Motor and Sensory Neurophysiology

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Outline

• Sensation: Tracking it from the nerves to the Brain
• Motor: Tracking it from the brain to the muscle!
• Practice Localization
What are Tracts?

• The path that information follows in the nervous system

• 3 Basic Principles / Types of Tracts
  • MOTOR (Descending)
  • SENSORY (Ascending)
  • Modulating
Keys to Understanding Tracts

• Different information travels separately
  • Because has different starting and ending points
  • Very orderly (somatotopy)
    • Within the tract, information acquired in close proximity stays in close proximity

• Lesion anywhere along the tract will disrupt the information from reaching the target
ASCENDING (Sensory)
NERVE ENDINGS

- Different nerve endings sense different sensations:
  - Pain
  - Pressure
  - Vibration
  - Temperature
Types of Sensory Nerves

• Small fibers
  • Carry pain and temperature sensation
  • Slow speed of conduction

• Large fibers (myelinated)
  • Carry proprioception and vibration sensation
  • FAST speed of conduction!

• Question: What are your patients going to complain about if they have a problem with large fibers?
Dermatomes from the peripheral nerves
The mergers of radicular nerves

- Brachial Plexus
Uh oh! Now they all look different!
Spinal Cord

Descending Tracts (Motor)
- Lateral Corticospinal Tract (Motor)
- Ventral Corticospinal Tract (Motor)

Region of Anterior Cord Syndrome

Ascending Tracts (Sensory)
- Doral Columns (Fine touch, Propioception, Vibration)
- Lateral Spinothalamic Tract (Pain, Temperture)
- Ventral Spinothalamic Tract (Light touch)
Spinothalamic Tract

• One of TWO primary ascending tracts
• **sPinoThalamic** = **Pain / T**emperature sense

• Question: Which type of nerve fibers are becoming this spinal tract?
Spinothalamic Tract

• DRG (receives input from pain/temp sensors)
• Enters/synapses in Spinal cord at level of nerve root
• Crosses within a few levels of entry
• Synapses again in Thalamus
• Projects to Sensory Cortex
Spinothalamic Tract and Associated Structures

- VPL
- CM
- PF
- IL
- Midbrain
- Pons
- Medial Lemniscus
- Inferior Olivary Nucleus
- Spinal Cord
- Spinothalamic Tract

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Question:

• How do you test for a problem in the spinothalamic tract or the small fiber nerves on physical exam?
Dorsal Columns – Medial Lemniscus Pathway

• Second of 2 Major ascending tracts
• Consist of:
  • Fasciculus gracilis
  • Fasciculus cuneatus
• Contain vibration/proprioception information

• Question: Which type of nerve fibers become the dorsal columns?
Dorsal Columns

- DRG (receives input from vib/prop receptors in muscles/tendons)
- Spinal cord at level of nerve root
- Stays ipsilateral and then crosses in medulla (medial lemniscus)
- Synapses again in thalamus
- Projects to Sensory cortex
Representative Brainstem Slices – Sensory Tracts

- Medulla
- Midbrain

- Medial lemniscus
- Spinothalamic tract
Question:

- How do you test for a problem in the large fibers or the dorsal columns on physical exam?
Primary Sensory Cortex

• Homunculus

Question: How would a stroke-related sensation loss seem on a person? A strip of skin that looks like a dermatome? Or a patch of body that does not stay within a particular nerve distribution?
Cortical Sensation Deficits

Nerves and spinal cord bring sensation to the thalamus where it is processed a little bit.

The cortex tells us what the sensation means.

Question: How do you test for cortical sensory problems?

Two point discrimination
Recognition of an object by touch with eyes closed
Graphaesthesia
DESCENDING (Motor)
Motor Nervous System Orientation

- Brain (and CN)
- Brainstem
- Spinal Cord
  -- Ant. Horn Cell
- Nerve Root
- Peripheral Nerve
- NMJ
- Muscle
Descending MOTOR Tracts

- Pyramidal Tracts
  - Corticospinal Tract
  - Corticobulbar Tract
- Extrapyrildimal Tracts
  - Vestibulospinal
  - Tectospinal
  - Reticulospinal
  - Rubrospinal
Corticospinal Tract

- Lateral corticospinal Tract
  - Motor information for the limbs
Corticospinal Tract
AKA Pyramidal (MOTOR)

- Primary Descending Tract
- Information Carried:
  - Voluntary movement
- Begins in Primary Motor Cortex (cortico-)
- Synapses in **spinal** cord (-spinal)
- Alpha motor neuron goes from spinal cord to NMJ/muscle
Corticospinal Tract - Midbrain
Corticospinal Tract – Pons

Rostral Pons

Mid Pons

Caudal Pons
Corticospinal Tract

- Crosses in medulla (lowest part of brainstem): called DECUSSIONATION OF THE PYRAMIDS
Corticospinal Tract – Clinical Correlation

• A Train Crossing – So What?
• Means that ABOVE the decussation (medulla and higher)
  • Lesion will produce contralateral weakness
• And BELOW the decussation (spinal cord and lower)
  • Lesion will produce ipsilateral weakness
Corticobulbar Tract

- Start: Primary Motor Cortex
- End: Nuclei for the MOTOR Cranial Nerves (motor to the face)
  - III, IV, VI – Eye movement
  - V – Muscles of mastication
  - VII – Facial muscles
  - IX, X – Muscles of pharynx
  - XII – Tongue movement
Corticospinal Tract – Clinical Correlation

- The **UPPER MOTOR NEURON** travels within the corticospinal tract
- Lesion anywhere along the course of CS tract will give UMN signs *BELOW* that level
  - Damage the tracks and train can go no further
Question:

- How do you tell on exam if there is a problem in the Upper motor neuron?

