Neurology 1
Cranial Nerves

Donna Quezada, DC, DICCP, DIBCN
With slides also by Chris Rorden
drdonnaq@gmail.com
Functional Classification of CN

• Spinal Nerve classification
  – General Efferent or Afferent: serve general motor, sensory.

• Cranial Nerves classification
  – Receptor type:
    • General - just like spinal nerves
    • Special – Use special receptors and neurons to serve additional specialized functions
  – Signal type
    • Efferent – Sensory
    • Afferent - Motoric
  – Voluntary or reflexive?
    • Somatic. Innervate somatic muscles (muscles that arise from the soma in the embryological stage – voluntary muscle control)
    • Visceral. Innervate visceral structures.
7 Functional Types

1. General Somatic Efferent (GSE) Activates Muscles from Somites (Skeletal, Extraocular, Glossal)
2. General Visceral Efferent (GVE) Activates Visceral Organs
3. Special Visceral Efferent (SVE) Activates Muscles of face, palate, mouth, pharynx and larynx Excludes eye and tongue muscles
4. Special Visceral Afferent (SVA) Mediates visceral sensation of taste from tongue Olfaction from Nose
5. General Visceral Afferent (GVA) Mediates sensory innervation from visceral organs
6. General Somatic Afferent (GSA) Mediates information from muscles, skin, ligament and joints
7. Special Somatic Afferent (SSA) Mediates special sensations of vision from retina and audition and equilibrium from inner ear
Peripheral Nervous System (PNS)

- 12 pairs of cranial nerves-
  - Sensory, motor, or mixed
    - “Some Say Marry Money But My Brother Says Bad Business Marrying Money”
  - Name pneumonics
    - “On Old Olympus Towering Top A Famous Vocal German Viewed Some Hops.” or
    - “On Old Olympus Towering Top A Fin And German Viewed Some Hops.”
Cranial Nerves (12 pair)

I. Olfactory: smell
II. Optic: vision
III. Oculomotor: eyelid and eyeball movement
IV. Trochlear: motor for vision (turns eye downward and laterally)
V. Trigeminal: chewing, face and mouth touch and pain
VI. Abducens: motor to lateral eye muscles
VII. Facial: controls most facial expressions, taste, secretion of tears & saliva
VIII. Vestibulocochlear: sensory for hearing and balance (aka Acoustic)
IX. Glossopharyngeal: sensory to tongue, pharynx, and soft palate; motor to muscles of the pharynx and stylopharyngeus
X. Vagus Nerve: sensory to ear, pharynx, larynx, and viscera; motor to pharynx, larynx, tongue, and smooth muscles of the viscera, 2 parts: superior laryngeal branch and recurrent laryngeal branch
XI. Spinal Accessory Nerve: motor to pharynx, larynx, soft palate and neck
XII. Hypoglossal Nerve: motor to strap muscles of the neck, intrinsic and extrinsic muscles of the tongue
I: Olfactory

Sensory

• Special Sensory: smell
  - Injured by shearing (car accident) – unilateral loss of smell

rad.usuhs.mil/cranial_nerves/timrad.html
II: Optic

Sensory

- Special Sensory: Sight
- Optic nerve nuclei are located in the lateral geniculate body
- Pupil constricts for light to contralateral eye, but not ipsilateral = Unilateral vision loss
  - (right eye pupil constricts when you shine a light into the left eye, but not when you shine it into the right eye = right eye vision loss)
III: Oculomotor Motor

• Somatic Motor: Superior, Medial, Inferior Rectus, Inferior Oblique
  – Difficulty with eye movements.

