Gross Morphology of Spinal Cord
Lecture Objectives

• Describe the gross anatomical features of the spinal cord.
• Describe the level of the different spinal segments compared to the level of their respective vertebrae.
• Identify important gross features of spinal cord, nerve roots, and spinal ganglia.
• Describe the internal features of spinal cord (gray matter and white matter) in the different regions.
• Summarize the location, origin, course and termination of the important ascending and descending tracts of spinal cord.
The Spinal Cord

• Together with brain forms the CNS
• Functions
  • spinal cord reflexes
  • integration (summation of inhibitory and excitatory) nerve impulses
  • highway for upward and downward travel of sensory and motor information
Spinal Cord

- Flattened cylinder
- 16-18 Inches long & 3/4 inch diameter
- In adult ends at L2
- In newborn ends at L4
- Growth of cord stops at age 5
- Cervical enlargement (C4-T1)
  - upper limbs
- Lumbar enlargement (L2-S3)
  - lower limbs
Inferior End of Spinal Cord

- Conus medullaris
  - cone-shaped end of spinal cord
- Filum terminale
  - thread-like extension of pia mater
  - stabilizes spinal cord in canal
- Caudae equinae (horse’s tail)
  - dorsal & ventral roots of lowest spinal nerves
- Spinal segment
  - area of cord from which each pair of spinal nerves arises
Spinal Nerves

• 31 Pairs of spinal nerves
• Named & numbered by the cord level of their origin
  • 8 pairs of cervical nerves (C1 to C8)
  • 12 pairs of thoracic nerves (T1 to T12)
  • 5 pairs of lumbar nerves (L1 to L5)
  • 5 pairs of sacral nerves (S1 to S5)
  • 1 pair of coccygeal nerves
• Exit through the IVF
Spinal Cord & Spinal Nerves

- Spinal nerves begin as roots
- Dorsal or posterior root is incoming sensory fibers
  - dorsal root ganglion (swelling) = cell bodies of sensory nerves
- Ventral or anterior root is outgoing motor fibers
Structures Covering the Spinal Cord

- Vertebrae
- Epidural space filled with fat
- Dura mater
  - Dense irregular CT tube
  - Ends at the lower border of S2
  - Follows the nerve roots and become continuous with epineurium
- Subdural space filled with interstitial fluid
- Arachnoid = spider web of collagen fibers
  - Ends at the lower border of S2
  - Follows the nerve roots into the IVF
- Subarachnoid space = CSF
  - Lumbar cistern (enlargement in subarachnoid space)
    - L2-S2
- Pia mater
  - Thin layer covers BV
  - Denticulate ligaments hold SC in place
Cervical Vertebral Canal: Content

- **Meninges**
  - Dura matter
    - Continuous with cranial dura matter (meningeal layer)
  - Arachnoid matter
  - Pia matter

- **Lower part of medulla oblongata**

- **Cervical segments of the spinal cord**
  - Contain the upper motor neurons for the upper and lower limbs
  - Other descending fibers to the spinal cord (e.g. reticulospinal fibers)
  - Contain the ascending (sensory) fibers from the neck below
  - Cervical enlargement
    - Innervation for the upper limb
      - Lower motor neurons

- **Cervical spinal nerves**
  - C1-C8
    - C1-C7 exit above the corresponding vertebra
      - C1 exit between the atlas and the occipital bone
    - C8 exit between the C7 and T1 vertebrae
  - C1-C4 form the cervical plexus
  - C5-T1 form the brachial plexus
Caudal Epidural Anesthesia

- Caudal epidural anesthesia during delivery
- Into sacral hiatus
- Sacral and coccygeal cornua are important landmarks
- Anesthetize S2-Co1 spinal nerves
Inferior End of vertebral canal: Content

- **Conus medullaris**
  - In adult ends at L2
  - In newborn ends at L4

- **Cauda equina (horse’s tail)**
  - dorsal & ventral roots of lowest spinal nerves (L1-Co1)

- **Spinal meninges**
  - **Dura matter**
    - Ends at S2-S3
  - **Arachnoid matter**
    - Ends at S2-S3
  - **Subarachnoid space = CSF**
    - **Lumbar cistern (enlargement in subarachnoid space)**
      - L2-S2
  - **Pia matter**
    - **Filum terminale**
      - thread-like extension of pia mater
      - stabilizes spinal cord in canal
Joints of Vertebral Bodies

- Cartilaginous joint- Symphysis
- Vertebral bodies covered with thin plates of hyaline cartilage
- IVD
- Ligaments
  - Anterior longitudinal ligaments
    - Wider & stronger
    - Attached to the vertebral bodies and the IVD
  - Posterior longitudinal ligaments
    - Weak and narrow
- Nerve supply: meningeal branches of the spinal nerves
Joints of Vertebral Arches

- Also called **zygapophysial joints**
- Plane synovial joint between the superior & inferior articular processes
  - Articular facets
  - Capsular ligament
- Ligaments
  - Supraspinous ligament
    - Between tips of spins
  - Intraspinal ligament
    - Between spines
  - Intertransverse ligaments
    - Between transverse processes
  - Ligamentum flavum
    - Between laminae
- Nerve supply: articular branches from posterior rami of the spinal nerves
Lumbar Puncture

- Lumbar puncture is used to withdraw CSF for diagnostic purposes
- LP performed from lumbar cistern to avoid the damage to the spinal cord
- LP approached mostly in L3-L4 or L4-L5

