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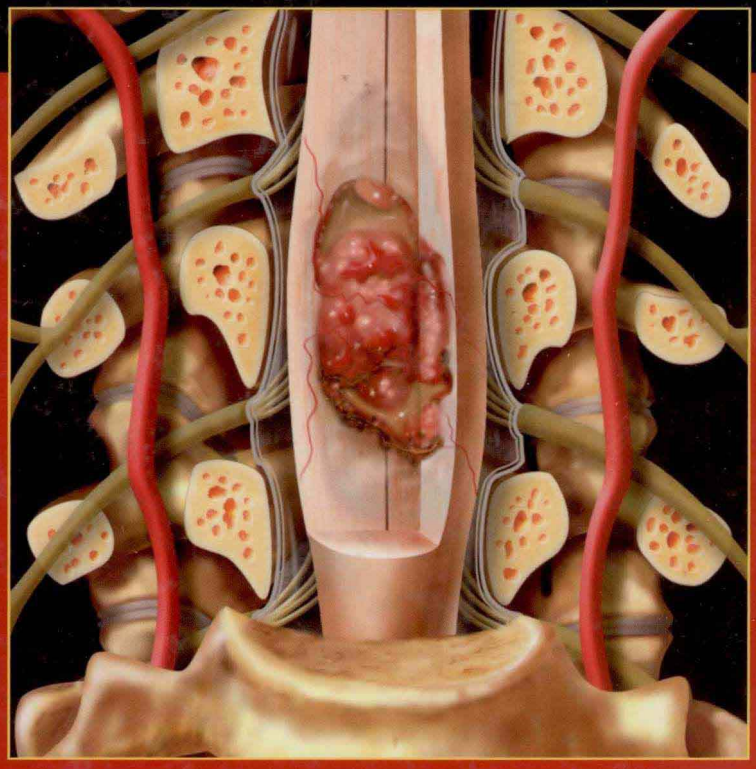

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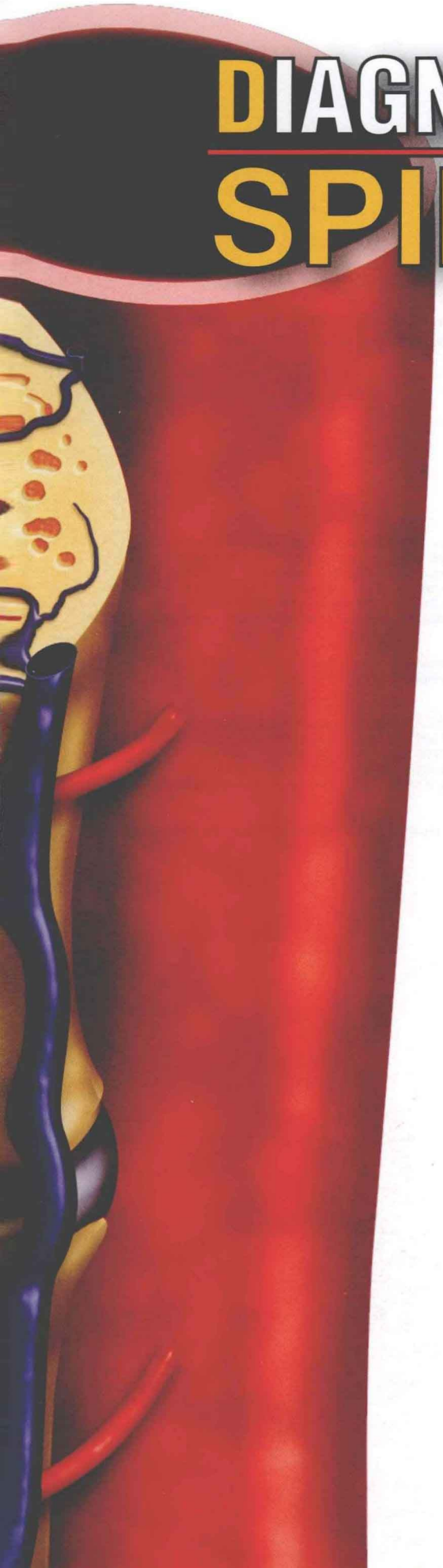

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SPINE
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Jeffrey S. Ross, MD
Neuroradiology
Barrow Neurological Institute
St. Joseph's Hospital
Phoenix, AZ

Kevin R. Moore, MD
Pediatric Neuroradiologist
Primary Children's Medical Center
Adjunct Associate Professor of Radiology
University of Utah School of Medicine
Salt Lake City, UT

