PHYSIOLOGY OF THE BRAIN STEM

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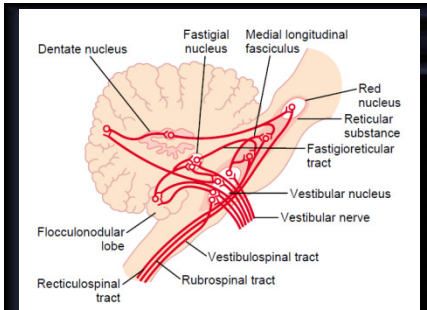


Figure 55–13

Connections of vestibular nerves through the vestibular nuclei (the large oval white area) with other areas of the central nervous system.

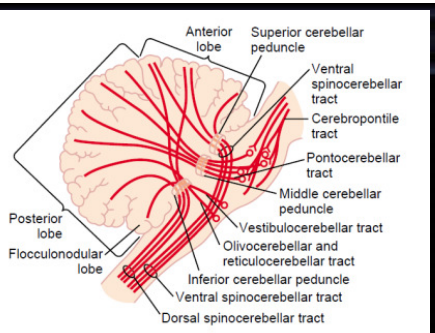


Figure 56–4

Principal *afferent* tracts to the cerebellum.

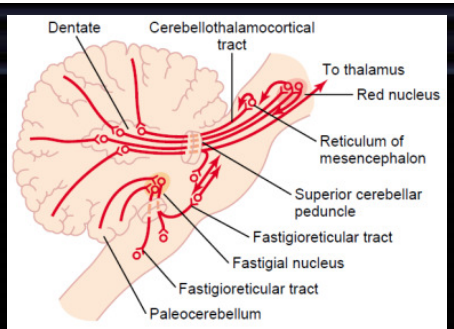


Figure 56–6

Principal *efferent* tracts from the cerebellum.

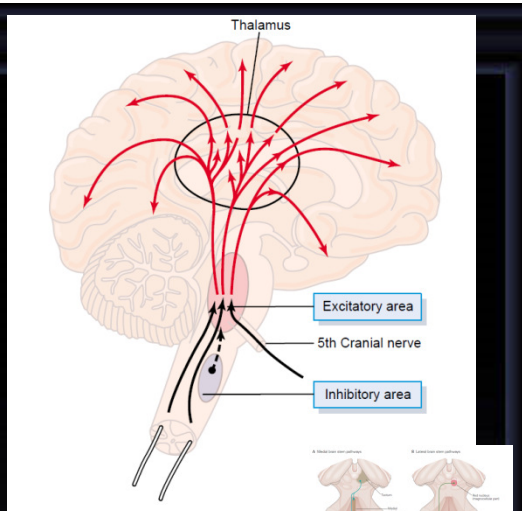


Figure 58–1

Excitatory-activating system of the br
inhibitory area in the medulla that can ir
vating system.

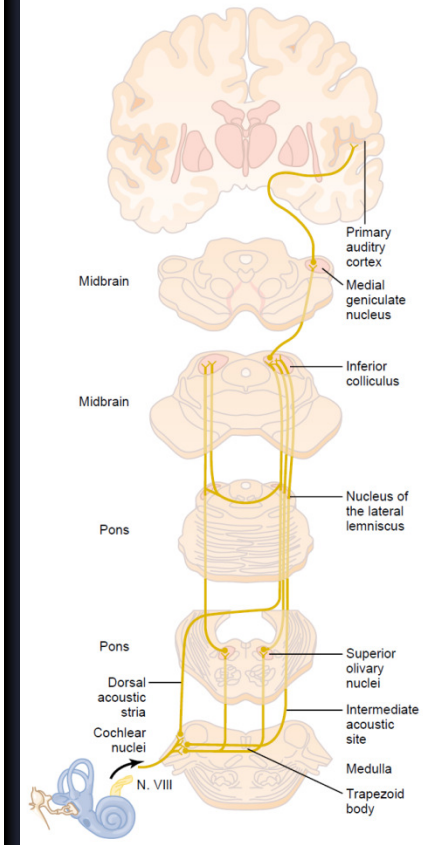


Figure 52–10

Auditory nervous pathways. (Modified from Brodal A: The auditory system. In Neurological Anatomy in Relation to Clinical Medicine, 3rd ed. New York: Oxford University Press, 1981.)

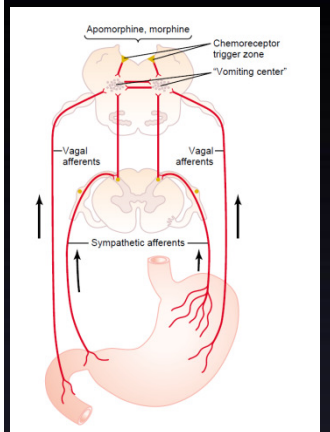


Figure 66–2

Neutral connections of the "vomiting center." This so-called vomiting center includes multiple sensory, motor, and control nuclei mainly in the medullary and pontile reticular formation but also extending into the spinal cord.