• Visceral Motor: Sphincter Pupillae
  – Pupil asymmetry, no pupil reflex – regardless of which eye observes light.
IV: Trochlear

• Somatic Motor: Superior Oblique
• Injury leads to diplopia (due to extorsion), esp when looking down
  – Moves the eye in and down
V: Trigeminal

Both

- Somatic Sensory: Face
- Somatic Motor: Mastication, Tensor Tympani, Tensor Palati

- light touch and pain on the forehead (V1), cheeks (V2) and chin (V3).
VI: Abducens
Motor

• Somatic Motor: Lateral Rectus

• Damage to the nerve is seen with decreased ability to abduct the eye. (diplopia: affected eye is pulled medially)
VII: Facial

Both

• Somatic sensory: Posterior External Ear Canal
• Special Sensory: Taste (Anterior 2/3 Tongue)
• Somatic Motor: Muscles Of Facial Expression
• Visceral Motor: Salivary Glands, Lacrimal Glands

• Drooping corner of mouth while at rest. Asymmetry of expressions (wrinkle forehead, raise eyebrows, etc)
VIII: Vestibulocochlear

- Special Sensory: Auditory/Balance
- Can patient hear finger rubbing near ear.
IX: Glossopharyngeal

Both

- Somatic Sensory: Posterior 1/3 Tongue, Middle Ear
- Visceral Sensory: Carotid Body/Sinus
- Special Sensory: Taste (Posterior 1/3 Tongue)
- Somatic Motor: Stylopharyngeus
- Visceral Motor: Parotid Gland

- Asymmetric palate while saying ‘Aaah’, poor gag reflex (sensory = IX, motor = X)
X: Vagus

• Somatic Sensory: External Ear
• Visceral Sensory: Aortic Arch/Body
• Special sensory: Taste Over Epiglottis
• Somatic Motor: Soft Palate, Pharynx, Larynx (Vocalization and Swallowing)
• Visceral Motor: Bronchoconstriction, Peristalsis, Bradycardia, Vomitting

• Asymmetric palate while saying ‘Aaah’, poor gag reflex
XI: Spinal Accessory

Motor

• Somatic Motor: Trapezius, Sternocleidomastoid

• Drooping shoulder. Weakness turning head in one direction, difficult to shrug shoulders against resistance.
XII: Hypoglossal

• Somatic Motor: Tongue

• Observe tongue while on floor of mouth. Twitching can suggest XII injury.
Branchial Origin of Speech-Related Muscles

- Speech related muscles = visceral?
- Six branchial arches present in embryo
  One disappears during development
- Some cranial nerves originate from 5 branchial arches and are special visceral efferent nerves
- Speech related nerves Include
  - Trigeminal (V)
  - Facial (VII)
  - Glossopharyngeal (IX)
  - Superior laryngeal and recurrent laryngeal branches of Vagus (X)
Cranial Nerve Nuclei

• Midbrain (3)- Control Eye Muscles
  – Two Motor N. of Oculomotor
  – One Motor N. of Trochlear

• Pons (6)
  – Three Sensory N. of Trigeminal
    • Mesencephalic N.
    • Primary Sensory N.
    • Spinal Trigeminal N.
  – Motor N. of Trigeminal N.
  – Abducens N.
  – Facial Motor N.
Cranial Nerve Nuclei: Medulla (9)

1. Cochlear N. (Hearing)
2. Vestibular N. (Equilibrium)
3. Salivary N. (Secretions)
4. Dorsal Motor N. of Vagus (Visceral Motor)
5. Hypoglossal N. (Tongue)
6. Nucleus Solitarius (Visceral Sensory) *afferent swallowing*
7. Spinal Trigeminal N. (Sensory)
8. Nucleus Ambiguus (Laryngeal & Pharyngeal Motor) *efferent swallowing*
9. Inferior Olivary N. (Info to Cerebellum)
Pathways - Corticobulbar Motor

• Corticobulbar tract
  – Fibers between cortex and brain stem

• Cross midline at different levels
  – Upper and Lower Motor Neurons

• Clinical Signs:

  – Upper Motor Neuron
    ● Spasticity
    ● Increased Tendon Reflexes
    ● Contralateral Paresis