Lubdha M. Shah, MD
Assistant Professor of Radiology
Division of Neuroradiology
University of Utah School of Medicine
Salt Lake City, UT

Brandon Borg, MD
Chief of Neuroradiology
David Grant Medical Center
Travis Air Force Base, CA

Julia Crim, MD
Chief of Musculoskeletal Radiology
Professor of Radiology
University of Utah School of Medicine
Salt Lake City, UT

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With love to Peg, Whitney, Tyler, and Jamie – my earthly foundation

Wisdom is supreme; therefore get wisdom.
Though it cost all you have, get understanding.
Proverbs 4:7 (NIV)

JRS

PREFACE

Welcome to the second edition of *Diagnostic Imaging: Spine*. Why a new edition? Six years is an eternity given the rapid pace of change in medicine.

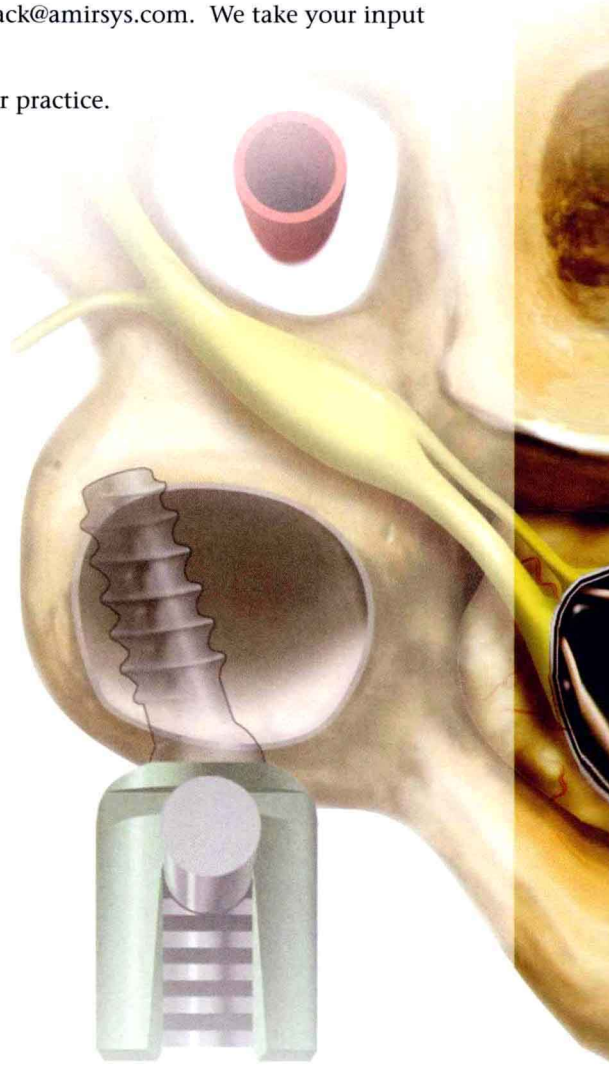
This edition has 40 new diagnoses and almost 4000 images (both in print and eBook). Thousands of images are new for this edition, and many beautiful new illustrations are included to emphasize key aspects of the diagnoses. The format retains the ease of use of the first edition, with individual diagnoses meant to stand by themselves, but with a tight integration within the sections. A key facts box starts each diagnosis, giving prompt access to the basics. The bulk of the text remains in a concise outline format, allowing for a dense amount of information but also the ability to scan rapidly to the area of interest. Prose text is now used for the introductory sections, which cover broad topics ranging from embryology to tumor spread. Also new in this edition are tables, allowing side by side placement of important data and measurements.

I am deeply indebted to my co-authors and the staff at Amirsys for all the hard work that went into this book. I don't have enough adjectives to describe the work ethic of my collaborators, but a few are "brilliant," "diligent," "conscientious," and "thorough."

Suggestions or comments on what you see or read? Email them to feedback@amirsys.com. We take your input very seriously, and you will get a prompt reply.

We hope you find this reference immensely useful on a daily basis in your practice.

