CENTRAL NERVOUS SYSTEM

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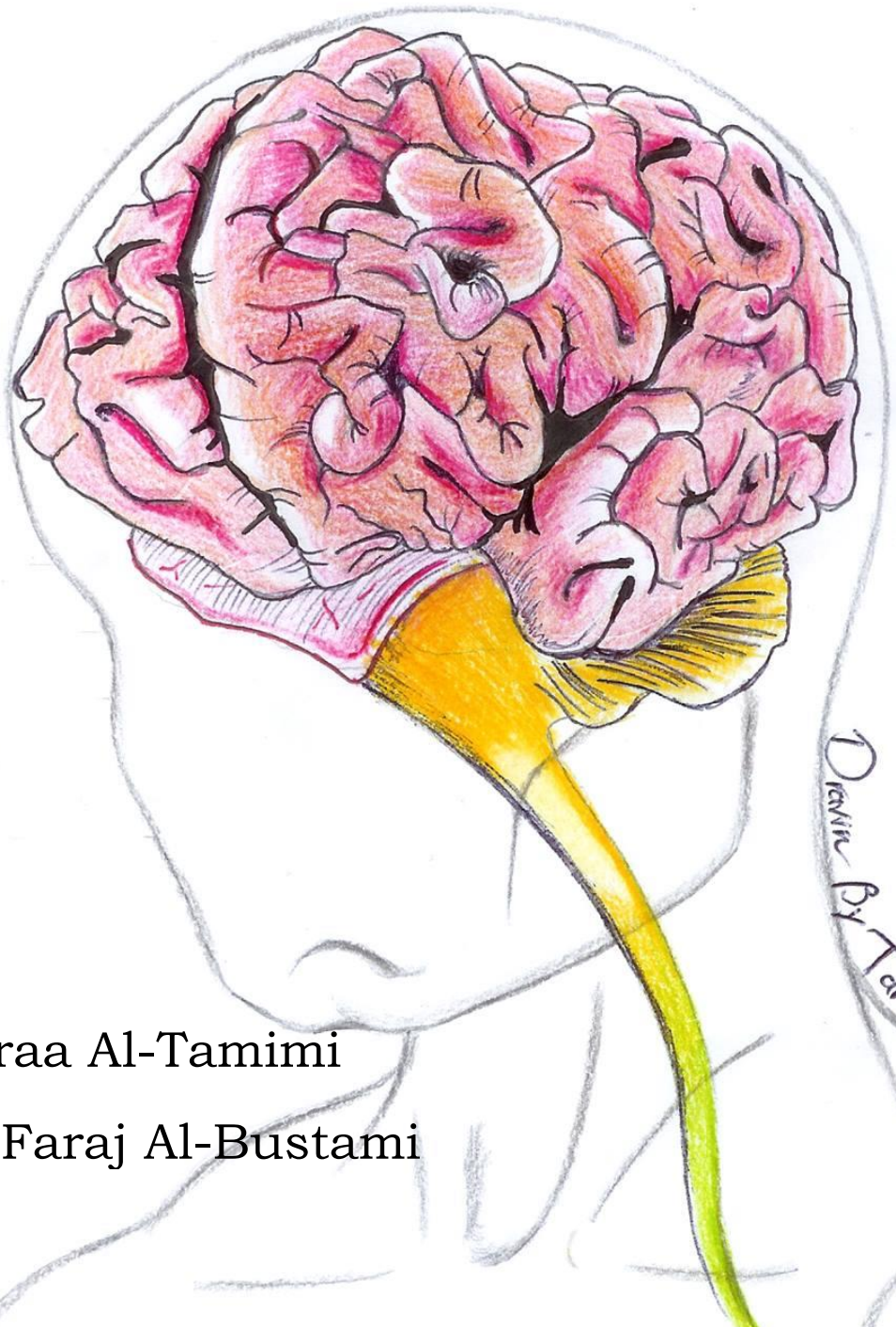


Drawn By Tariq Bushnaq...

Done By: Zahraa Al-Tamimi

Dr. Name: Dr. Faraj Al-Bustami

Lec #: 18

CRANIAL NERVES

In this lecture, we will talk about two cranial nerves, the Trigeminal nerve (CNV) and the Facial nerve (CNVII).

Before we do that, however, we should review some things.