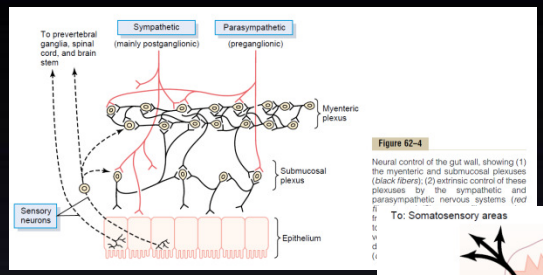


Figure 62–4

Neural control of the gut wall, showing (1) the myenteric and submucosal plexuses (*black fibers*); (2) extrinsic control of these plexuses by the sympathetic and parasympathetic nervous systems (*red fi*

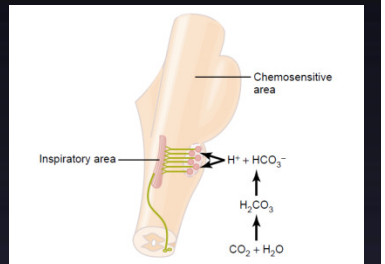
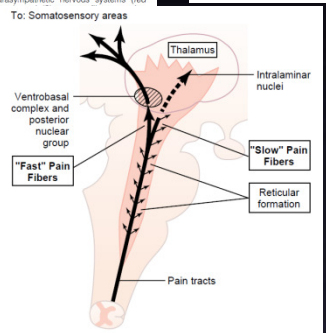


Figure 41–2

Stimulation of the *brain stem inspiratory* area by signals from the *chemosensitive area* located bilaterally in the medulla, lying only a fraction of a millimeter beneath the ventral medullary surface. Note also that hydrogen ions stimulate the chemosensitive area, but carbon dioxide in the fluid gives rise to most of the hydrogen ions.



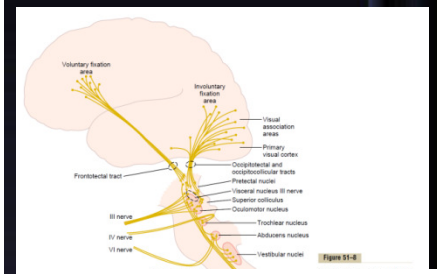


Figure 51–8

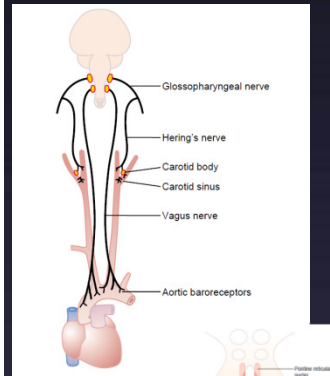
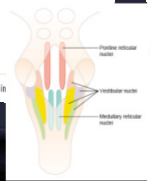


Figure 18–5

The baroreceptor system for controllin



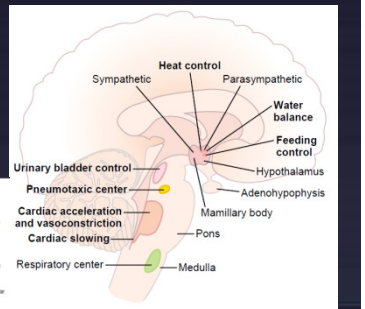


Figure 60–5

Autonomic control areas in the brain stem and hypothalamus.

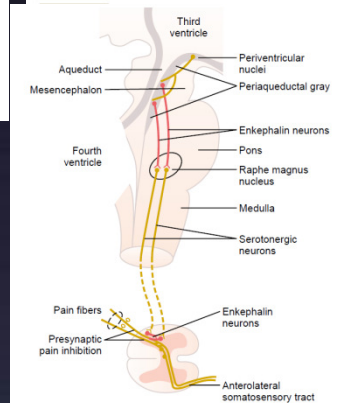


Figure 48–4

Analgesia system of the brain and spinal cord, showing (1) inhibition of incoming pain signals at the cord level and (2) presence of *enkephalin-secreting neurons* that suppress pain signals in both the cord and the brain stem.

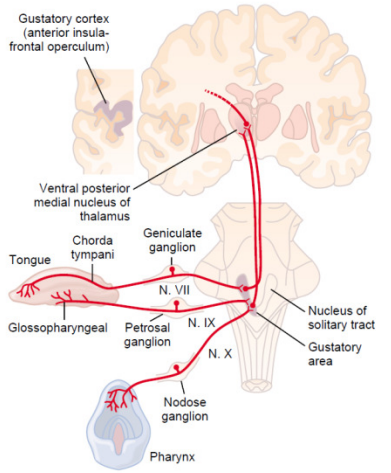


Figure 53–2

Transmission of taste signals into the central nervous system.

OBJECTIVES

At the end of this lecture the student should be able to :

- *Enumarate Components of Brain stem*
- *List Important structures in brain stem*
- *DescribeFunctions of the Brain Stem*
- *Describe Signs & Symptoms of brain stem lesion*
- *Understand brain stem function tests*

A sample Case

A 58 y/o female patient was referred to you because of recent onset of left hemiparesis, left-sided loss of proprioception and right-sided tongue deviation. What CNS structures are affected?