- Epidural anesthesia
  - Target the epidural space
  - Same approach as LP
  - Could be approached from the sacral hiatus
Spinal Nerves: Level of Exit

- From T1 to L5, spinal nerves exit from the IVF below their encountered vertebrae
- S1-S4 rami exit from their encountered sacral foramens
- S5 & Co1 exit from sacral hiatus
### TABLE 4.13. NUMBERING OF SPINAL NERVES AND VERTEBRAE

<table>
<thead>
<tr>
<th>Segmental Level</th>
<th>Number of Nerves</th>
<th>Level of Exit from Vertebral Column</th>
</tr>
</thead>
</table>
| Cervical        | 8 (C1–C8)        | Nerve C1<sup>a</sup> (suboccipital nerve) passes superior to arch of vertebra C1  
|                 |                  | Nerves C2–C7 pass through IV foramina superior to the corresponding vertebrae  
|                 |                  | Nerve C8 passes through the IV foramen between vertebra C7 and T1 |
| Thoracic        | 12 (T1–T12)      | Nerves T1–L5 pass through IV foramina inferior to the corresponding vertebrae |
| Lumbar          | 5 (L1–L5)        |                                   |
| Sacral          | 5 (S1–S5)        | Nerves S1–S4 branch into anterior and posterior rami within the sacrum, with the respective rami passing through the anterior and posterior sacral foramina |
| Coccygeal<sup>a</sup> | 1 (Co1)        | The 5th sacral and coccygeal nerves pass through the sacral hiatus |

<sup>a</sup>The first cervical nerves lack posterior roots in 50% of people, and the coccygeal nerves may be absent.

(Modified from Barr’s The Human Nervous System.)
Gray Matter of the Spinal Cord

- Gray matter is shaped like the letter H or a butterfly
  - contains neuron cell bodies, unmyelinated axons & dendrites
  - dorsal gray horns (sensory neurons)
  - ventral gray horns (motor somatic neurons)
  - lateral horns (motor autonomic neurons) only present in thoracic spinal cord
  - gray commissure crosses the midline
- Central canal continuous with 4th ventricle of brain
Nerve Cell Columns in the Gray Matter

• Motor
  • Medial motor nucleus (cell column)
    • Axial muscles
    • Entire SC
  • Lateral motor nucleus
    • Limb muscles
    • Enlargements
  • Intermediolateral cell column
    • Autonomic
    • T1-L2, S2-4
Nerve Cell Columns in the Gray Matter

• Sensory
  • Substantia gelatinosa
    • Entire SC
    • Pain, temperature & touch
  • Nucleus proprius
    • Entire SC
    • Proprioception (sense of position & movement), two-point discrimination & vibration
  • Nucleus dorsalis (Clarke’s column)
    • C8-L2
    • Proprioceptive endings
Cell columns in the anterior gray horn of the spinal cord: somatotopic organization
• White matter covers gray matter
• Anterior median fissure deeper than Posterior median sulcus
• Anterior, Lateral and Posterior White Columns contain axons that form ascending & descending tracts
(Segment C1)

(Segment C8)

(Segment T2)

(Segment L4)

(Segment S3)
Tracts of the Spinal Cord

• Function of tracts
  • highway for sensory & motor information
  • sensory tracts ascend
  • motor tracts descend

• Naming of tracts
  • indicates position & direction of signal
  • example = anterior spinothalamic tract
    • impulses travel from spinal cord towards brain (thalamus)
    • found in anterior part of spinal cord
Location of Tracts inside Cord

- Motor/descending tracts
  - pyramidal tract (corticospinal)
  - extrapyramidal tracts
- Sensory/ascending tracts
  --- spinothalamic tract
  --- posterior column
  --- spinocerebellar ?
Functions of Spinal Tracts

**Sensory**
- Spinothalamic tract
  - pain, temperature, deep pressure & crude touch
- Posterior columns
  - proprioception, discriminative touch, two-point discrimination, pressure and vibration

**Motor**
- Direct pathways (corticospinal & corticobulbar)
  - precise, voluntary movements
- Indirect pathways (rubrospinal, vestibulospinal)
  - programming automatic movements, posture & muscle tone, equilibrium & coordination of visual reflexes
White Matter of the Spinal Cord

- Ventral white commissure
- Lissaur’s tract (dorsolateral fasciculus)
- Intersegmental fibers (fasciculus proprius)
Blood Supply to SC

- One anterior spinal a.
  - Vertebral aa.
- Two posterior spinal aa.
  - Vertebral aa. 25%
  - PICA 75%

- Anterior & posterior radicular aa.
  - Arise at every spinal level
  - Serve their respective roots & ganglia
Blood Supply to SC

- Anterior & posterior spinal medullary aa.
  - Arise at intermittent levels
  - Serve to augment the BS to SC
- Artery of Adamkiewicz
  - Unusually large spinal medullary a.
  - Usually on the left
  - In low thoracic or upper lumbar levels
Blood Supply to SC

- **Spinal cord Ischemia**
- **Anterior spinal a.**
  - Small & tenuous
    - Occlusion produces bilateral damage (below lesion)
- **Affects**
  - Corticospinal tracts
    - Paraplegia below lesion
  - Spinothalamic tracts
    - Thermoanesthesia and analgesia
  - Descending autonomic tracts
    - Loss of bladder & bowel control
  - Anterior gray horn
    - Near enlargement – weakness of limb muscles