  – Lower Motor Neuron
    ● Paralysis
    ● Absent Reflexes
    ● Flaccid Muscle Tone
    ● Fibrillation
    ● Fasciculations (twitching)
    ● Atrophy
Pathways - Sensory

• 3 Major types of sensory pathways
  – 1st order - Outside brainstem
  – 2nd order - Cell bodies in gray matter of brainstem
  – 3rd order - Cell bodies in Ventral Posterior Medial Nucleus of Thalamus projecting to cortex in Parietal Lobe

• Smell, hearing and vision are exceptions to rule three
Olfactory Nerve (I)

• Special visceral afferent
• Parts
  – Olfactory Bulb
  – Olfactory Tract
  – Temporal Cortex
Olfactory Nerve (I)

- Fibers pass through
  - foramina in the cribriform plate
  - olfactory bulb
  - olfactory tract
  - temporal cortex (uncus, amygdaloid N. and parahippocampal gyrus).
    - Connects to limbic system and emotional brain.

- Olfactory ability decreases with age

- Anosmia: impaired smell
  - Does infant respond to breast milk/formula on a cotton ball.
  - Ask child to identify familiar odors
Optic Nerve (II)

- Special somatic afferent
- Retina to Optic Nerve to Optic Chiasm
- To Lateral Geniculate Body
- To Optic Radiations
- To Visual Cortex in Occipital Lobe

Clinically:
- Injury results in visual field loss
- Common visual field losses are an excellent way to determine what part of the brain has pathology
The optic tract

- Lesions at different locations lead to different forms of visual field cuts.
- Important diagnostic tool to infer brain injury.
Visual Field Defects/Losses

- Field defects reveal anatomical injury
  A. Monocular blindness
  B. Bitemporal hemianopia
  C. Homonymous hemianopia
  D. Upper quadrantanopia
  E. Lower quadrantanopia
  F. Homonymous hemianopia
Visual Field Defects/Losses
Oculomotor Nerve (III)

• General somatic efferent
  – Innervate extrinsic muscles of eye

• General visceral efferent
  – Provides parasympathetic projections to constrictor fibers of iris and ciliary muscles
  – Provides motor innervation for iris to adjust to light and lens to focus
  – Edinger-Westphal Nucleus - parasympathetic
Clinical Info: Oculomotor Nerve (III)

- Ptosis - eyelid droop
- Ophthalmoplegia
  - problems in adjusting to light
  - Pupillay problems during accommodation
  - deviation of eye movements
  - diplopia (double vision)
Left Oculomotor (III) Nerve Paralysis

- Left eye is deviated laterally
- Does not move medially

Diplopia
Diplopia

Cranial Nerve III Palsey
III, IV, VI Eye Movement

CNs & Muscles That Control Extra Occular Movements

LR- Lateral Rectus
MR- Medial Rectus
SR- Superior Rectus
IR- Inferior Rectus
SO- Superior Oblique
IO- Inferior Oblique

SO ‘4’, LR ‘6’, All The Rest ‘3’
II, IV, VI Palsey

THIRD
vasculopathic
tumor
aneurysm

FOURTH
vasculopathic
tumor
congenital
trauma

SIXTH
vasculopathic
tumor
cranial pressure

http://ophthobook.com/photos/eyepalsy-14-cranialnervepalsy.jpg
Trochlear IV

- General somatic efferent
- Only CN to exit brainstem dorsally
- Only CN that exits contralaterally
- Superior oblique muscle for eye movement is only function
- Clinical
  - Difficulty looking downward and outward when Trochlear is injured
  - Eye drifts upward relative to the normal eye
Trigeminal (V)

- General somatic afferent
- Principal sensory nerve for head, face, orbit and oral cavity
- mediate sensations of pain, temperature, proprioception and fine discriminative touch
- Sensations from anterior 2/3 of tongue
- Three sensory branches
  - Ophthalmic
  - Maxillary
  - Mandibular
Trigeminal (V)
Trigeminal (V)