- The most important part of the internal capsule is the posterior limb. A lesion in the posterior limb leads to contralateral spastic hemiplegia, contralateral weakness of the face (the angle of the mouth deviates to the side of the lesion), and contralateral temporary hemianesthesis (the patient regains sensations later but only crudely, at the level of the thalamus).
- The sensory cortex is necessary for stereognosis and discriminative touch (two point discrimination). It's made of 4 areas, 3a, 3b, 1, 2. 3a and 2 are responsible for proprioception, while 3b and 1 are responsible for cutaneous sensations (exteroception).
- A lesion in the internal capsule prevents the connection between the thalamus and the cortex (sensory radiation, which is part of the internal capsule). The patient can regain sensations eventually, crudely at the level of the thalamus, EXCEPT stereognosis and discriminative touch.
- The geniculocalcarine tract (the optic radiation) is located in the retrolentiform part of the internal capsule. If all of the optic radiation is injured (this doesn't usually happen/it's rare), we get contralateral homonymous

hemianopia. Therefore, an extensive lesion in the internal capsule involving the posterior limb and the retrolentiform part results in **contralateral** hemiplegia, hemianesthesia, hemiface and **homonymous hemianopia**.

- If the lesion was very extensive and involved the posterior limb, retrolentiform part and sublentiform part "auditory radiation" (again, this is rare), we get impaired hearing bilaterally but mostly on the contralateral side (plus everything we mentioned above).
- The **blood supply of the internal capsule** is important because most injuries occur there. The blood supply to the anterior limb, genu, and posterior limb is primarily from the lenticulostriate arteries. These parts of the internal capsule receive blood from the central/perforating branches of the middle cerebral artery (including the lateral striate arteries).
    1. **Part of the Anterior limb:** medial striate artery aka recurrent artery of Heubrner (from the anterior cerebral artery).
    2. **Genu:** middle cerebral and directly from internal carotid.
    3. **Posterior limb:** anterior choroidal (lower part) and middle cerebral.
    4. **Retrolentiform (optic radiation):** anterior choroidal.

    Medulla: vertebral artery branches.
    Pons: basilar artery.
    Midbrain: posterior cerebral.

- Before the basilar artery divides into the posterior cerebral it gives off a branch called superior cerebellar. The oculomotor nerve (CNIII) lies between the posterior cerebral and the superior cerebellar. An **aneurysm** in the posterior cerebral artery could compress and damage the oculomotor nerve.
- A lesion in the oculomotor nerve leads to a downward and outward deviation of the eye (external squint). Results in double vision, marked ptosis, and dilated pupil that is not responsive to light or accommodation reflexes. (Remember: mild ptosis is seen in Horner's syndrome)

Please study the blood supply well. It's very important.

Corneal Reflex:

Afferent: CNV-Trigeminal (nasociliary from ophthalmic division). Sensation from the cornea.

Efferent: CNVII-Facial. To orbicularis oculi to close eyes.

HAS NOTHING TO DO WITH THE OCULOMOTOR NERVE. Oculomotor nerve is a motor nerve but this reflex is a sensory reflex.

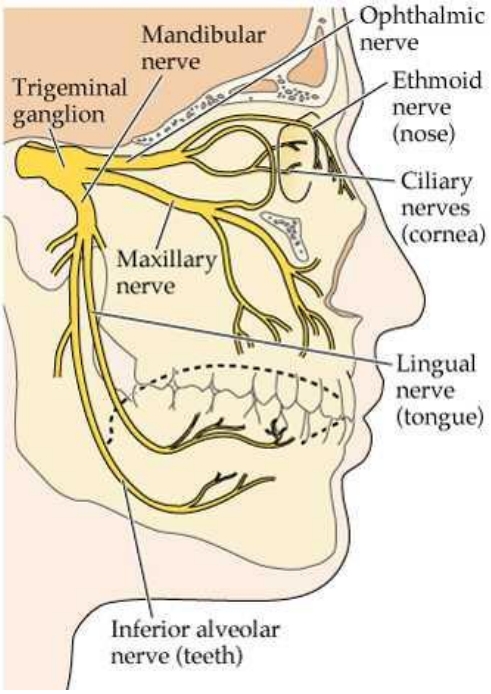
Hemiplegia could result from a lesion in the internal capsule, cortex, or in the brain stem. We can tell it's in the brain stem if there is damage of a cranial nerve. In this case, the lesion is on the same side as the manifestation of the cranial nerve injury.

