Functional Anatomy of the Brain
Stem, Cranial Nerves and
Associated Pathways

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Disclosures
• I have no financial relations to disclose
• My compensation comes only from teaching and seeing patients for the University of Oklahoma
• I have been a medical provider for the Oklahoma City Red Hawks (triple A team for the Texas Rangers)
• I am a South Side Chicago native, so I do not much like the Cubs, just like you’s guys.

Things to consider
• Cranial nerves are numbered in the order they have to be cut to get the brain out!
• The first few are devoted to special senses and are related to higher order brain areas and functions
• The next few are related to eyes and eye movements
• The next several are related to what are called branchial arches or gill slits
• Then we get down to the ear, the guts and lastly (ironically) the tongue

A few simple rules about functional components
• Most cranial nerves (7) do one thing and one thing only!
• Only two cranial nerves have two functions
  – Oculomotor – VE to ciliary muscles, SE to extraocular muscles
  – Trigeminal – SA from face, SE to Muscles of Mastication (1st arch)
• There are three with more than two functions and the all have the same functions (VII, IX, X)
  – VE (Parasympathetics) / VA
  – SA from the ear
  – Motor for muscle of the 2nd, 3rd, 4th and 6th branchial arches
  – Taste from anterior 2/3 of tongue, posterior 1/3 of tongue and the area around the epiglottis
Review of Regions of the Brainstem

- Midbrain
- Pons
- Medulla

Review of Cranial Nerves

- **Forebrain** (telencephalon)
  - I – no really – that is it!
- **Diencephalon**
  - II
- **Midbrain**
  - III, IV
- **Pons**
  - V, VI, VII, VIII
- **Medulla**
  - IX, X, XI and XII

Postolivary Sulcus – IX, X, XI
Preolivary Sulcus – XII

Cranial Fossae/Cranial Fossa

- **Anterior Cranial Fossa**
  - I – no really – that is it!
- **Middle Cranial Fossa**
  - Cranial Nerves II-VI
  - Everything associated with the eye
  - Motor (III, IV, VI and V)
  - Sensory (II, V₁, V₂ and V₃)
- **Posterior Cranial Fossa**
  - Cranial Nerves VII-XII
  - VII, VIII in the IAM
  - IX, X, XI in the Jugular F.
  - XII in the Hypoglossal Canal
Olfactory Nerve

Lesion of the Olfactory Nerves

- Possibly a history of trauma
- Food Tastes funny
- Nose is running (CSF)

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Optic Nerve
Why is the Optic Nerve is **NOT** a Peripheral Nerve

- The eye is an outgrowth of the diencephalon
- Retinal cells send axons directly to thalamus (and midbrain)
  - No other cranial nerves do this
- The so-called nerve does not have Schwann Cells as their axon sheath cells
  - Oligodendroglia create the myelin
- Optic nerve axons are supplied by the ophthalmic artery of the internal carotid
- Diseases that effect CNS tracts also effect the optic nerve (Optic neuritis in MS)

Visual Fields/Projections Made Ridiculously Simple

Stare at this
Dark dot!

This pink triangle
is in you right
cortex!

How did they get there?

This green
rectangle is in
you left cortex!

Visual Pathways

**Left Visual Field**
- Temporal Visual Field
- Nasal Retinal Field
- Temporal Retinal Projections
- Right Visual Field
- Lateral Geniculate

**Right Visual Field**
- Temporal Visual Field
- Nasal Retinal Field
- Temporal Retinal Projections
- Left Eye

Cranial Nerve Three and Friends

**Right Eye**
- Blindsight
- (amnesia for gaze)

**Left Eye**
- Nerve Lesion

**Nasal Retinal Field**
- Bitemporal Hemianopia

**Right Retinal Projections**
- Right Eye

**Left Retinal Projections**
- Left Eye

**Lateral Geniculate**
- Wait – this doesn’t look simple!
Organization of the Motor Nuclei of the Cranial Nerves

- Motor neurons for the eye muscles and tongue are on the midline
- Motor neurons for Branchial Arch muscles are ventral lateral (V, VII, IX, X)

Oculomotor, Trochlear, Abducens

Parasympathetics for the Sphincter Pupillae
LR6 – SO4
All the rest are 3

Lesion of Cranial Nerve III

Cannot move the eye "in" and/or pupil is big

Lesions of CN IV

Diplopia with attempted down and out
Lesion of CN VI

- There may be diplopia with certain eye movements without detectable gross eye movement changes
- Patients may say they are dizzy
- If they cannot look out and only one eye is involved, think VI
- CN VI is vulnerable to Cavernous sinus infections or clots!

