Spinal Cord and Reflexes

An Introduction
Spinal Cord – Cross Section

1. Sensory nerve
2. Motor nerve
3. Posterior root ganglion
4. Posterior root
5. Anterior root
6. Spinal nerve
7. Posterior white column
8. Anterior white column
9. Anterior grey horn
10. Posterior grey horn
11. Grey commissure
12. Central canal
13. Anterior median fissure
14. Posterior median fissure
15. Lateral white column
Spinal Cord Levels -- Anatomy

- Cervical: greatest white matter
- Cervical enlargement: grey matter large; innervates extremities
- Thoracic: grey matter large; innervates extremities
- Lumbar/Lumbar enlargement: grey matter large; innervates extremities
- High sacral: grey matter large; innervates extremities; least white matter

- Grey matter
- Spinal root of XI
Spinal Cord Levels -- Physiology

- **Cervical enlargement (C3-T1)**:
  - Hand
  - Forearm
  - Arm

- **T2-L1**:
  - Ribs
  - Back
  - Abdomen

- **L2-S5**:
  - Foot
  - Leg
  - Thigh
  - Hip

1. Flexor
2. Adductor
3. Extensor
4. Abductor
Spinal Cord Levels – Clinical Applications
Dermatomes

1. Considerable overlap between neighboring dermatomes – as much as up to 8 dermatomes away
2. Borders are not exactly the same for touch as for pain and temperature
3. Dermatomes for pain and temp somewhat less extensive
4. Touch fibers belonging to a dorsal root overlap with those from neighboring roots moreso than do fibers for pain and temp.
Applications of Dermatomes

• Intact Dermatomes
  1. C3-5 = diaphragm = ok
  2. C4 = shoulder shrugs = ok
  3. C5 = deltoid and elbow flexes = ok
  4. C7 = wrist flexes = ok
  5. C5-6 = biceps reflex = ok
  6. C7 = triceps reflex = ok
  7. L2 = hip flexes = ok
  8. L3-4 = knee extends = ok
  9. L5-S1 = dorsiflexion = ok
  10. S1-S2 = plantarflexion = ok

• Lesions and Functional Goals
  1. C5 → run electric wheelchair with mouth
  2. C6 → feed self with clip-ons
  3. C7 → drive car with hand controls
  4. C8 → transfer by self to/from bed, auto, toilet
  5. T1-8 → transfers self to/from tub
  6. T9-12 → ambulate with braces and crutches
  7. S1-2 → ambulate with cane
Cord Overview

Discriminative touch
Joint sensation
Vibration/Pressure
Temp, Pain, Touch
Deep Pressure

Proprioceptives: pressure
Position A's

Medial lemniscus tract

Cortico-spinal tract
Spinothalamic tract

Target
Organ

Sensory: Ascending fibers
Sensory: Ascending fibers
Proprioceptive fibers

SAME
Discriminative Sensation

- Is the capacity to recognize differences of the objects in contact with the skin, e.g.,
  1. Size
  2. Form
  3. Texture
  4. Surface characteristics
Discriminative Sensation

- There are Four (4) General Types of Receptors:
  1. Mechanoceptors
  2. Thermoceptors
  3. Pain receptors
  4. Joint receptor endings
Discriminative Sensation –
Mechanoceptors

• One (1) type of RAPID adapting receptors
• Two (2) types of SLOW adapting receptors
Rapid Adapting Receptors

- Surrounds hairs
- Responds to slight movements of a hair
- Bald guys and hats
Slow Adapting Receptors

Type I = Merkel’s Disks
1. Receptive field (skin area from which the fiber can be excited) is smallest on distal parts of the body, e.g., dorsum of fingers
2. Found on skin of lips and external genitalia
3. Scarce in hairy skin

Type II = Meissner’s Corpuscles
1. Found in dermis/dermal papillae
2. Especially numerous in hairless volar (palm/sole) of fingers, toes, hands and feet
Pressure/Vibration Mechanoceptors

**Pacinian Corpuscles**
- Universally occurring
  - 1-4 mm in length
  - White egg-shaped bodies
    - In SQ
- Especially abundant in fingertips and toetips, palms and soles
  - Follow Meissner’s corpuscles?????
- Also in ligaments, periosteum, mesenteries, pancreas and other viscera
  - Record vibration from steady pressure
  - Show regressive changes with advancing age
  - Vibratory sensibility tested with tuning forks
Thermoceptors

**Ruffini’s Corpuscles**

- Are most sensitive in the range of 25-45°C (some literature says 38-43 °C).
- When these receptors are activated, the brain interprets this as a painful burning sensation.

