Lecture 6: Cranial Nerves

Objective: To understand the organization of cranial nerves with respect to their nuclei within the brain, their course through and exit from the brain, and their functional roles.
Cranial Nerves 1-7 overview

Cranial Nerves and their Functions

<table>
<thead>
<tr>
<th>Name and Number</th>
<th>Brain Region Associated With</th>
<th>Function (Functional Components)</th>
<th>Clinical Examination</th>
<th>Symptom Seen After Injury</th>
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<tbody>
<tr>
<td>Olfactory - I</td>
<td>Cerebrum</td>
<td>Smell (SVA)</td>
<td>Owner’s Observations</td>
<td>Anosmia (Loss of Smell)</td>
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<tr>
<td>Optic - II</td>
<td>Diencephalon</td>
<td>Vision (SSA)</td>
<td>Menace Response</td>
<td>Anopsia (Loss of Vision)</td>
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<tr>
<td>Oculomotor - III</td>
<td>Midbrain</td>
<td>Eye Movement (SE, VE)</td>
<td>Horizontal Eye Movement; Pupillary Light Reflex</td>
<td>Strabismus: eye deviated down &amp; out. Large Pupil</td>
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<tr>
<td>Trochlear - IV</td>
<td>Midbrain</td>
<td>Eye Movement (Dorsal Oblique Muscle: SE)</td>
<td>Extend head and look for dorso-lateral strabismus</td>
<td>Cal; dorsal aspect of vertical pupil deviated laterally</td>
</tr>
<tr>
<td>Trigeminal - V</td>
<td>Pons</td>
<td>Masticatory Movements, sensation from face (SE, GSA)</td>
<td>Jaw movement Eye blink reflex</td>
<td>Bilateral damage = Dropped jaw, Asymmetric chewing, atrophy</td>
</tr>
<tr>
<td>Abducent - VI</td>
<td>Medulla</td>
<td>Eye Movement (Lateral Rectus Muscle; SE)</td>
<td>Lateral Eye Movement</td>
<td>Double vision; Strabismus: eye deviated medially</td>
</tr>
<tr>
<td>Facial - VII</td>
<td>Medulla</td>
<td>Facial Movement; Taste, rostr. tongue (SE, SVA, VE)</td>
<td>Facial Movement</td>
<td>Facial paralysis, drooling</td>
</tr>
</tbody>
</table>
## Cranial Nerves 8-12 Overview

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Section</th>
<th>Function</th>
<th>Sensory/Motor Functions</th>
<th>Other Functions</th>
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<tbody>
<tr>
<td>Vestibulocochlear - VIII</td>
<td>Medulla</td>
<td>Hearing and Balance (SSA)</td>
<td>Vertical Eye Movement</td>
<td>Deafness, Head tilt, Nystagmus</td>
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<tr>
<td>Glossopharyngeal - IX</td>
<td>Medulla</td>
<td>Tongue and Pharynx (GVA, VE, SVA)</td>
<td>Pharyngeal gag reflexes</td>
<td>Choking, Swallowing Difficulty</td>
</tr>
<tr>
<td>Vagus - X</td>
<td>Medulla</td>
<td>Pharynx, Larynx, Heart, Viscera (SE, VE, GVA ...)</td>
<td>Gag reflexes, Blood Pressure, Heart Rate</td>
<td>Hoarseness, Inspiratory Dyspnea</td>
</tr>
<tr>
<td>Spinal Accessory - XI</td>
<td>Medulla</td>
<td>Trapezius, + three neck mm. (SE) sternocephalic</td>
<td>Neck movement</td>
<td>Weakened turning of neck</td>
</tr>
<tr>
<td>Hypoglossal - XII</td>
<td>Medulla</td>
<td>Tongue Muscles (SE)</td>
<td>Tongue movement</td>
<td>Deviation of Tongue toward Side of lesion</td>
</tr>
</tbody>
</table>
I. Factors Responsible for the Complex Internal Organization of the Brain Stem
leads to altered location of cranial nerve nuclei in adult brain stem

1. Development of the Fourth Ventricle
   a. Medulla and Pons develop ventral to the 4th ventricle
   b. Alar plate is displaced lateral to basal plate
2. Cranial nerve nuclei form discontinuous columns
3. Some cranial nerve nuclei migrate from their primitive embryonic positions (e.g., nuclei of V and VII)
Factors responsible for the complex internal organization of the brainstem:

4) Special senses develop in association with the brainstem.

5) Development of the cerebellum and its connections

Nuclei of special senses
II. Cranial Nerve Nuclei: Nucleus = column of neuron cell bodies. Efferent nuclei are composed of cell bodies of alpha or gamma motor neurons (SE) or preganglionic parasympathetic neurons (VE).

III. Motor Efferent Nuclei (Basal Plate Derivatives):

1. SE (Somatic Efferent) Nuclei: SE neurons form two longitudinally oriented but discontinuous columns of cell bodies in the brain stem. Neurons that comprise these columns are responsible for innervating all of the skeletal musculature of the head.
A) Oculomotor, Trochlear, Abducent and Hypoglossal Nuclei-
Are formed by a column of cells located near the dorsal midline of the
brainstem. The nuclei innervate muscles of the tongue (12) and eye
(3, 4 and 6) which are derived from somites.
Damage or lesion to these nuclei or their nerves (III, IV, VI and XII) result in the following clinical signs:

1) **Oculomotor, trochlear or abducent nuclei** (or nerves): abnormalities in eye movement, deviation of the eyes (known as strabismus).