TRIGEMINAL NERVE (CNV):

Functional components:

1. Sensory (most of the nerve): GSA. Bringing sensation from the body wall.
2. Motor (small part of the nerve; mandibular): SVE to muscles of mastication (medial pterygoid, lateral pterygoid, masseter, temporalis) and other 4 muscles. Derived from the 1st arch).

Every spinal nerve carries on its dorsal root a ganglion because every spinal nerve has a sensory component. Each cranial nerve that has a sensory component should also have a ganglion (1st order neuron). 3/4 of the trigeminal nerve is sensory so we expect to have a large ganglion at the base of the skull, at the apex of the petrous part of the temporal bone. Inside the trigeminal ganglion there are pseudo-unipolar or bipolar cells. They have a peripheral process (from receptors) and a central process (to the sensory nucleus "2nd order neuron"). The peripheral process of the trigeminal nucleus forms the ophthalmic division, maxillary division and the sensory part of the mandibular division of the trigeminal nerve.



Three sensory nuclei (2nd order neurons) belong to the trigeminal.

1. Spinal trigeminal nucleus: receives pain and temperature from a wide area. It's divided into:
   i) **Pars oralis:** the most rostral part. It receives touch sensation from the mouth.
   ii) **Pars interpolaris:** receives pain from the teeth.
   iii) **Pars caudalis:** it's the biggest part. It receives all sensations (pain, touch, temperature) from wide areas of the face, like the cornea (involved in the corneal reflex- if you touch one cornea with a cotton ball, both eyes close), skin of the face, nose, and mouth; external ear, middle ear, Eustachian tube; skin of the neck (trough **dorsal rami of C2,3**. C1 has no dorsal ramus). It also receives sensations from the dura matter above tentorium cerebelli via the **ophthalmic** branch of

trigeminal, and below tentorium cerebelli via **C2, C3, and vagus**. In addition, it receives fibers from the pharynx and esophagus.

To summarize all of the above: part of the central processes descend and form the spinal trigeminal tract. They synapse on second order neurons in the spinal trigeminal nucleus.

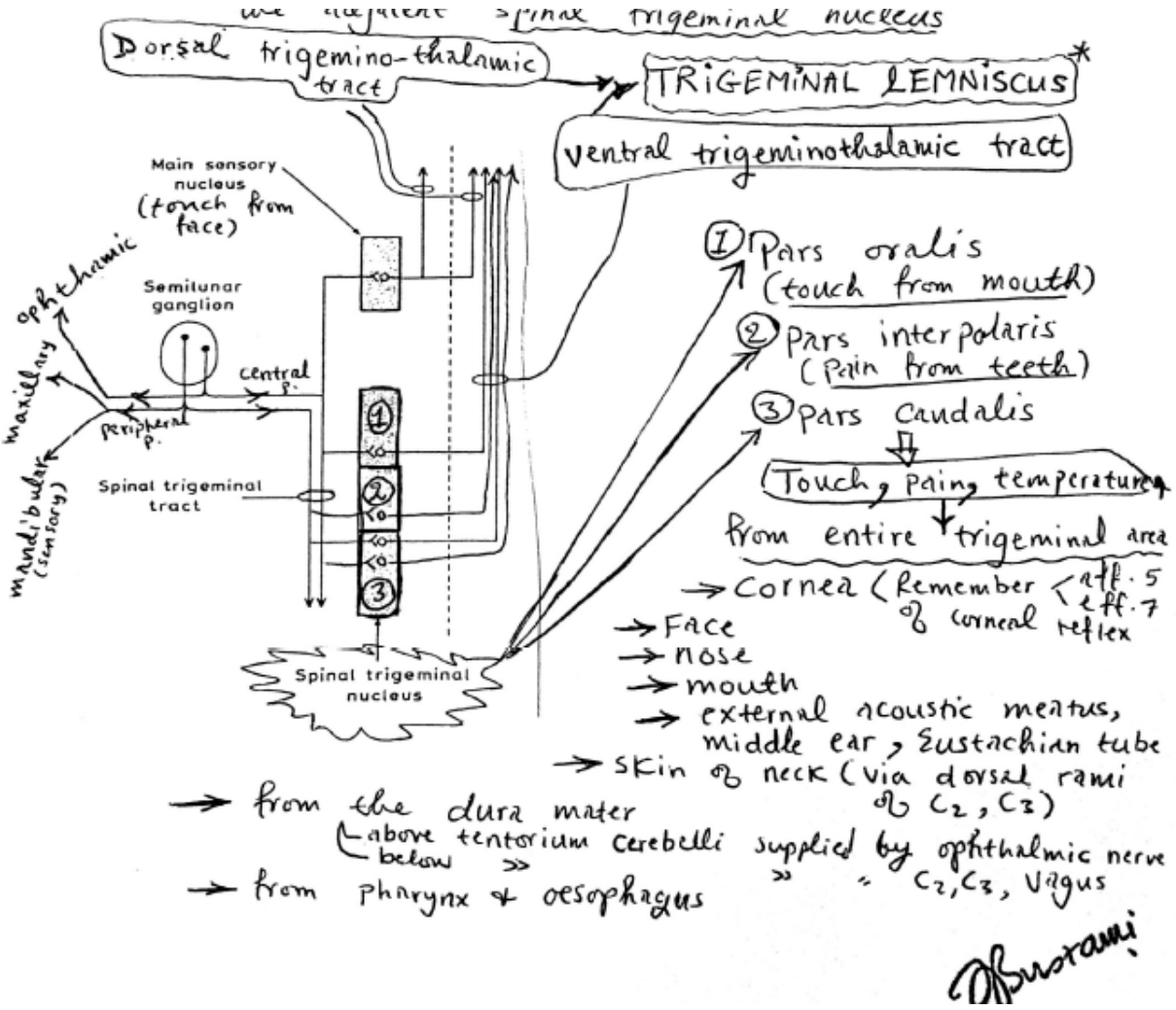
If we follow the axons of the above mentioned 2nd order neurons, we find that they cross the middle line in medulla and form the **ventral trigemino-thalamic tract**, which is part of the **trigeminal lemniscus**. The tract terminates in the third order neurons (**VPM**) in the **thalamus**. From there, fibers travel to the **somatosensory cortex** Area 3a,3b,1,2 (made up of 4 parts not 3!).