**Krause’s End Bulbs**

- Are sensitive to cold and are activated at temperatures below 20° C (68° F).
- Some literature says 16-27 °C.

- The stimulus is NOT the absolute temperature, but the *change of temperature*; a change of temperature of about 0.2 °C (0.36 °F) is sufficient for discharge of these receptors.
Pain Receptors (Nociceptors) – Two Types

- Fast, First or Pricking Pain
  - Type I
    - Discharge as a result of superficial penetration with a fine, sharp needle
      - Abrupt in onset
      - Hurts little
      - Accurately localized
    - Disappears when stimulus ceases
      - Thin, myelinated fibers
      - 8-11 μm in diameter
      - Bigger fibers

- Slow, Second or Stinging Pain
  - Type II
    - Discharge occurs as a result of deep penetration
    - Requires a short latent period
      - More intense
      - More diffuse
    - Outlasts stimulus
      - Un-myelinated fibers
      - 3-5.5 μm in diameter
      - Smaller fibers
## Nociception

### Nociceptor Fiber Types

<table>
<thead>
<tr>
<th>Primary Afferent Nociceptors -- PAN</th>
<th>TYPE I -- fibers</th>
<th>TYPE II -- fibers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-α</td>
<td>A-β</td>
<td>A-Δ</td>
</tr>
<tr>
<td>Myelinated</td>
<td>Non-myelinated</td>
<td></td>
</tr>
<tr>
<td>Fast</td>
<td>Slow</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>Small</td>
<td>Smallest</td>
</tr>
<tr>
<td>Muscle Sensory</td>
<td>Skin Sensory</td>
<td>PAN</td>
</tr>
<tr>
<td>Transmit light pressure to deep muscle; soft touch to skin; vibration – message gets to dorsal horn the fastest</td>
<td>Sharp, pointed stimulation, short duration, well localized; message goes slower to dorsal horn</td>
<td>Dull sensation; aching sensation; burning sensations; diffuse, slow onset, long duration; message goes the slowest to dorsal horn</td>
</tr>
</tbody>
</table>
## Joint Receptor Endings

<table>
<thead>
<tr>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myelinated</td>
<td>Myelinated</td>
<td>Myelinated</td>
<td>Un-Myelinated</td>
</tr>
<tr>
<td>Fibrous joint capsule</td>
<td>ONLY in fibrous joint capsules</td>
<td>Extrinsic/intrinsic ligaments</td>
<td>Fibrous capsule, ligaments, subsynovial fat pads</td>
</tr>
<tr>
<td>Slowly adapting mechanoreceptors for stretch</td>
<td>Rapidly adapting (accelerator receptors)</td>
<td>Slow adapting with high threshold</td>
<td>Pain receptors</td>
</tr>
<tr>
<td>5-8 μm</td>
<td>8-12 μm</td>
<td>? μm</td>
<td>? μm</td>
</tr>
<tr>
<td>Sensitive to stretch in the joint</td>
<td>Sensitive to rapid movements in any position of the joint</td>
<td>Record position of joint</td>
<td>Register pain in joint</td>
</tr>
</tbody>
</table>
1. Gracile fasciculi – to medulla; body position, recognize touch, shape, texture, size
2. Cuneate fasciculi – Ibid.
4. Posterior spinocerebellar tract – to cerebellum; movement and posture
6. Anterior spinocerebellar tract – Ibid.
9. Vestibulospinal tract – from vestibular nuclei; equilibrium and balance