Jeffrey S. Ross, MD
Neuroradiology
Barrow Neurological Institute
St. Joseph's Hospital
Phoenix, AZ



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Text Editing
Arthur G. Gelsinger, MA
Katherine Riser, MA
Dave L. Chance, MA
Matthew R. Connelly, MA

Image Editing
Jeffrey J. Marmorstone

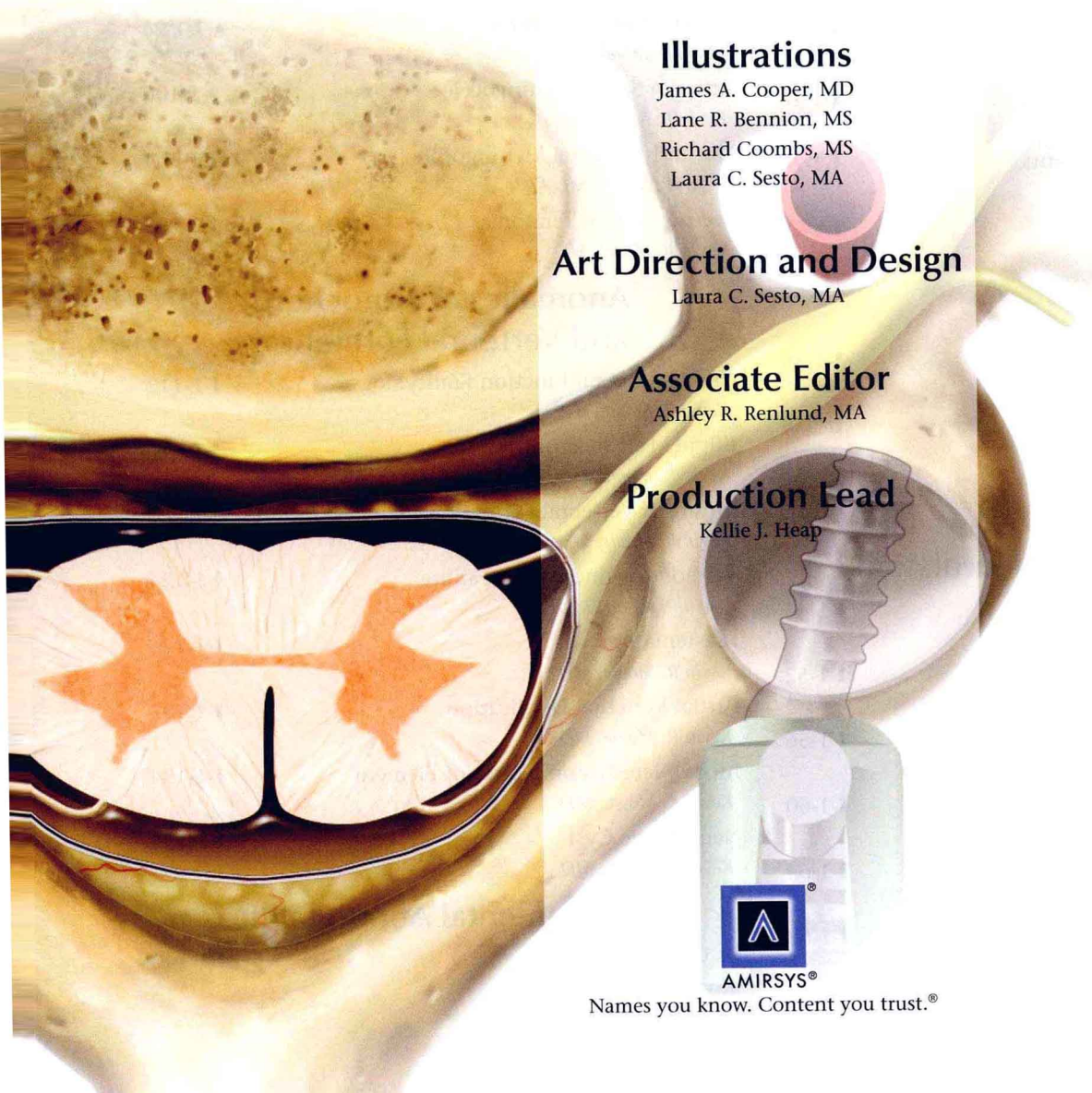
Medical Editing
Lea Alhilali, MD
Saeed Fakhran, MD

Illustrations
James A. Cooper, MD
Lane R. Bennion, MS
Richard Coombs, MS
Laura C. Sesto, MA