2) **Hypoglossal (XII)**: paralysis or atrophy of tongue muscles; deviation of the tongue toward the side of damage; problems chewing and swallowing.
Strabismus: deviation of the alignment of one eye in relation to the other

- Medial Strabismus
- Ventrolateral Strabismus
- Rotational Strabismus

Damage (lesions) of the 3rd, 4th or 6th cranial nerves or their nuclei of origin cause the following symptoms that can be observed clinically:

- Damage to the Oculomotor nerve
- Damage to the Abducens nerve
- Medial Strabismus
- Ventrolateral Strabismus
- Damage to the Trochlear Nerve
- Rotational Strabismus

Normal Eye Position
Strabismus

- Oculomotor nerve
  - Peripheral
    - Trauma
    - Retrobulbar masses
    - Neurofibroma
    - Lymphosarcoma
  - Central
    - Infection
    - Inflammatory disease
    - Neoplasia

Ventrolateral strabismus
Hypoglossal nucleus (XII Nerve):
Normal Function: Tongue movement;
Damage --> paralysis or atrophy of tongue muscles
B) Motor Nucleus of the Trigeminal N. (cranial n. V), Facial Nucleus (nerve VII) and Nucleus Ambiguus (IX & X) - are formed by a column of cells located in the ventrolateral brainstem-->innervate muscle derived from somitomeres in pharyngeal arches.
Motor Nucleus of the Trigeminal Nerve
Damage to the motor nucleus of the Trigeminal Nerve or to the motor Root--> animal can’t close mouth (drop-jaw).
Location of Facial Nucleus and Nerve

--> innervates muscles of facial expression
Damage to Facial Nucleus or Facial Nerve --> Facial paralysis
Nucleus ambiguus innervates muscles of the soft palate, larynx and pharynx (involved with speech, coughing, swallowing and gag reflexes; damage --> swallowing and vocalization difficulties
2. **VE (Visceral Efferent) Nuclei**: represent the *cranial* portion of the parasympathetic division of the autonomic nervous system (contain preganglionic parasympathetic neurons). Two important nuclei:

1) **Parasympathetic nucleus of III**: innervates the pupillary constrictor muscle & the ciliary body muscle of the eye

2) **Parasympathetic nucleus of the Vagus**: innervates cervical, thoracic and abdominal viscera; damage results in accelerated heart rate, increased blood pressure & GI disturbances
Parasympathetic nucleus of III--damage causes loss of pupillary constriction in response to light in the eye on the side of the lesion.
You examine the Parasympathetic Nucleus of III and its nerve fibers by testing the pupillary light reflex.
Basal plate Nuclei

Alar plate derived nuclei
IV. Sensory Afferent Nuclei (Alar Plate derivatives):
1. GSA (General Somatic Afferent) Nuclei: Represented by the sensory trigeminal complex which is located laterally in the brain stem.
   a) **Nucleus of the spinal trigeminal tract** (spinal trigeminal nucleus)- located in the medulla-relays pain and temperature sensation from the face & mouth
   b) **Pontine nucleus of the trigeminal nerve**: located in the pons, relays touch and pressure sensation from the face and oral cavity
   c) **Mesencephalic Nucleus of trigeminal nerve**- unipolar neurons located in the midbrain, relay proprioceptive information to motor nucleus of V- > control force of animals bite.
Location of the Trigeminal Nuclei in the brain stem

Damage can result in loss of sensation from the face and oral cavity
2. **GVA: General Visceral Afferent Nucleus:** Located lateral to the GVE column and comprised of a single nucleus termed the nucleus of the solitary tract (Nucleus solitarius). GVA portion of this nucleus is associated with cranial nerves IX and X. It mediates visceral sensation from the pharynx, larynx and part of the esophagus.
3. SVA (Special Visceral Afferent) Nuclei; Taste & Olfaction

A. There is a **taste** SVA component in the **nucleus of the solitary tract**. Taste is associated with cranial nerves 7, 9 & 10 which convey taste from the tongue and pharynx. Lesions to nucleus solitarius disrupt taste sensation.

B. The **olfactory nerve** is associated with **olfactory SVA sensation** (smell). Lesions or damage to nerve will interrupt olfaction.
4. **SSA (Special Somatic Afferent Nuclei):** These brainstem nuclei relate to the sense of **vision** (lateral geniculate nucleus), the sense of **hearing** (cochlear nuclei) and the ability to maintain **balance** (vestibular nuclei).

The medullary SSA column related to hearing and balance is located dorsally and laterally in the brain stem and is related to cranial nerve VIII.
**Vision:** The SSA nucleus related to vision is located in the thalamus and is associated with the optic nerve/tract input. Damage to cranial nerves II or VIII or their associated nuclei will have profound effects on the animals ability to see or hear, respectively.

Test cranial nerve II using the Menace Response
And you thought you were tired!