Ipsilateral activity
Spinal Cord Tracts – Physiology, too --

3. Lateral corticospinal tract – aka pyramidal tract; voluntary movements

5. Rubrospinal stract – from red nucleus; movement and posture

7. Lateral spinothalamic tract – to thalamus; pain and temperature

8. Reticulospinal tract – from reticular activating system; increases motor activity

10. Anterior spinothalamic tract – to thalamus; pressure, crude touch, posture and muscle action

11. Anterior corticospinal tract – part of pyramidal tract; from motor cortical area; voluntary movements

Contralateral activity
Cord Overview -- Again
Cord by Region

Cervical Cord
C = shortest, thinnest axons
S = longest, thickest axons

Thoracic Cord
Cord by Region -- 2
Cord by Region -- 3

- Note “lamination” of regions
- Note “loss” of regions as the cord goes farther down
- Note orientation of laminates between AP and PA views
Sensory Abnormality Problems and Patterns

An Elementary Overview
Thalamic Lesion

- Complete hemianalgesia (The inability to feel pain on one side of the body.)
Cauda equina Lesion

- Loss of sensation over sacral segments
- May be unilateral – usually bilateral
- Referred to as “saddle sensory disturbances” in a generic sense
Central cord Lesion

- Temperature and pain sensation loss
- Normal touch
Half-cord Lesion

1. Pain/Temp sensation loss
2. Positional/vibrational loss
Whole-cord Lesion

- Complete loss of sensation at a specific level
- May not make 100% sense given overlap of dermatome and myotome activities
Pyramidal Tracts – aka Corticospinal Tracts
Motor Neurons

Upper Motor Neurons
• Found in corticospinal (or pyramidal tract) in brain/spinal cord

Clinical Signs:
1. Loss of voluntary movement
2. Spasticity
3. Sensory loss
4. Pathological reflexes (2+ is “normal”; >2+)

Injury:
1. Hemiplegia (paralysis of half of the body)
2. Paraplegia (paralysis of lower portion of body and both legs)
3. Quadriplegia (paralysis of all 4 limbs – aka tetraplegia)

Lower Motor Neurons
• Include anterior horn cells, nerve roots, peripheral nervous system cells

Injury
1. Diminished reflexes (< 2+)
2. Flaccid paralysis
3. Muscular atrophy
Cardiac “Circuit Diagram” -- Homeostasis
Cardiac Circuitry

**Carotid Sinus Massage**

1. 5-10 seconds
2. Unilaterally
3. Patient must be supine
4. When no bruit is present!!! (bruit: murmurs heard best over carotid bifurcation; not of cardiac origin; caused by partial obstruction of the carotid)
5. Use an EKG and obtain BP
6. Pt must have no hx of TIA (→ ↑’d risk of CVA)

**Causes Vasovagal Response**

1. Vasodepressor response (BP reduced by ≥50 mm Hg)
2. Cardioinhibitory response (HR by ≥ 3 second sinus pause)
Carotid Massage Mechanism

- Carotid Sinus Massage not used much, any more – if at all.
- Periodically, one will run across its use in the literature or online.
- Adenosine used now.
Carotid Sinus Syncope

• Syncope ≡ is temporary loss of consciousness and posture, described as "fainting" or "passing out." It's usually related to temporary insufficient blood flow to the brain.
• Another way to define it is that of the room spinning around you.
• Of Cardiac origin

• Vertigo ≡ a sensation of spinning [around the room or wherever you may be].
• Of Neurological origin
Vasovagal Response

- A vasovagal episode or vasovagal response or vasovagal attack (also called neurocardiogenic syncope) is mediated by the vagus nerve. When it leads to syncope or "fainting", it is called vasovagal syncope, which is the most common type of fainting.

- Prior to losing consciousness, the individual frequently experiences a prodrome of symptoms such as lightheadedness, nausea, diaphoresis, tinnitus, uncomfortable feeling in the heart, weakness and visual disturbances such as lights seeming too bright, fuzzy or tunnel vision.

- These last for at least a few seconds before consciousness is lost (if it is lost), which typically happens when the person is sitting up or standing. When sufferers pass out, they fall down (unless this is impeded); and when in this position, effective blood flow to the brain is immediately restored, allowing the person to wake up.