Art Direction and Design
Laura C. Sesto, MA

Associate Editor
Ashley R. Renlund, MA

Production Lead
Kellie J. Heap



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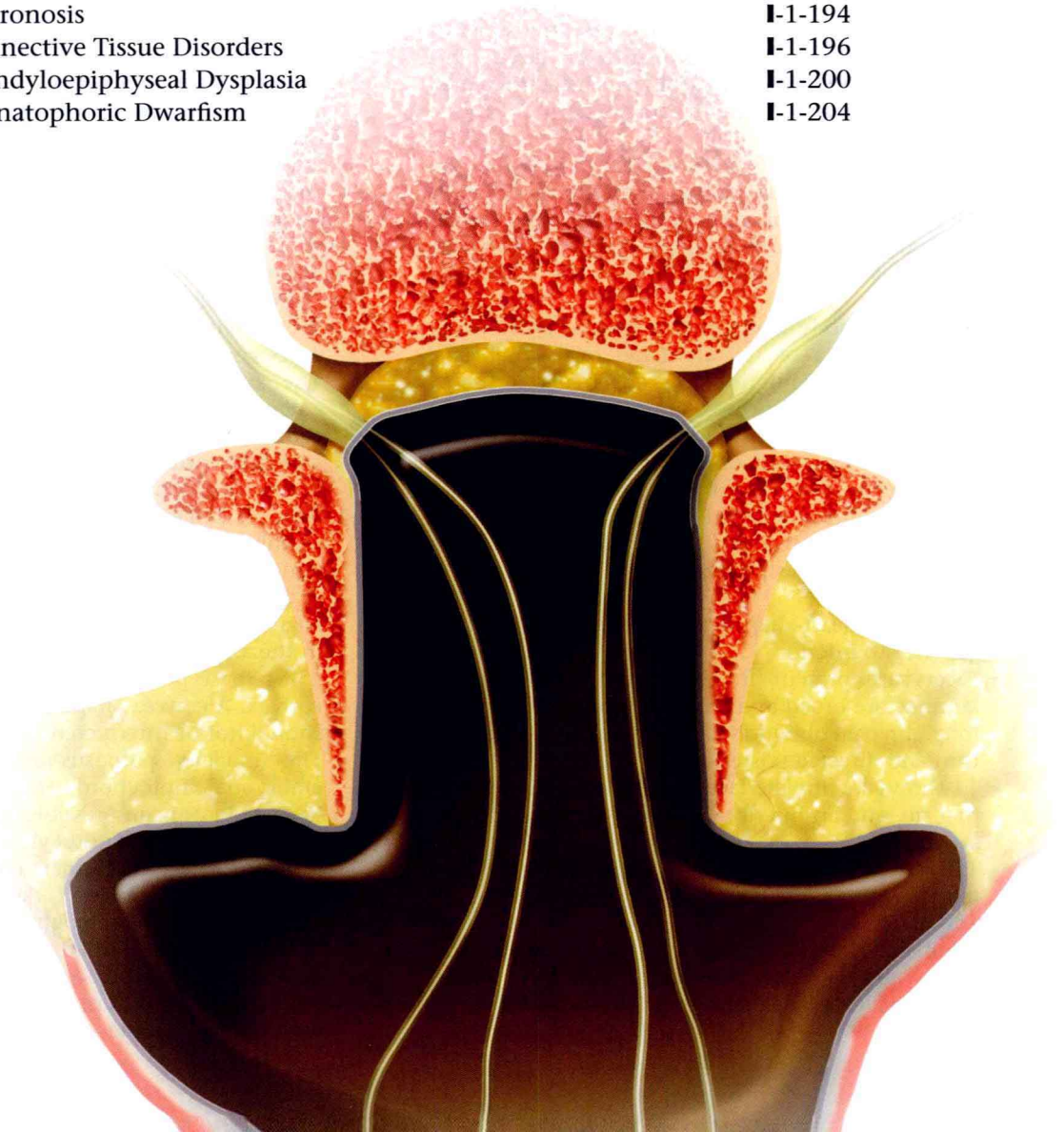

Imaging Anatomy

There are **33** spinal vertebrae, which are comprised of two components: A cylindrical ventral bone mass which is the vertebral **body** and the dorsal **arch**.