Disturbances of Lateral Gaze

- There may be diplopia with certain eye movements without detectable gross eye movement changes
- If both eye can move to a side (2, 3) – think Frontal eye fields or PPRF
- Internuclear lesions (3) may interrupt conjugate movements of the medial rectus

Trigeminal Nerve, Sensory Component

Portio Major

- V1
- V2
- V3

Trigeminal Nerve, Motor Component

Portio Minor

- CN V

Note that the tip of the nose is V1 – the ophthalmic division

Weakness in muscles Of Mastication – jaw clench
Problems with the Trigeminal

- Loss of muscle tone on the side of the lesion
- Wasting of the Muscles of Mastication
- Anesthesia over head – distribution depends on part of the nerve that is interrupted
- When asked to open the jaw, the mandible deviates to the side of the lesion
- Trigeminal Neuralgia (Tic de la Rue)

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Facial Nerve

- To – temporal
- Zanzibar – Zygomatic
- By – Buccal
- Motor – Mandibular
- VII Car - Cervical
- Geniculate Ganglion

Lesions of CN VII

- Symptoms depend on the location of the insult
- Facial nerve palsy with increase in sound – **good**
- Facial nerve palsy with decreased hearing is **bad**!
- Preservation of upper part of facial muscles – think Cortex/Internal Capsule!
Problems with CN VIII

- Vertigo
- Meniere's disease
- Saccades
- Nystagmus
- Stabismis

IX, X and XI Effect Swallowing, Taste and Phonation

Glossopharyngeal Nerve

Sensory:
- Carotid Body/Sinus
- Endodermal portion of tongue (posterior 1/3), palate, pharynx

Motor:
- Stylopharyngeus M. (3rd Branchial Arch)

Gag Reflex
Frey's Syndrome: Sweating with eating after Parotid surgery

Problems with CN IX

- Loss of gag reflex
- Glossopharyngeal neuralgia

Problems with CN X

- Uvula and palate do not elevate
Lesion of CN XI

- Loss of shoulder shrug

Hypoglossal Nerve

- Innervates all muscles intrinsic and extrinsic to the tongue except palatoglossus
- Nerve is lateral to carotid a. and crosses the bifurcation
- Joined by C1 motor elements of the cervical plexus to create the N. To Geniohyoid
- N. To Thyrohyoid
- Superior root of the ansa cervicalis
- Tongue points to the side of the lesion

CN XII and the Preolivary Sulcus
Lesions of the CN XII

- Tongue points toward the side of the lesion

Crossed Bulbospinal Hemiplegias

- Cortical outflow goes right past three cranial nerves as they exit the brain
- Lesions can hit the pyramidal tract and one of these three nerves
- Pyramidal lesion leaves the opposite side of the body with an upper motor neuron lesion
- There will be a lower motor neuron lesion of one of the three nerves
  1. Oculomotor in the midbrain
  2. Abducens in the caudal pons
  3. Hypoglossal on the medulla

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A Word About Somatic Sensations From the Head

SA
V
VII
IX
X

The trigeminal is the major nerve for general sensation from the head

The others have a small but clinically important role by innervating the ear
## Parasympathetics Associated with Cranial Nerves

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Function</th>
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<tbody>
<tr>
<td>III</td>
<td>Ciliary ganglion for smooth muscles in the Eye</td>
</tr>
<tr>
<td>VII</td>
<td>Pterygopalatine ganglion for lacrimal gland and nasal cavity</td>
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<tr>
<td></td>
<td>Submandibular ganglion for the submandibular gland</td>
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<tr>
<td>IX</td>
<td>Otic ganglion for the parotid gland</td>
</tr>
<tr>
<td>X</td>
<td>To the heart, lungs and foregut</td>
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