- Tabor's describes this as the "feeling of impending death" caused by expansion of the aorta, drawing blood from the head and upper body.
Carotid Sinus Syncope

• If chronic and due to cardioinhibitory response (head turned, tight shirt collar), is “fixable” with permanent pacing
• Other tx ≡ surgical removal, by stripping, of nerves from the carotid artery above and below the bifurcation
Stretch Reflex – Mono-Synaptic

- **Agonist**: QUADS, TRICEPS
- **Antagonist**: HAM STRINGS, BICEPS
- **Contraction**: 1, 2, 4, 5
- **Relaxation**: 3, 6, 7

Knee jerk: calf extends on thigh
Triceps: forearm extends on upper arm
Deep Tendon Reflexes – DTR’s – Polysynaptic – Reverses Stretch Reflex
Crossed Extensor/Flexor Mixed Reflex

- The “Defend-Yourself” Reflex
- The “Step On-A-Tack” Reflex
Reflexes

An Introduction
Achilles’ Tendon Reflex

- Percuss the Achilles’ tendon
- Foot plantar flexes
- The flexion is exaggerated with upper motor neuron damage
- Flexion is decreased or absent with lower motor neuron damage
- aka ankle jerk reflex

- May percuss as above
- May percuss as shown in lab
Babinski – A Busy Feller

Babinski’s Reflex

• Dorsiflexion of Toe #1 following lateral to medial stroking of the sole (normal)
• If toe extends and outer toes flare = + for pyramidal tract lesions
• Abnormal response is present in infants until right at 6 months’ of age

Babinski’s Sign

• Decreased or absent achilles’ tendon reflex in sciatica
Biceps Reflex

- Percuss the biceps brachii insertion tendon
- Forearm flexes (may need to feel tendon jerk under thumb)
- May percuss as shown to the right
- May percuss as shown in lab
“C” Reflexes

<table>
<thead>
<tr>
<th>Ciliospinal</th>
<th>Corneal</th>
<th>Cremasteric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke/pinch/scratch skin of back of neck</td>
<td>Eyelids close due to corneal irritation</td>
<td>Stroke front of inner thigh</td>
</tr>
<tr>
<td>Observe pupillary dilation</td>
<td></td>
<td>Causes testicular retraction</td>
</tr>
</tbody>
</table>
Light Reflex

- Pupil constricts with light shone into it
Moro Startle Reflex

- Blow in face
- Blow on top of abdomen
- Infant responds with rapid abduction/extension of arms with adduction of arms (embracing/hugging)
- Disappears after 1-2 months’ of age
- If absent or unilateral, the presence of this reflex may suggest brain damage or a birth-originated injury
Patellar Reflex

• aka knee jerk
• Percuss patellar ligament
• Lower leg extends
• In lower motor neuron damage: diminished/abolished reflex
• In upper motor neuron damage: muscle tone/response is greatly increased (pathological reflex)

• May percuss as above.
• May percuss as demonstrated in lab.
## “P” Reflexes

<table>
<thead>
<tr>
<th>Pilomotor</th>
<th>Plantar/palmar grasp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goose flesh due to skin cooling rapidly or after emotional reaction</td>
<td>Lightly stroke the palm</td>
</tr>
<tr>
<td></td>
<td>Grasps at stimulus; Present at birth; Gone by about 6 months’ of age</td>
</tr>
</tbody>
</table>
Perez Reflex

1. Clean penis or pudendum
2. Hold face down
3. Suprapubic pressure
4. Stroke para spinous muscles firmly
5. Collect urine
6. Baby cries
7. Back extends
8. Leg/arm reflexion
9. Baby urinates
“R” Reflexes

Red Light Reflex
- Reflected red light on ophthalmological exam (photos, too).
- Generally indicates a lack of cataracts.

Rooting Reflex
- Stroke cheek.
- Mouth moves to stimulus.
- Present at birth.
- Gone by 4 months’ of age if awake when tested.
- Gone by 7 months’ of age if asleep when tested.
Triceps Reflex

• Percuss triceps insertion tendon.
• Causes forearm extension (sort of) while arm is held loosely in bent position.
• May percuss as shown, right.
• May percuss as shown in lab.