7 cervical, 12 thoracic, 5 lumbar bodies

- 5 fused elements form the sacrum
- 4-5 irregular ossicles form the coccyx

Arch

- 2 pedicles, 2 laminae, 7 processes (1 spinous, 4 articular, 2 transverse)
- Pedicles attach to the dorsolateral aspect of the body
- Pedicles unite with a pair of arched flat laminae
- Lamina capped by dorsal projection called the spinous process
- Transverse processes arise from the sides of the arches
- 2 articular processes (zygapophyses) are diarthrodial joints: (1) Superior process bearing a facet with the surface directed dorsally, and (2) an inferior process bearing a facet with the surface directed ventrally

Pars interarticulars is the part of the arch that lies between the superior and inferior articular facets of all subatlantal movable elements. The pars are positioned to receive biomechanical stresses of translational forces displacing superior facets ventrally, while inferior facets remain attached to dorsal arch (spondylolysis). C2 exhibits a unique anterior relation between the superior facet and the posteriorly placed inferior facet. This relationship leads to an elongated C2 pars interarticularis, which is the site of the hangman's fracture.

Cervical

- Cervical bodies are small and thin relative to the size of the arch and foramen, with the transverse > AP diameter. Lateral edges of the superior surface of the body are turned upward into uncinate processes. The transverse foramen perforates the transverse processes
- C1 has no body and forms a circular bony mass. Superior facets of C1 are large ovals that face upwards and the inferior facets are circular in shape. Large transverse processes are present on C1 with fused anterior and posterior tubercles
- C2 complex consists of the axis body with dens/odontoid process. Odontoid embryologically arises from the centrum of the first cervical vertebrae
- C7 shows transitional morphology with a prominent spinous process

Thoracic

- Bodies are heart-shaped and increase in size from superior to inferior
- Facets are present for rib articulation and the laminae are broad and thick. Spinous processes are long, directed obliquely caudally. Superior facets are thin and directed posteriorly
- T1 shows a complete facet for the capitulum of the first rib, and an inferior demifacet for capitulum of second rib
- T12 resembles upper lumbar bodies with the inferior facet directed more laterally

Lumbar

- Lumbar vertebral bodies are large, wide and thick, and lack a transverse foramen or costal articular facets. The pedicles are strong and directed posteriorly. Superior articular processes are directed dorsomedially and almost face each other. The inferior articular processes are directed anteriorly and laterally

Joints

- **Synarthrosis** is an immovable joint of cartilage, and occurs during development and in the first decade of life. The neurocentral joint occurs at the union point of two centers of ossification for two halves of the vertebral arch and centrum
- **Diarthrosis** is a true synovial joint that occurs in the articular processes, costovertebral joints, and atlantoaxial and sacroiliac articulations. The pivot type joint occurs at the median atlantoaxial articulation. All others are gliding joints
- **Amphiarthroses** are nonsynovial, movable connective tissue joints. **Symphysis** is a fibrocartilage fusion between two bones, as in the intervertebral disc. **Syndesmosis** is a ligamentous connection common in the spine, such as the paired ligamenta flava, intertransverse ligaments, and interspinous ligaments. An unpaired syndesmosis is present in the supraspinous ligament
- Atlantooccipital articulation is composed of a diarthrosis between the lateral mass of atlas and occipital condyles and the syndesmoses of the atlantooccipital membranes. Anterior AO membrane is the extension of the ALL. Posterior AO membrane is homologous to the ligamenta flava
- Atlantoaxial articulation is a pivot joint. The transverse ligament maintains the relationship of the odontoid to the anterior arch of atlas. Synovial cavities are present between the transverse ligament/odontoid and the atlas/odontoid junctions

Disc

- The intervertebral disc is composed of three parts: The cartilaginous endplate, the annulus fibrosis, and the nucleus pulposus. The height of the lumbar disc space generally increases as one progresses caudally. The annulus consists of concentrically oriented collagenous fibers which serve to contain the central nucleus pulposus. These fibers insert into the vertebral cortex via Sharpey fibers and also attach to the anterior and posterior longitudinal ligaments. Type I collagen predominates at periphery of annulus while type II predominates in the inner annulus. The normal contour of the posterior aspect of the annulus is dependent upon the contour of its adjacent endplate. Typically this is slightly concave in the axial plane, although commonly at L4-5 and L5-S1 these posterior margins will be flat or even convex. A convex shape on the axial images alone should not be interpreted as degenerative bulging.
- The nucleus pulposus is a remnant of the embryonal notochord and consists of a well-hydrated noncompressible proteoglycan matrix with scattered chondrocytes. Proteoglycans form a major macromolecular component, including chondroitin 6-sulfate, keratan sulfate, and hyaluronic acid. Proteoglycans consist of protein core with multiple attached glycosaminoglycan chains. The nucleus occupies an eccentric position within the confines of annulus and is more dorsal with respect to the center of the vertebral body.