- Special visceral efferent
- Motor for mastication muscles for chewing and speaking
  - Internal and external pterygoid
  - Temporalis
  - Masseter
  - Mylohyoid
  - Anterior belly of digastric
  - Tensor veli palatini
  - Tensor tympani
- Reflex for jaw jerk reflex (mandibular)
Trigeminal (V)

- Ophthalmic
- Maxillary
- Mandibular
Motor Branch of Trigeminal Nerve

- Mylohyoid
- Anterior belly of digastric
- Tensor palatine
- Tensor tympani
- Temporalis muscle
- Masseter muscle
- Pterygoid muscles
  - Lateral (external)
  - Medial (internal)
Clinical Info: Trigeminal (V)

• Sensory
  – Test for touch discrimination in different facial zones
  – Check for sneeze and corneal reflexes
  – Tic of douloureux (trigeminal neuralgia) which is excruciating pain

• Motor
  – Check for paralysis or paresis of ipsilateral muscles of mastication
  – Check for absent or exaggerated jaw reflex
  – Look for deviation of jaw toward side of injury
  – Unilateral lesion has mild effect on bite strength while bilateral has severe effect
    • Check how the infant sucks
Abducens (VI)

• General somatic efferent
• Innervates only a single muscle: lateral rectus muscle which moves eye laterally

• Clinical Info:
  – When injured, medial rectus muscle is unopposed – eye shifts medially
  – Susceptible to disruption
  – Check for medial strabismus
    • Turns in medially
    • Double vision
Left Abducens (VI) Nerve Paralysis

- Diplopia Disappears on Eye Movement to the Right
Facial Nerve (VII)

• General visceral efferent
  – Parasympathetic innervation of lacrimal gland and palatal saliva
  – Innervation of mucous membrane secretions in mouth and pharynx

• Special visceral afferent
  – Gustatory sensations from anterior 2/3 of tongue
Facial Nerve (VII)

- Special visceral efferent
- Primary motor nerve for facial muscles
- Extrinsic Muscles of ear
  - Stapedius Muscle
    - Contraction attenuates sound
- Swallowing
  - Stylohyoid Muscle
  - Posterior Belly of Digastric Muscle
- Lacrimal secretion - Tears
Clinical Info: Facial Nerve (VII)

• Upper Motor Neuron Disease
  – Why is it hard to only raise one eyebrow?
  – Unilateral paresis of muscles of lower half of face
  – Muscles above bilaterally innervated
  – Bilateral lesion can cause paralysis of upper and lower muscles bilaterally

• Lower Motor Neuron Disease
  – Injury near pons can cause lower motor neuron disease
  – Unilateral Paralysis of all facial muscles, stapedial muscle and taste in 2/3 of tongue
Clinical Examples: Facial Nerve

UMN

LMN
Clinical Examples: Facial Nerve
Clinical Info: Facial Nerve (VII)

• Bell’s Palsy
  – LMN syndrome with sudden onset of paralysis of ipsilateral facial muscles
  – Inflammatory injury, infection or degenerative disease
Vestibulo-acoustic Nerve (VIII)

• Special somatic afferent
• Vestibular Nerve
  – Gives feedback about position of head in space and balance
• Acoustic Nerve
  – Hearing
• Clinical Info
  – Tests for equilibrium, vertigo or dizziness, nystagmus and hearing loss
Glosso-pharyngeal Nerve (IX)

• General visceral afferent
  – Mediates general visceral sensation from soft palate, palatal arch, posterior 1/3 of tongue and carotid sinus

• General visceral efferent
  – Secretion from parotid gland (salivary gland)

• Special visceral afferent
  – Taste sensation form posterior 1/3 of tongue

• Special visceral efferent
  – Contributes to swallowing through stylopharyngeus and upper pharyngeal constrictor fibers
Clinical Info: Glosso-pharyngeal (IX)

• May be evident in dysphagia or loss of taste to posterior 1/3 of tongue
• Loss of gag reflex
• Excessive oral secretions
• Dry mouth
• Need bilateral damage of nerve to have strong clinical signs
Vagus Nerve (X)