Explain the symptoms with regards to structures affected.

Where is the lesion?

Functions of the Brain Stem

Though it is small, brain stem is an extremely important part of the brain:

1. A Conduct structure (way station) .
2. Provides the origin of the cranial nerves (CN III-XII).
3. Conjugate eye movement motor coordination of the eyes that allows for bilateral fixation on any object.
4. Many many Integrative functions.

Brain Stem Functions

1. Control of respiration
2. Control of the cardiovascular system
3. Partial control of gastrointestinal function
4. Control of many stereotyped movements of the body
5. Control of equilibrium
6. Control of eye movements

Brain Stem Functions (cont.)

- The **autonomic nervous system** is activated mainly by centers located in the spinal cord, brain stem, and hypothalamus (Cardiovascular Gastrointestinal Autonomic Reflexes.)

- Functions of Brain Stem Nuclei in **Controlling Subconscious, Stereotyped Movements** (anencephaly)

- Motor branch of the fifth cranial nerve, and the **chewing** process is controlled by nuclei in the brain stem and also **swallowing, salivary secretion, vomiting** (chemoreceptor trigger zone). The actual mechanics of feeding are controlled by centers in the brain stem.

- **Vasomotor center** for CV control (Baroreceptors) in medulla and **Respiratory** Nuclei

- Brain stem **Neurohormonal Systems** in the human brain for activating four neurohormonal systems

- Many of the **behavioral functions** elicited from the hypothalamus and other limbic structures are also mediated through the reticular nuclei in the brain stem and their associated nuclei.

Brain Stem Functions (cont.)

- Although the **micturition reflex** is an autonomic spinal cord reflex, it can also be inhibited or facilitated by centers in the cerebral cortex or brain stem in pons
- **Accommodation** Is Controlled by Parasympathetic Nerves by 3rd CN
- Neural Pathways for Control of **Eye Movements**. also shows brain stem nuclei for the third, fourth, and sixth cranial nerves by medial longitudinal fasciculus
- **Auditory Nervous Pathways** → superior olivary nucleus
- Nucleus of tractus solitarious → **Taste pathway** → Sup & Inf Salivatory Nuclei
- Bulboreticular facilitatory area of brain stem for **gamma efferent system** (stabilizes joints)
- Control of Cerebral Activity by Continuous Excitatory Signals from the Brain Stem (**Reticular Excitatory Area of the Brain Stem** → bulboreticular facilitory area→it is the same brain stem reticular area that transmits facilitatory signals to maintain tone in the antigravity muscles and spinal cord reflexes.

INTEGRATIVE FUNCTIONS

- It controls **consciousness & sleep cycle** (alertness and arousal) through reticular formation.
- It has centers for **cough, gag, swallowing and vomiting.**
- Sense of body **balance** (Vestibular functions)
- Substantia nigra which is a part of the basal ganglia is present in midbrain and is involved in **control of movements.**
- Midbrain also contain **red nucleus** which regulate the motor activity through cerebellum.
- Inferior and superior colliculi are situated on the dorsal surface of the midbrain and is involved in **auditory & visual processing** required for head movements.
- **Pain sensitivity control:** Periaqueductal grey matter of mesencephalon is an area which is rich in endogenous opioid and is important in modulation of painful stimuli.

1. Conduct functions (way station)

All information related from the body to the cerebrum and cerebellum and vice versa, must traverse the brain stem.

a) The ascending sensory pathways

- **The spinothalamin tract for pain and temperature sensation.**
- **The dorsal column, fasciculus gracilis, and cuneatus for touch, proprioceptive and pressure sensation.**