At birth, approximately 85-90% of the nucleus is water. This water content gradually decreases with advancing age. Within the nucleus pulposus on T2-weighted sagittal images, there is often a linear hypointensity coursing in an anteroposterior direction, the intranuclear cleft. This region of more prominent fibrous tissue should not be interpreted as intradiscal air or calcification

Anterior longitudinal ligament (ALL)

- Runs along the ventral surface of the spine from the skull to the sacrum. The ALL is narrowest in the cervical spine and is firmly attached at the ends of each vertebral body. It is loosely attached at the midsection of the disc

Posterior longitudinal ligament (PLL)

- Runs on the dorsal surface of bodies from the skull to the sacrum. The PLL has a segmental denticulate configuration and is wider at the disc space but narrows and becomes thicker at the vertebral body level

Craniocervical ligaments

- Located anteriorly to spinal cord and occur in three layers: Anterior, middle, and posterior. Anterior ligaments consist of the odontoid ligaments (apical and alar). Apical ligament is a small fibrous band extending from dens tip to basion. Alar ligaments are thick, horizontally directed ligaments extending from the lateral surface of dens tip to anteromedial occipital condyles. The middle layer consists of the cruciate ligament. Transverse ligament is strong horizontal component of cruciate ligament extending from behind dens to the medial aspect of C1 lateral masses. Craniocaudal component consists of fibrous band running from transverse ligament superiorly to foramen magnum and inferiorly to C2. Posteriorly, the tectorial membrane is the continuation of PLL and attaches to anterior rim of the foramen magnum

Vertebral artery

- The vertebral artery arises as the first branch of subclavian artery on both sides. The vertebral artery travels cephalad within foramen transversarium within transverse processes. The first segment of the vertebral artery extends from its origin to the entrance into the foramen of the transverse process of the cervical vertebrae, usually the 6th. The most common variation is the origin of the left vertebral from the arch, between the left common carotid and the left subclavian arteries (2-6%). The vertebral artery in these cases almost always enters the foramen of the transverse process of C5. The second segment runs within the transverse foramen to the C2 level. Nerve roots pass posterior to vertebral artery. The third segment starts at the C2 level where the artery loops and turns lateral to ascend in C1 transverse foramen. It then turns medial crossing on top of C1 in a groove. The fourth segment starts where the artery perforates the dura and arachnoid at lateral edge of posterior occipitoatlantal membrane, coursing ventrally on the medulla to join with the other vertebral to make the basilar artery

Vertebral column blood supply

- Paired segmental arteries (intercostals, lumbar arteries) arise from aorta and extend dorsolaterally around middle of vertebral body. Near transverse process segmental artery divides into lateral and dorsal branches. Lateral branch supplies dorsal musculature and the dorsal branch passes lateral to foramen giving off branch(es) providing major vascular supply to bone and vertebral canal contents. Posterior central branch supplies disc and vertebral body while the prelaminal branch supplies inner surface of arch and ligamenta flava, regional epidural tissue. Neural branch entering neural foramen supplies pia, arachnoid, and cord. Postlaminar branch supplies musculature overlying lamina and branches to bone

Nerves

- Spinal nerves are arranged in 31 pairs and grouped regionally: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal
- Ascensus spinalis is the apparent developmental rising of the cord related to differential spinal growth
- Course of nerve roots becomes longer and more oblique at lower segments
- C1 nerve from C1 segment and exits above C1
- C8 nerve from C7 segment and exits at C7-T1
- T6 nerve from T5 segment and exits at T6-T7
- T12 nerve from T8 segment and exits at T12-L1
- L2 nerve from T10 segment and exits at L1-2
- S3 nerve from T12 segment and exits at the S3 foramen

Meninges are divided into dura, arachnoid, and pia

- **Dura** is a dense, tough covering corresponding to the meningeal layer of the cranial dura. Epidural space is filled with fat, loose connective tissue and veins. The dura continues with spinal nerves through the foramen to fuse with the epineurium. Cephalic attachment of the dura is at the foramen magnum and the caudal attachment at the back of the coccyx
- **Arachnoid** is the middle covering, which is thin, delicate, and continuous with cranial arachnoid. The arachnoid is separated from the dura by the potential subdural space
- **Pia** is the inner covering of delicate connective tissue closely applied to the cord. Longitudinal fibers are laterally concentrated as denticulate ligaments lying between posterior and anterior roots, and attach at 21 points to dura. Longitudinal fibers are concentrated dorsally as the septum posticum attaching the dorsal cord to the dorsal midline dura

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