<table>
<thead>
<tr>
<th>Clinical test</th>
<th>Upper motor neuron</th>
<th>Lower motor neuron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflexes</td>
<td>Hyperreflexia</td>
<td>Hyporeflexia</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Increased/Spastic</td>
<td>Decreased/Flaccid</td>
</tr>
<tr>
<td>Fasciculation</td>
<td>None</td>
<td>Present</td>
</tr>
<tr>
<td>Atrophy</td>
<td>None</td>
<td>Severe</td>
</tr>
<tr>
<td>Babinski sign</td>
<td>Present</td>
<td>Absent</td>
</tr>
</tbody>
</table>
Motor Nerves

- Myotomes
  - Synapse in the Anterior Horn of the Spinal Cord.
- Lower motor Neuron (LMN)
- Every bit as complicated as dermatomes

<table>
<thead>
<tr>
<th>Myotome</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Shoulder abduction and external rotation; elbow flexion</td>
</tr>
<tr>
<td>C6</td>
<td>Wrist extension</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow extensors and wrist flexion</td>
</tr>
<tr>
<td>C8</td>
<td>Thumb extension and finger flexion</td>
</tr>
<tr>
<td>T1</td>
<td>Finger abduction</td>
</tr>
<tr>
<td>L1/L2</td>
<td>Hip flexion</td>
</tr>
<tr>
<td>L3</td>
<td>Knee extension</td>
</tr>
<tr>
<td>L4/L5</td>
<td>Ankle dorsiflexion</td>
</tr>
<tr>
<td>L5</td>
<td>Great toe extension</td>
</tr>
<tr>
<td>S1</td>
<td>Ankle plantar flexion</td>
</tr>
<tr>
<td>S4</td>
<td>Bladder and rectum motor supply</td>
</tr>
</tbody>
</table>
Question:

• What viral disease of childhood causes the Lower Motor Neuron to die at the Anterior Horns?
Neuromuscular Junction

- Signal is transmitted from the motor axon to the muscle at the NMJ.
- The neurotransmitter: acetylcholine
- The final goal is to achieve muscle contraction.
What happens in NMJ disorders?

- Failure of neuromuscular transmission due to different mechanisms:
  - **Presynaptic**: impaired Ach release.
    - Lambert-Eaton myasthenic syndrome (LEMS): antibodies against P/Q voltage-gated calcium channels (VGCC) in the nerve terminal.
    - Botulism: botulin toxin cleaves various docking proteins (SNARE complex).
  - **Postsynaptic**: impaired Ach signaling.
    - Myasthenia gravis: antibodies against nicotinic Ach R.
Localization Practice

• A patient presents with the sudden onset of loss of sensation as well as weakness in the left face, arm, and leg. They have no changes in their cognition and no neglect.

• What is the most likely etiology? Where is the lesion?
Localization Practice

- Refresh Corticospinal Tract
- A lesion here would cause what symptoms?
Localization

• A 21 year old woman has had about 4 months of increasing double vision, slurred speech, and difficulty climbing stairs and raising her arms above her head. Her sensation is all totally normal. But you find on your exam that she has weakness in her arms and legs worse proximally as well as facial, eyelid, and eye muscle weakness. Where is the localization?
Myasthenia Gravis – Neuromuscular Junction

- First recognized neurological autoimmune disease.
- Often associated with thymoma.
- Ocular myasthenia is the mildest form.
- Highly variable disease with fatigable weakness.
- Generalized MG can be fatal with respiratory failure (and aspiration pneumonia).
Localization Practice

A patient was getting an abdominal surgery. Post operatively, he had weakness in both legs with increased reflexes at both ankles and both knees and increased tone (spastic) in both legs two weeks later. This patient also lost the ability to feel pinprick in the legs. However, strength, reflexes, and tone are all normal in the arms. And the patient can feel vibration in their feet. Where is the lesion?
Localization Practice

• Anterior spinal artery syndrome – at T6 level
One day Jesus was teaching, and Pharisees and teachers of the law were sitting there. They had come from every village of Galilee and from Judea and Jerusalem. And the power of the Lord was with Jesus to heal the sick. Some men came carrying a paralyzed man on a mat and tried to take him into the house to lay him before Jesus. When they could not find a way to do this because of the crowd, they went up on the roof and lowered him on his mat through the tiles into the middle of the crowd, right in front of Jesus.
When Jesus saw their faith, he said, “Friend, your sins are forgiven.” The Pharisees and the teachers of the law began thinking to themselves, “Who is this fellow who speaks blasphemy? Who can forgive sins but God alone?” Jesus knew what they were thinking and asked, “Why are you thinking these things in your hearts? Which is easier: to say, ‘Your sins are forgiven,’ or to say, ‘Get up and walk’? But I want you to know that the Son of Man has authority on earth to forgive sins.” So he said to the paralyzed man, “I tell you, get up, take your mat and go home.” Immediately he stood up in front of them, took what he had been lying on and went home praising God. Everyone was amazed and gave praise to God. They were filled with awe and said, “We have seen remarkable things today.”
By Next Week!

• Reading assignment on Vision
• Handout assignment