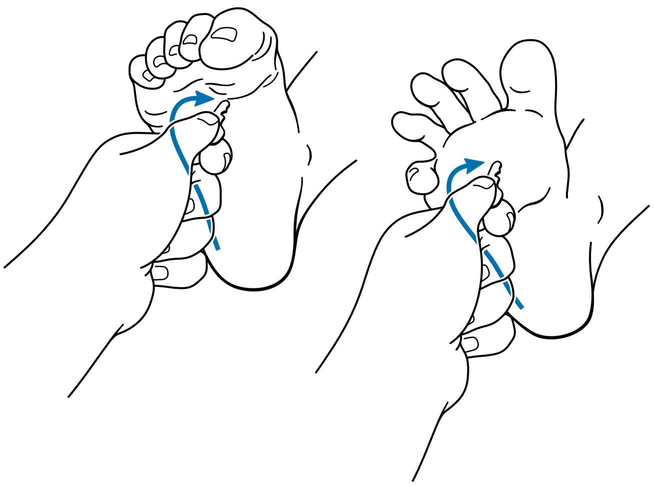


Figure 2–17: Babinski's sign.

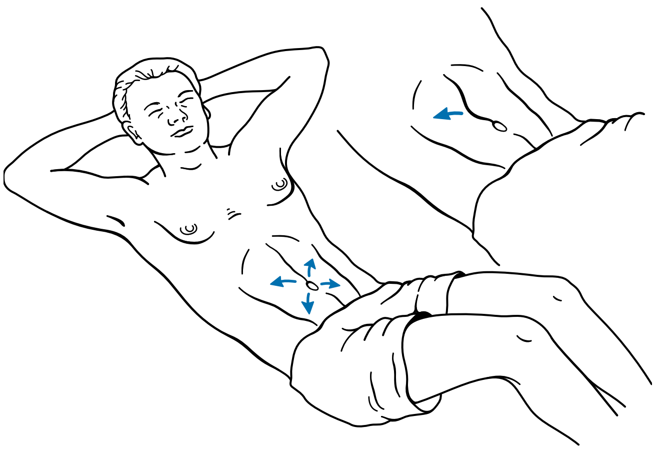


Figure 2–19: Beevor's sign.