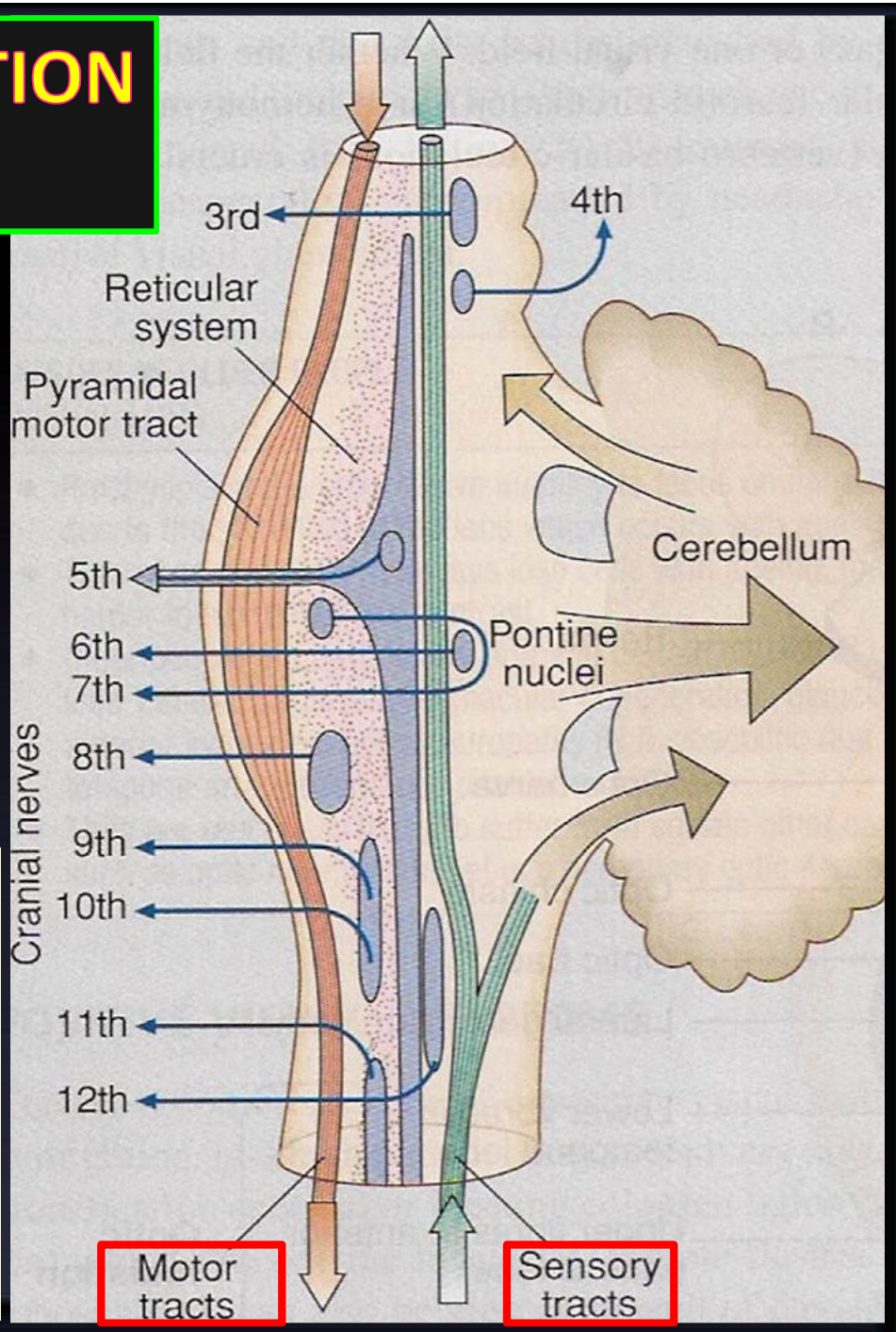
b) Descending motor tracts

- **The corticospinal tract (UMN): runs through the crus cerebri, the basal part of the pons and the medullary pyramids; 70-90 % of fibers cross in the pyramidal decussation**

- Upper motor neurons that originate in the brain stem's vestibular, red, and reticular nuclei, which also descend and synapse in the spinal cord.

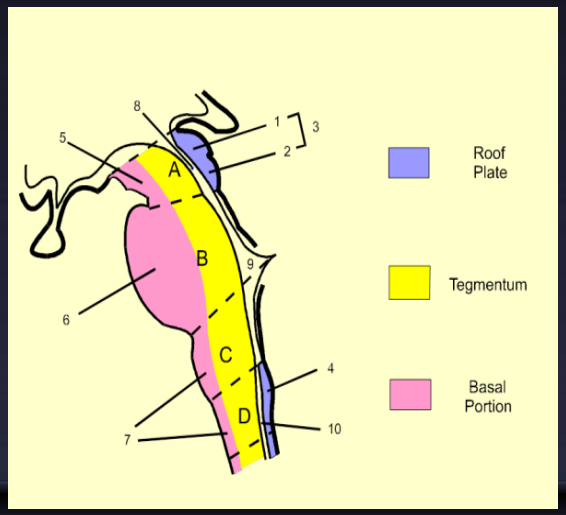
FUNCTIONAL ORGANIZATION OF THE BRAIN STEM

- Ventral layer of brainstem is **MOTOR** in function.
- Middle layer is **SENSORY** in function & contains medial lemniscus which conveys sensory information from dorsal column.



Basic Structure of Brain Stem

1. Roof Plate
2. Tegmentum
3. Basal Portion



Origin & functions of the cranial nerves

FROM MIDBRAIN

- CN III (oculomotor)
- CN IV (trochlear)

  Both moves eyes; CN III constricts the pupils, accommodates.

FROM PONS

- CN V (trigeminal): Chews and feels front of the head.
- CN VI (abducens): Moves eyes.
- CN VII (facial): Moves the face, tastes, salivates.
- CN VIII (acoustic): Hears, regulates balance.

FROM MEDULLA

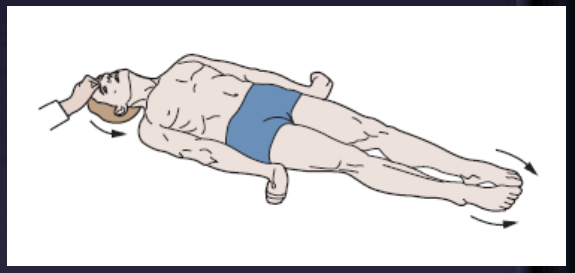
- CN IX (glossopharyngeal): Tastes, salivates, swallows, monitors carotid body and sinus.
- CN X (vagus): Tastes, swallows, lifts palate, talks, communication to and from thoraco-abdominal viscera.
- CN XI (accessory): Turns head, lifts shoulder.
- CN XII (hypoglossal): Moves tongue.