Other fibers carrying touch bifurcate: some descend in the spinal trigeminal tract, while others ascend and synapse on the chief sensory nucleus of the trigeminal nerve (in the Pons), which receives half of the touch sensations of the face.

From the Handout: The central processes enter the lateral aspect of the Pons and distribute themselves as follows:

- Some fibers descend in the Pons, Medulla, and down to the level of C2 and C3 spinal segments and form the spinal trigeminal tract. They carry pain and temperature sensations. Throughout their course, they project upon the neurons of the adjacent spinal trigeminal nucleus. Axons of neurons in the spinal trigeminal nucleus cross the midline and form the ventral trigemino-thalamic tract (part of the trigeminal lemniscus).

- Other fibers enter the Pons then divide into ascending and descending branches which convey touch sensations.
    - The descending branches join the spinal tract of the trigeminal nerve and follow the course outlined above.
    - The shorter ascending branches project upon the chief sensory nucleus. The chief sensory nucleus gives off fibers from second order neurons which ascend ipsilaterally and contralaterally, forming the dorsal trigemino-thalamic tract (second part of the trigeminal lemniscus).



Why do some fibers go to the chief trigeminal nucleus, while others are part of the spinal trigeminal tract?

Because touch is very important, it shouldn't follow only one pathway. Not all fibers carrying touch from the face cross to the other side. Some of them stay on the same side.

The dorsal and ventral trigemino-thalamic tracts form the trigeminal lemniscus, which runs in the Pons and the Midbrain until it reaches the thalamus. Once the trigeminal lemniscus reaches the thalamus, it synapses at the VPM, which contains the third order neurons sending their axons to the cortex.

The spinal trigeminal nucleus receives sensations from a wide area of the face:

- The most anterior part of the face sends fibers to the most **upper part of pars caudalis**.
- The **lower part of pars caudalis** receives fibers from C2 and C3.

