M555 Medical Neuroscience
The Spinal Cord and Brain Stem

OBJECTIVES

1. Recognize cervical, thoracic, lumbar and sacral levels of the spinal cord.
2. Be able to locate major structures in the spinal cord and brain stem.
3. Recognize major nuclei and tracts in the spinal cord and brain stem.
4. Know basic anatomy to localize lesions in the spinal cord and brain stem.

Notes

1. Slides will be available in lab for several weeks.

2. Many structures cited in the sections are can be seen again and again from slide to slide and level to level. Part of the purpose for examining these sections is to see how these structures are arranged throughout the length of the brain stem.

3. It is not necessary to look for every structure on every slide. Choose a representative series of slides throughout the length of the brain stem to examine.

4. The comments in parenthesis are included as brief explanations to put some of the anatomy in context. You’re not expected to memorize these comments.

I. SPINAL CORD

Look over the slide containing the four levels of the spinal cord (cervical, thoracic, lumbar and sacral).

Look for the following structures on the spinal cord:

- spinal cord enlargements (cervical and lumbar)
- conus medullaris
- cauda equina
- spinal nerve
  - dorsal root
  - dorsal root ganglion
  - ventral root

Look for the following structures or their approximate locations on sections of the spinal cord:

- central canal
- gray matter
  - dorsal horn
    - substantia gelatinosa
    - dorsolateral tract (Lissauer’s Fasciculus)
  - intermediolateral gray column or nucleus (thoracic and upper lumbar levels)
    “lateral horn”
  - ventral horn
  - large motor neurons in the ventral gray matter
Compare the size and the relative amounts of gray and white matter at the four levels of the spinal cord so that you can identify the spinal level when shown a cross-section of the cord.
All of the brain stem sections are taken from one human brain. They were cut 40 microns thick and the interval between the sections is about 1 mm. The sections are stained with Luxol fast blue and counterstained with cresyl violet. In general, white matter appears darker (bluer) than gray matter on these slides. The sections can also be seen in shades of gray on the web (www.indiana.edu/~m555/stem/stem.html).

II. MEDULLA [slides 1 - 12]

The following structures can be found in at one or sites in these slides.

Ventricular Space

- fourth ventricle

Nuclei - Notable Clusters of Nerve Cells

Sensory nuclei arranged from caudal to rostral in the alar portion of the medulla.

- gracile nucleus (axons in gracile fasciculus of dorsal column terminate on nerve cells here)
- cuneate nucleus (axons in cuneate fasciculus of dorsal column terminate on nerve cells here)
- nucleus of the solitary tract (receives visceral input, including taste via solitary tract in center; cranial nerves VII, IX and X provide the input)
- vestibular nuclei (receive input from vestibular structures of inner ear via CN VIII)
- cochlear nuclei (receive input from cochlea of inner ear via CN VIII)

Sensory nucleus extends throughout entire brain stem and high cervical spinal cord.

- nucleus of the trigeminal tract (receives somatosensory input from face via the descending trigeminal tract)
II. MEDULLA [slides 1 - 12]

Motor nuclei in the basal portion of the caudal medulla.
- hypoglossal nucleus (cranial nerve XII motor neuron cell bodies)
- dorsal motor nucleus of vagus nerve (preganglionic neurons of vagus nerve)
- nucleus ambiguus (motor neurons to skeletal muscles in throat)

Other notable groups of nerve cells found along the length of the medulla.
- reticular formation
- nuclei of raphe (part of reticular formation, located on midline; rich in serotonin)
- inferior olivary nucleus (neurons send “climbing fiber” input to Purkinje cells in cerebellum)

Ascending Fibers - Prominent Bundles of Axons
- anterolateral system (carrying pain and temperature information from spinal cord to thalamus)
- gracile fasciculus of dorsal column (carry fine touch, proprioceptive input from lower body)
- cuneate fasciculus of dorsal column (carry fine touch, proprioceptive input from upper body)
- solitary tract (axons of CNS VII, IX and X end in nucleus of the solitary tract)
- internal arcuate fibers (axons of cells in gracile and cuneate nuclei as they cross midline)
- medial lemniscus (axons from gracile and cuneate nuclei ascending to thalamus)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)
- inferior cerebellar peduncle (bundles of axons that mostly carry input to cerebellum from medulla and spinal cord)

Descending Fibers - Prominent Bundles of Axons that Originate at Upper Levels and End at Lower Levels
- corticospinal/corticobulbar tract axons in pyramids (cerebral cortex ----> brain stem/spinal cord/)
- motor decussation (fibers from cerebral cortex crossing midline to form corticospinal tract)
- descending trigeminal tract (axons of cranial nerve V; carry somatosensory input from face; terminates in nucleus of the trigeminal tract)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)
III. PONS [slides 14 - 29]
The following structures can be found at one or more sites in these slides.