FUNCTIONS OF MIDBRAIN

- Nerve pathway to cerebral hemispheres.
- Auditory and Visual reflex centers.
- Cranial Nerves:
- CN III - Oculomotor [motor]. (Related to eye movement).
- CN IV - Trochlear [motor]. (Superior oblique muscle of the eye which rotates the eye down and out).

Signs & Symptoms of midbrain lesion

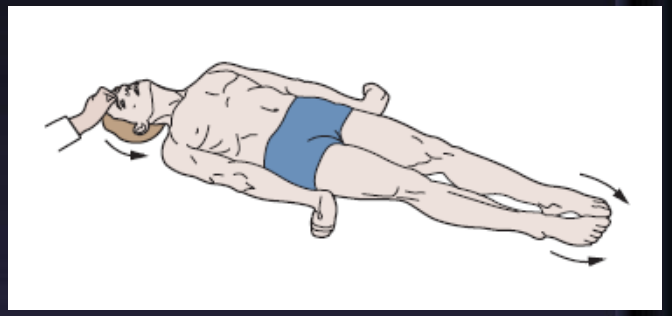
CN Deficits: Ipsilateral CN III, CN IV palsy and ptosis (drooping).
Pupils: Size: Midposition to dilated.
Reactivity: Sluggish to fixed.
Posture: Abnormal extensor response (Lower).
Respiratory: Hyperventilating.
Loss of consciousness (LOC): Varies



FUNCTIONS OF PONS

- Respiratory Center.
- Cranial Nerves:
  - CN V - Trigeminal [motor and sensory]. (Skin of face, tongue, teeth; muscle of mastication).
  - CN VI - Abducens [motor]. (Lateral rectus muscle of eye which moves eye laterally).
  - CN VII - Facial [motor and sensory]. (Muscles of expression).
  - CN VIII - Acoustic [sensory]. (Hearing)

Signs & Symptoms of pons lesion



- Pupils size: Pinpoint
- LOC: Semi-coma
- Posture: Abnormal extensor response.
- Respiratory: -Apneustic (Abnormal respiration marked by sustained inhalation). -Hyperventilation.
- CN Deficits: CN V, CN VI, CN VII, CN VIII.

FUNCTIONS OF MEDULLA OBLONGATA

- Crossing of motor tracts.
- Cardiac Center.
- Respiratory Center.
- Vasomotor Center (nerves having muscular control of the blood vessel walls)
- Centers for cough, gag, swallow, and vomit.
- Cranial Nerves:

- CN IX - Glossopharyneal [mixed]. (Muscles & mucous membranes of pharynx, the constricted openings from the mouth & the oral pharynx and the posterior third of tongue).
- CN X - Vagus [mixed]. (Pharynx, larynx, heart, lungs, stomach).
- CN XI - Accessory [motor]. (Rotation of the head and shoulder).
- CN XII - Hypoglossal [motor]. (Intrinsic muscles of the tongue).