One can describe the topographical representation of the face in pars caudalis as **onion-like.**

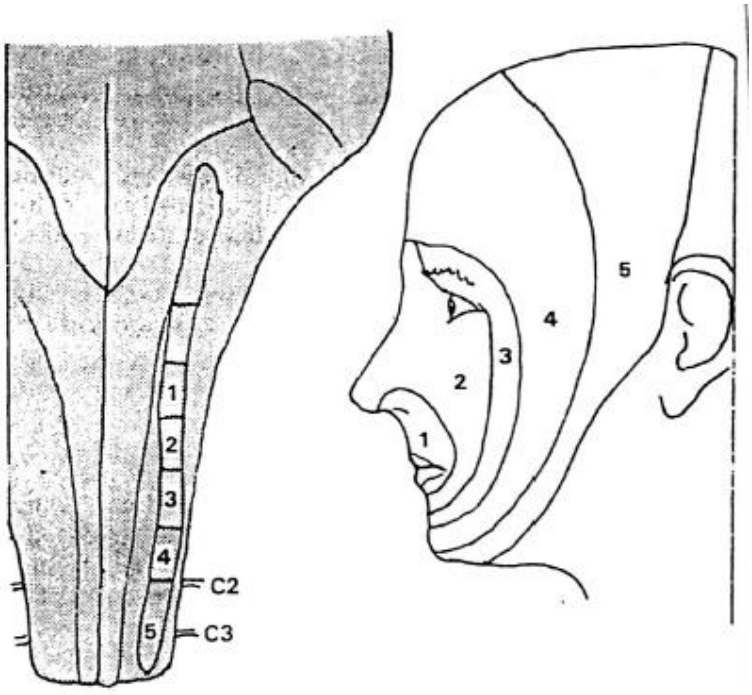


Fig. 34-4 Representation of the face in the pars caudalis of the spinal nucleus of trigeminal nerve. (C1 often has no posterior nerve root.) (Adapted from Sears and Franklin, 1980.)

Now, let's discuss the third trigeminal nucleus, the **mesencephalic nucleus**. It is located in the midbrain and receives proprioception (conscious and unconscious). It contains pseudo-unipolar cells, which are expected to be present in ganglia (outside the brain). The only pseudo-unipolar neurons that are found in the brain not in a ganglion are located in this nucleus. Their central processes go to the thalamus (carrying conscious proprioception) and to the cerebellum (carrying unconscious proprioception). Peripheral processes go to muscle spindles in the muscles of mastication (rich in muscle spindles), extraocular muscles (rich), and muscles of facial expression (poor).

When you chew, sensation is transferred from the temporomandibular joint (TMJ) to the mesencephalic nucleus (so sometimes we call this nucleus "nucleus of bite"?).

Therefore, this nucleus transmits sensation from muscles in the face and the TMJ.

Trigeminal Neuralgia:

Neuralgia: pain somewhere in the body of unknown etiology.

In Trigeminal Neuralgia, the patient complains of attacks of excruciating (severe) pain. This pain could be caused when the wind hits his face, or while brushing his teeth. When the patient points to the site of pain on the face, you need to know exactly what nerve branch supplies it. We need to know the map of the trigeminal nerve.

Fig. 34-6 The five lines required to make a trigeminal sensory map.

Draw a vertical line coming out up from external acoustic meatus. The second line spans from the chin to the external ear. A third line from the lateral angle of mouth to the middle of the first line. The fourth line spans from the lateral angle of eye to the middle of the first line. The last one is from the medial angle of the eye to the ala of the nose. See figure 34-6.

Based on the above diagram, one can conclude that:

- Pain at dorsum of nose is due to the ophthalmic nerve.
- Pain in upper eyelid (skin or conjunctiva**) = ophthalmic
- lower eyelid (skin and conjunctiva) = maxillary
- Ala of nose = maxillary
- upper lip (skin+ mucosa) = maxillary
- lower lip (skin + mucosa) = sensory part of mandibular

**Note: the eyelid is covered from outside by skin and from inside by the conjunctiva. The conjunctiva covers the eye ball and the inside of the eyelid.

It's important to know what each nerve supplies to make a correct diagnosis. Pain could be due to sinusitis and the location of pain can indicate what sinus is affected.

- Pain above eye = frontal air sinus.
- Pain below eye = maxillary sinus.

However, if pain is SEVERE/EXCRUTIATIING, then it's due to trigeminal neuralgia.

Motor part of the Trigeminal Nerve

Not all of the mandibular nerve is motor fibers; it is both sensory and motor fibers.