Ventricular Space
- fourth ventricle

Nuclei - Notable Clusters of Nerve Cells

Sensory nuclei arranged from caudal to rostral in location.
- vestibular nuclei (receive input from vestibular structures of inner ear via CN VIII)
- cochlear nuclei (receive input from cochlea of inner ear via CN VIII)
- principal nucleus of trigeminal tract (receives somatosensory input from face)

Sensory nucleus extends throughout entire brain stem and high cervical spinal cord.
- nucleus of the trigeminal tract (receives somatosensory input from face via the descending trigeminal tract.)

Motor nuclei caudal to rostral in pons
- facial nucleus (cranial nerve VII motor neuron cell bodies)
- abducens nucleus (cranial nerve VI motor neuron cell bodies)
- trigeminal motor nucleus (cranial nerve V motor neuron cell bodies)

Other structures and nuclei
- pontine nuclei (neurons here receive input from cerebral cortex, axons project to cerebellum)
- deep cerebellar nuclei (clusters of neurons in white matter of cerebellum)
- locus ceruleus (rich source of norepinephrine input to much of brain)
- nuclei of raphe (part of reticular formation, located on midline; rich in serotonin)

Ascending Fibers - Prominent Bundles of Axons that Originate at Lower Levels and End at Upper Levels
- anterolateral system (carrying pain and temperature information from spinal cord to thalamus)
- medial lemniscus (axons from gracile and cuneate nuclei ascending to thalamus)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)

Descending Fibers - Prominent Bundles of Axons Originating at Upper Levels and Ending at Lower Levels
- corticospinal/corticobulbar tract axons in and around pontine nuclei (cerebral cortex ----> spinal cord/brain stem)
- descending trigeminal tract (axons of cranial nerve V; carry somatosensory input from face; terminates in nucleus of the trigeminal tract)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)

Other Prominent Fibers
- middle cerebellar peduncle (huge bundles of axons; pontine nuclei ----> cerebellum)
- superior cerebellar peduncle (bundles of axons; mostly cerebellum ---> midbrain and thalamus)
IV. MIDBRAIN (and a bit of the caudal DIENCEPHALON) [slides 30 - 40]
The following structures can be found in at one or sites in these slides.

Ventricular Space
- cerebral aqueduct

Nuclei - Notable Clusters of Nerve Cells
- Sensory nucleus
  - mesencephalic nucleus of the trigeminal nerve
    (a real oddity - contains the cell bodies of sensory afferent neurons located within the CNS; the cell bodies of sensory afferent neurons are normally found in the dorsal root ganglia of spinal nerves or ganglia of cranial nerves - PNS structures)

Motor nuclei caudal to rostral in midbrain
- trochlear nucleus (cranial nerve IV motor neuron cell bodies)
- oculomotor nucleus (cranial nerve III motor neuron cell bodies)
  - Edinger-Westphal portion of oculomotor nucleus (parasympathetic autonomic)

Other structures and nuclei
- inferior colliculus
- superior colliculus
- pretectal area (rostral to superior colliculus, close to diencephalon)
- red nucleus
- substantia nigra (compact and reticular regions)
- medial geniculate nucleus (in thalamus, auditory center)
- lateral geniculate nucleus (in thalamus, visual center)
- mammillary bodies (in caudal part of hypothalamus)

Ascending Fibers - Prominent Bundles of Axons that Originate at Lower Levels and End at Upper Levels
- anterolateral system (carrying pain and temperature information from spinal cord to thalamus)
- medial lemniscus (axons from gracile and cuneate nuclei ascending to thalamus)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)

Descending Fibers - Prominent Bundles of Axons Originating at Upper Levels and Ending at Lower Levels
- corticospinal/corticobulbar tract axons in cerebral peduncles
  (cerebral cortex ----> spinal cord/brain stem)
- medial longitudinal fasciculus (axons beneath ventricle along midline, extend into spinal cord)
- rubrospinal tract (red nucleus to spinal cord)
- tectospinal tract (superior colliculus to cervical spinal cord)

Commissural Fibers - Connection Across the Midline
- posterior commissure