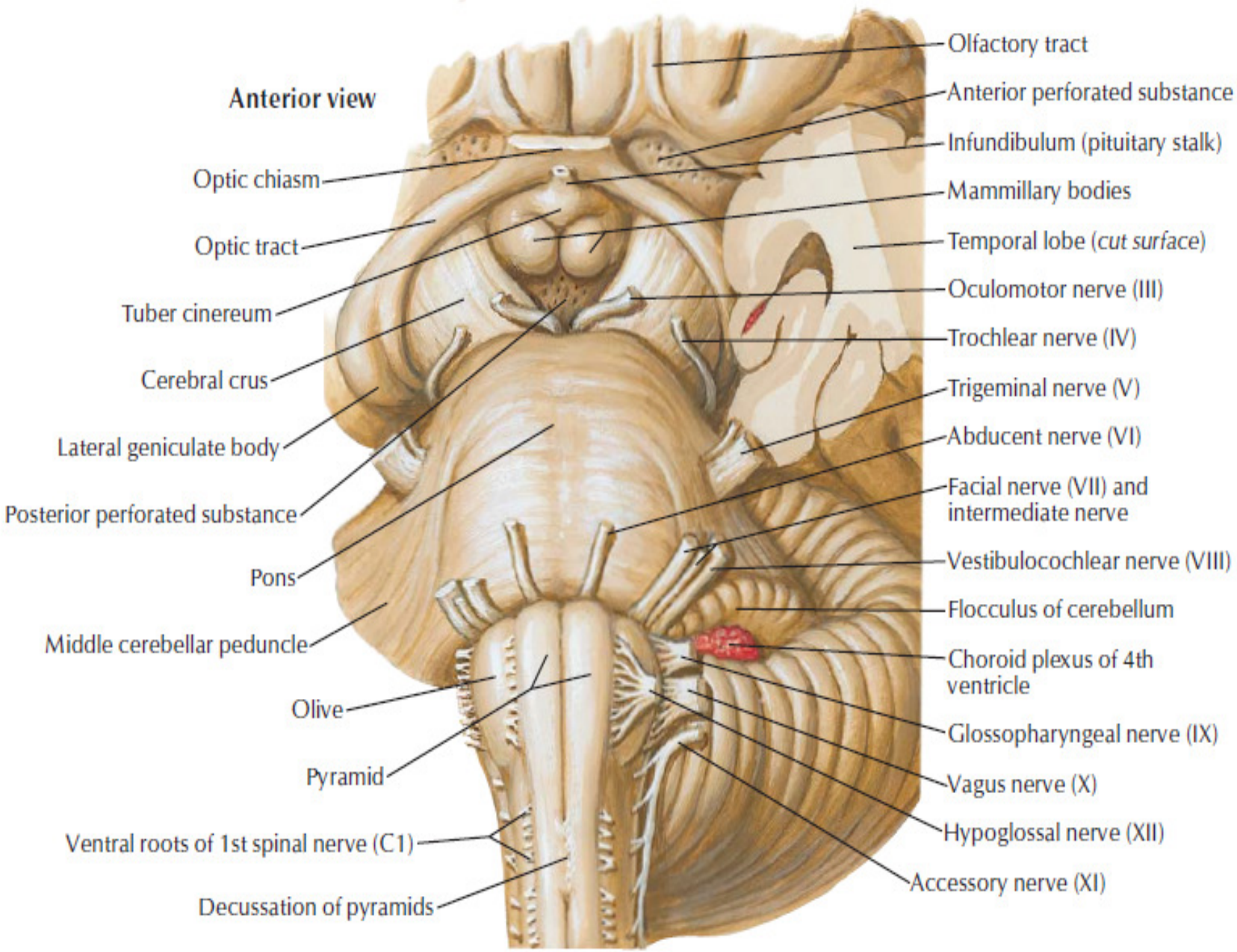
Signs and symptoms of lesion in medulla

- Movement: Ipsilateral paralysis.
- Pupils: Size: Dilated. Reactivity: Fixed.
- Respiratory: Abnormal breathing patterns
- CN Palsies: Inability to control movement. Absent cough & gag reflex.
- LOC: Comatose.

BRAIN STEM FUNCTION TESTS

- **To test reticular formation**
  - Alertness, Consciousness & Sleep.
- **Corticospinal tract**
  - Motor power, reflexes
- **Pain response**
  - Facial grimacing on firm pressure over the supra orbital ridge.
- **To test respiratory center**
  - look for the normal pattern of respiration

- **To test cardiovascular functions**
  - Look for normal circulatory function
- **To test brainstem reflexes:**
  - Pupilary and corneal reflexes.
  - Vestibulo-ocular reflex: Injection of iced water into the ear will produce eyes movement.
  - Oculo-cephalic reflex: Eyes will be fixed when head is moved in one or another directions.
  - Gag reflex.
  - Cough reflex


Anterior view
Optic chiasm
Optic tract
Tuber cinereum
Cerebral crus
Lateral geniculate body
Posterior perforated substance
Pons
Middle cerebellar peduncle
Olive
Pyramid
Ventral roots of 1st spinal nerve (C1)
Decussation of pyramids
Olfactory tract
Anterior perforated substance
Infundibulum (pituitary stalk)
Mammillary bodies
Temporal lobe (cut surface)
Oculomotor nerve (III)
Trochlear nerve (IV)
Trigeminal nerve (V)
Abducent nerve (VI)
Facial nerve (VII) and intermediate nerve
Vestibulocochlear nerve (VIII)
Flocculus of cerebellum
Choroid plexus of 4th ventricle
Glossopharyngeal nerve (IX)
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)