The motor part of the mandibular nerve supplies the muscles of mastication (medial pterygoid, lateral pterygoid, masseter, temporalis) plus other 4 muscles which include tensor tympani, tensor palatine, mylohyoid, and the anterior belly of the digastric. All these 8 muscles are

derived from the first pharyngeal arch and are supplied by the 1st pharyngeal arch nerve; the motor part of trigeminal nerve (motor part of mandibular).

Injury of the motor part of the mandibular is rare.

When pain of trigeminal neuralgia got unbearable, doctors used to perform surgery to cut a sensory branch (ophthalmic, maxillary, or sensory part of mandibular depending on location of pain). If the surgeon accidentally cuts the motor root, the result would be that when the patient opens his mouth, the lower jaw deviates to side of the lesion.

The lateral pterygoid muscles on the right and left push the mandible up and to the opposite side. What pushes the jaw **to the right side**? The **left lateral pterygoid**. A lesion on the right side affects the right mandibular nerve, so the right lateral pterygoid stops working. As a result, the left lateral pterygoid pushes jaw to the right, the WHOLE MANDIBLE not just the angle of the mouth.

Jaw Jerk:

When you test jaw jerks, don't tap the mandible directly, it could break that way. Put your finger over the mandible just below the lips, and then tap your finger.

Ask the patient to open his/her mouth, tap the mandible as instructed above. The response would be an elevation of the mandible

This jerk is a type of stretch reflex. When you tap the mandible, the masseter gets stretched and activates the

muscle spindle which activates stretch reflex, muscles contract, the mandible is elevated and the mouth is closed.

Hyperreflexia in this reflex can only be seen due to a bilateral stroke (bilateral UMNL). Taping the mandible in the middle causes both the right and left muscles to stretch. Unless there is abnormal muscle tone, strong contraction on both sides won't elevate the mandible. This is the only reflex in which hyperreflexia tests for a bilateral supranuclear lesion. If the lesion was unilateral, we wouldn't see this reflex.

As we said, there are three sensory nuclei for the trigeminal nerve. We talked about the spinal trigeminal nucleus (the largest and most important), the chief sensory nucleus, and the mesencephalic nucleus. The fourth nucleus is the motor nucleus.

The mesencephalic nucleus has central and peripheral processes. The peripheral processes pass in the semilunar (trigeminal) ganglion without doing anything. Usually mother cells are located inside the semilunar ganglion itself (as is the case for the fibers that transfer pain, temperature, and touch in the spinal or chief nuclei). However, the mesencephalic nucleus peripheral processes just pass right through it. See the figure below.