• General visceral afferent
  – Sensation from pharynx, larynx, thorax, abdomen
  – Regulates nausea, oxygen intake, lung inflation

• General visceral efferent
  – Innervates glands, cardiac muscles, trachea, bronchi, esophagus, stomach and intestine

• Special visceral afferent
  – Mediates taste sensation from posterior pharynx and epiglottis

• Special visceral efferent
  – Controls muscles of larynx, pharynx, soft palate for phonation, swallowing and resonance
Clinical Info: Vagus Nerve (X)

- Bilateral lesion of the brainstem can be fatal due to respiratory involvement
- Unilateral lesion can result in ipsilateral paresis or paralysis of soft palate, pharynx and larynx
- Pharyngeal Branch
  - Pharynx and soft palate involvement
  - Uvula pulled to unaffected side, bilateral soft palate droops
- Recurrent Laryngeal Branch
  - Unilateral: Paralysis of vocal folds
  - Bilateral: Inspiratory stridor and aphonia
Clinical Info: Vagus Nerve (X)

Normal Soft Palate  Unilateral Paralysis  Bilateral Paralysis
Clinical Info: Vagus Nerve (X)

• Autonomic reflexes reduced
• Anesthesia of pharynx and larynx and loss of taste
• Superior Laryngeal Branch
  – Loss of ability to change pitch
• Passes between the Occiput and the Atlas
  – Adjust, adjust, adjust and listen for borborygmi
    • Tummy gurgles
Spinal Accessory Nerve (XI)

- General visceral efferent
  - Controls head position by controlling trapezius and sternocleidomastoid muscles
- Clinical Information
  - Affects ability to control head movements
  - Ask patient to rotate head and note control
Hypoglossal Nerve (XII)

- General somatic efferent
  - Controls tongue movement
  - Controls extrinsic and intrinsic muscles of tongue except palatoglossal (X)
  - Eating, sucking and chewing reflexes
Clinical Info: Hypoglossal (XII)

• LMN unilateral lesion can cause wrinkling and flaccidity of tone with atrophy over time
• Dysarthria and Dysphagia
• Unilateral UMN lesions do not have much affect as tongue is bilaterally innervated
• Ask patient to complete oral motor movements
Clinical Info: Hypoglossal (XII)

Unilateral Tongue Paralysis

Bilateral Tongue Paralysis
Innervation of the tongue

- **General (tactile, etc.)**
  - Glosso-pharyngeal (IX) Nerve
  - Trigeminal (V) Nerve
- **Special (taste)**
  - Glosso-pharyngeal (IX) Nerve
  - Facial (VII) Nerve
Cranial Nerve Combinations

• More than one nerve involved with some structures
• Eyes muscle control
• Sensory fibers to tongue
  – Anterior 2/3 special and general sensation: Facial and Trigeminal,
  – Posterior 1/3 special and general sensation: Glossopharyngeal
Cranial Nerve Combinations

- Motor Nerve Supply to Soft Palate and Pharynx
  - Vagus, Trigeminal and Glossopharyngeal

- Sensory Nerve Supply to Soft Palate and Pharynx
  - Glossopharyngeal, Vagus and Trigeminal
Nerve Classifications

• This division give rise to a classification based on whether a nerve is:
  • Afferent, efferent, or both
  • Somatic or visceral, or both
  • Special, general, or both
  • The only combination that does not exist is: Special, somatic, efferent.
Case # 1

- Setting: Neonatal intensive care unit (NICU)
- Patient: Pt. is a two-day old male. Delivery was complex and completed with cesarean section, neurological exam suggests a right facial paralysis without other prominent symptoms.

1. What cranial nerve(s) is/are involved?
2. Discuss the probable cause of the right facial paralysis
3. In what cases will the symptoms resolve?
4. What are some possible current functional problems that may be present?
5. What are some possible future functional problems?