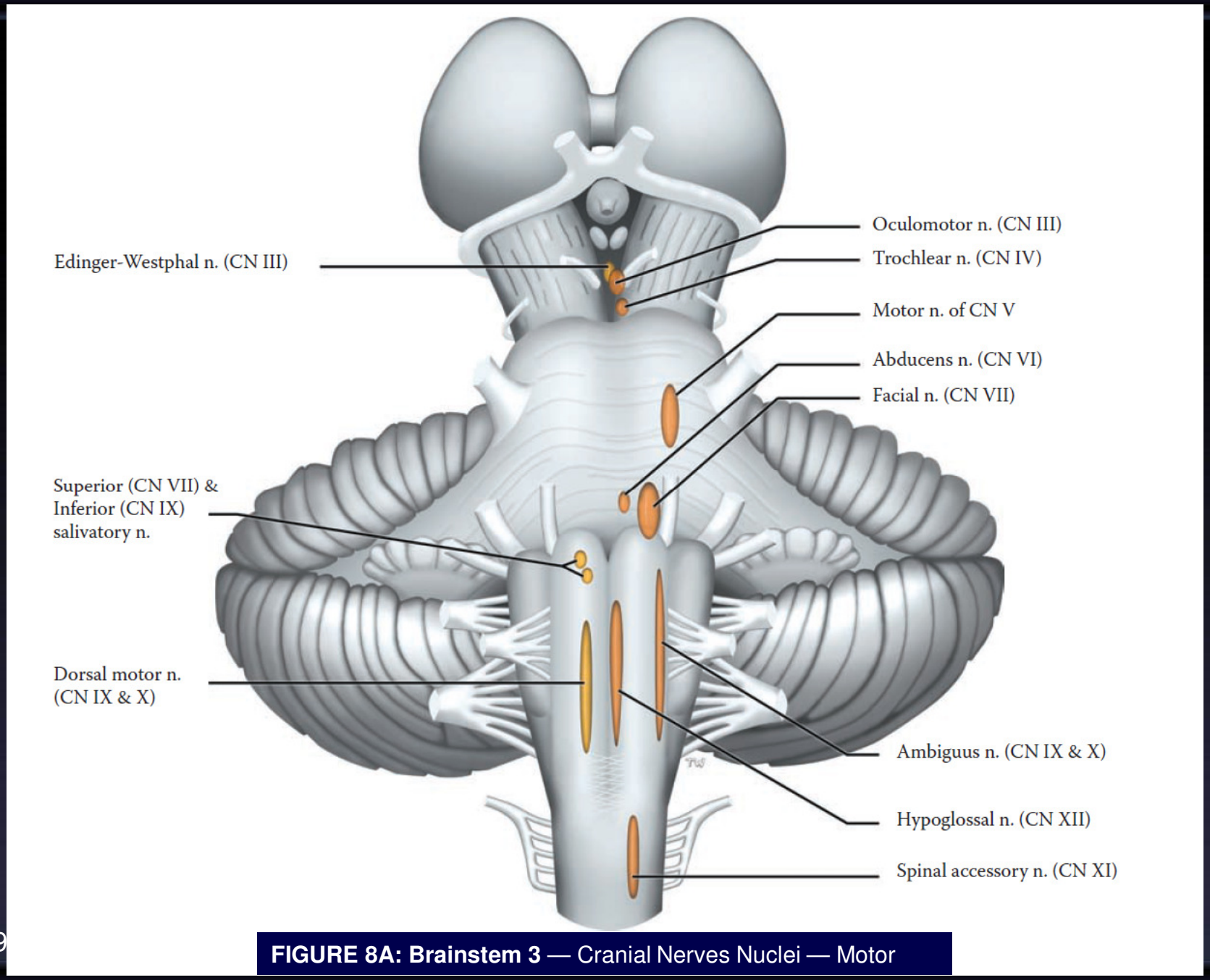


FIGURE 8A: Brainstem 3 — Cranial Nerves Nuclei — Motor

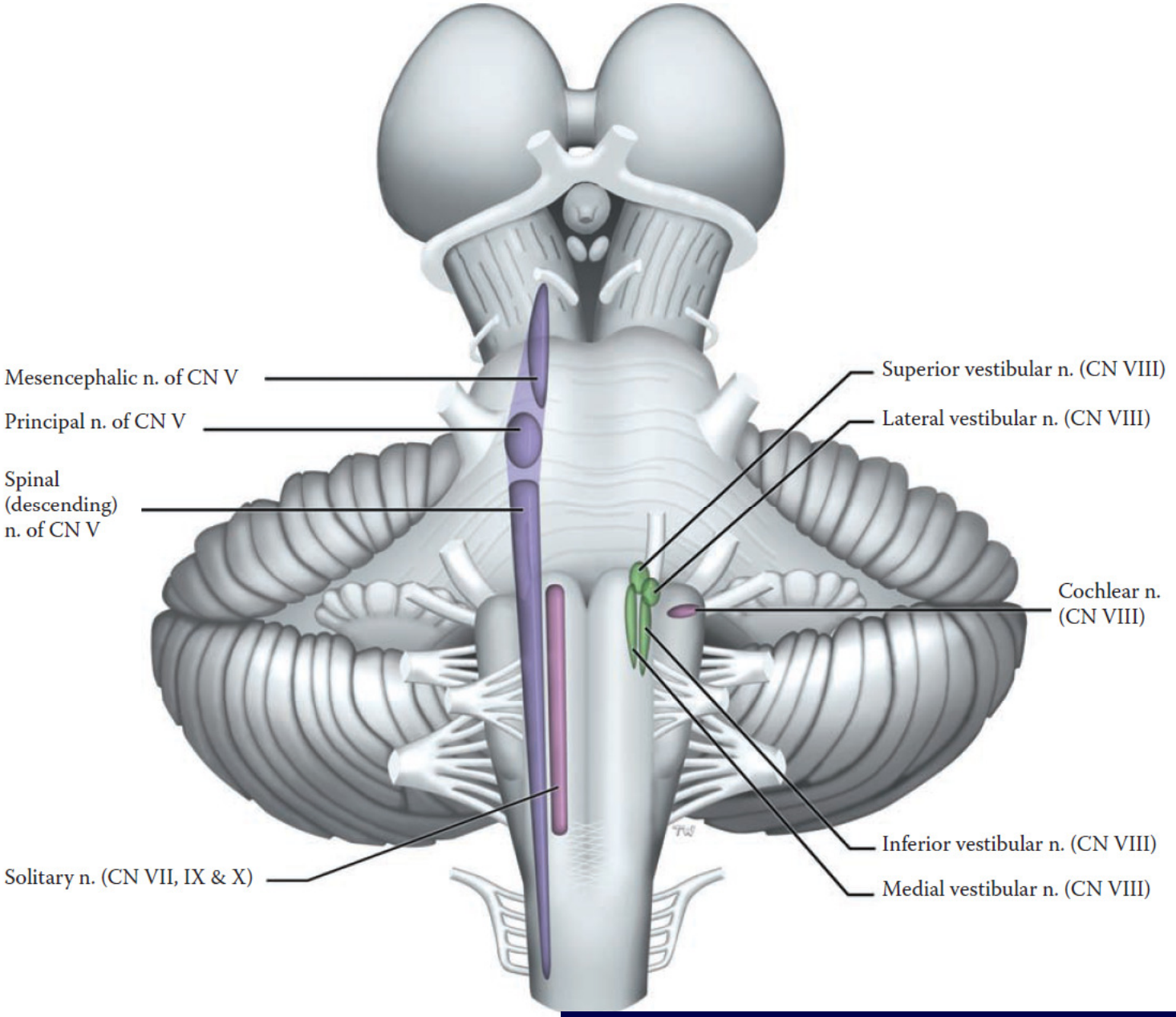


FIGURE 8B: Brainstem 4 — Cranial Nerves Nuclei — Sensory

1. 4 structures in 'midline' and begin with 'M'	•Motor pathway (Contralateral weakness) •Medial leminiscus (Contralateral propioception/ vibration loss) •Medial longitudinal fasciculus (Ipsilateral internuclear ophthalmoplegia) •Motor nucleus and nerve (Ipsilateral CN Func Loss)
2. 4 motor nuclei in midline and are those that are divisors of 12 (3,4,6,12)	•CN divides number 12 •CN 3, 4, 6, 12 are midline •3, 4, 6, 12 nucleus are midline •5, 7, 9, 11 lateral
3. 4 structures to the 'side' (lateral) and begin with 'S'	•Spinocerebellar pathway (Ipsilateral ataxia) •Spinothalamic pathway (Contralateral pain/temp sensory loss) •Sensory nucleus of CN5 (Ipsilateral pain/ temp loss in face) •Sympathetic pathway (Ipsilateral Horner's Syndrome)
4. 4 CN in medulla, 4 in pons and 4 above pons	Medulla:9,10,11,12 Pons: 5,6,7,8 Above Pons:1,2,3,4

*Gates, P. The rule of 4 of the brainstem: Internal Medicine Journal 2005; 35: 263-266

Midline Structures	DEFICIT
Motor pathway (Corticospinal tract)	Contalateral weakness
Medial lemniscus	Contralateral propioception/ vibration loss
Medial longditudinal fasciculus	Ipsilateral internuclear ophthalmoplegia
Motor nucleus and nerve	Ipsilateral CN function loss

Lateral Structures	DEFICIT
Spinocerebellar pathway	Ipsilateral ataxia
Spinothalamic	Contralateral pain/temp sensory loss
Sensory nucleus of CN5	Ipsilateral pain/ temp loss in face
Sympathetic pathway	Ipsilateral Horner's syndrome

4 CN Medulla

	DEFICIT
Glossopharyngeal CN9	Ipsilateral pharyngeal sensory loss
Vagus CN10	Ipsilateral palatal weakness
Spinal accessory CN11	Ipsilateral shoulder weakness
Hypoglossal CN12	Ipsilateral weakness of tongue

4 CN Pons	DEFICIT
Trigeminal CN5	Ipsilateral facial sensory loss
Abducent CN6	Ipsilateral eye abduction weakness
Facial CN7	Ipsilateral facial weakness
Auditory CN8	Ipsilateral deafness

4 CN Above Pons

DEFICIT

Olfactory CN1	Not in midbrain
Optic CN2	Not in midbrain
Occulomotor CN3	Eye turned out and down
Trochlear CN4	Eye unable to look down when looking towards nose

A sample Case

A 58 y/o female patient was referred to you because of recent onset of left hemiparesis, left-sided loss of proprioception and right-sided tongue deviation.

58 year old woman		
•Left hemiparesis •Left-sided loss of propioception •Right-sided tongue deviation	•Motor (CS tract, R) •Medial lemniscus, R •CN12, R	•Medial •Medial •Medulla Medial

Medial medullary syndrome (R)

Vertebral artery, medullary branch (R)

A sample Case

A 58 y/o female patient was referred to you because of recent onset of Left-sided meiosis, anhydrosis, ptosis, •Left-sided ataxia, Uvula deviated to right

58 year old woman **•Left-sided meiosis, anhydrosis, ptosis** **•Left-sided ataxia** **•Uvula deviated to right**	**•Sympathetic tract, Left** **•Spinocerebellar** **•CN10, Left**	**•Side, Left** **•Side, Left** **•Medulla**

Lateral medullary syndrome (L)

Posterior inferior cerebellar artery (L)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