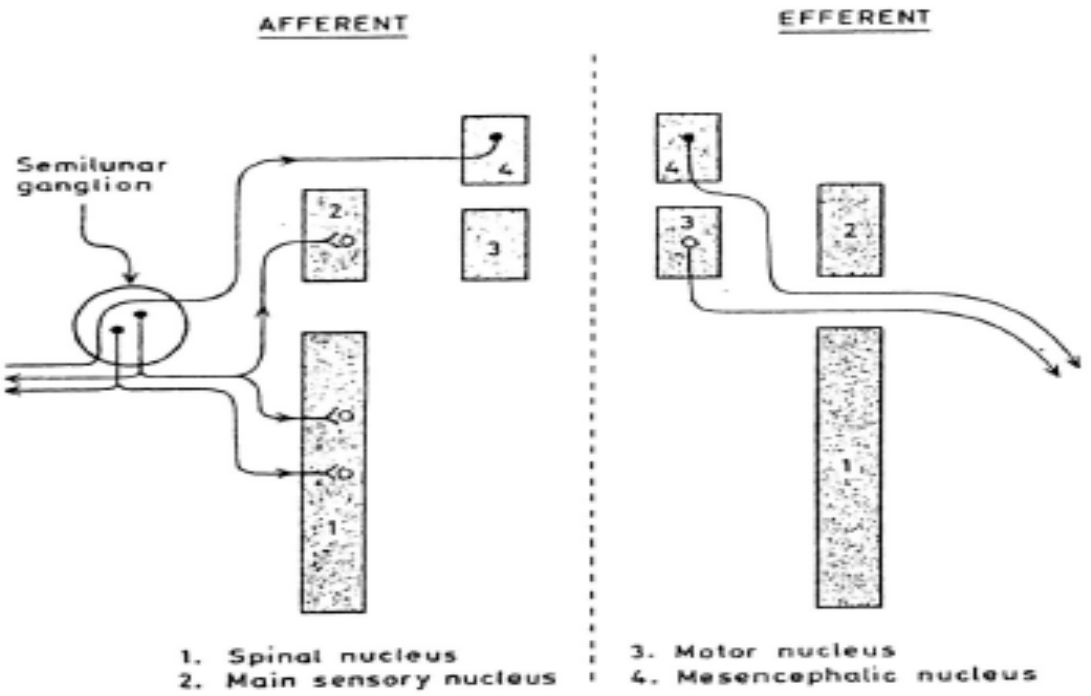


Figure 7.23. Composite schematic diagram of the afferent and efferent roots of the trigeminal (CN V) nerve and their nuclei.

FACIAL NERVE:

It is the most frequently paralyzed of all peripheral nerves. If you're asked which nerve in your body gets paralyzed most frequently, the answer is the facial nerve.

The facial nerve leaves the pons and goes through the stylomastoid foramen. If compressed there, facial/Bell's palsy occurs. It's very important to differentiate stroke from facial nerve injury. In stroke only the lower face is paralyzed on the contralateral side. In facial nerve injury, both the upper and lower face are paralyzed on the same side.

The facial nerve is composed of motor fibers to special muscles (SVE), which is the most important part. It supplies the muscles of facial expression (mimetic muscles). These muscles insert into the skin. When they

contract, they pull the skin and facial expressions are formed. Mimetic muscles are muscles of the second arch.

The cell bodies of these fibers are found in the facial motor nucleus which is located in pons but not in the posterior part of the Pons (the floor of the 4th ventricle). The facial motor nucleus migrates to the inside (like the nucleus ambiguous). Fibers from the facial motor nucleus move around abducens nucleus, forming the **facial colliculus**, and then move out.

Parasympathetic fibers constitute the second component of the facial nerve (GVE): the mother cells of these fibers are located in the superior salivatory nucleus in the Pons. These fibers run as part of the facial nerve to all glands in the face (lacrimal, nasal, palatine, submandibular salivary, sublingual salivary, intralingual salivary [which are located inside the tongue]) except the parotid gland. The intralingual glands work between meals, while the other salivary glands (parotid, submandibular, sublingual) work during swallowing and mastication (during eating).

The sensory component (SVA) of the facial nerve transfers taste from the anterior two thirds of the tongue. These fibers constitute a branch from the facial nerve called cordia tympani.

The last part are sensory fibers (GSA) transferring sensation from the skin of the external ear. Cranial nerve 7,9, and 10 all have some of their fibers to skin of external ear. The most important one is the Vagus nerve (CN10). If someone is hit on the ear, the Vagus nerve might be stimulated and severe bradycardia to the point of shock might occur.

In the following figure, the motor components are on one side and the sensory on the other.

The mother cells of the sensory components are in the geniculate ganglion.

Pathway: the facial nerve leaves the pons and runs laterally then posteriorly. At the junction of the lateral and posterior parts of its pathway lies the geniculate ganglion. The geniculate ganglion only contains the cell bodies of sensory fibers. The facial nerve continues down between the mastoid process and the middle ear. It exits the skull (emerges) through the stylomastoid foramen.

The facial nerve supplies the following muscles: occipitofrontalis (muscle of the scalp), the posterior belly of digastric, and stylohyoid. These muscles are derived from the second arch (the facial nerve is the nerve of the second arch).

Once it leaves the stylomastoid foramen, the facial nerve enters the parotid gland, where it divides into 6 terminal branches which collectively supply the upper and lower facial muscles. The terminal branches are: the temporal, zygomatic, buccal (1 or 2 of them), marginal, mandibular, and cervical branches.

The upper facial muscles include the frontal belly of occipitofrontalis (makes wrinkles of forehead), and orbicularis oculi (orbital, palpebral, lacrimal part). The zygomatic and buccal branches go to the middle and lower parts of the face and supply the buccinator, levator anguli oris, and levator LABII superioris. The lower face (this is important) is composed of orbicularis oris and surrounding

muscles; muscles of lower face on each side pull the angle of the mouth towards their side. Weakness in one side means the angle of mouth is deviated to the other side. If the facial nerve is cut because of a carcinoma of the parotid gland, the upper and lower face is affected. If a stroke occurs, only the lower facial muscles (the perioral muscles) are affected.

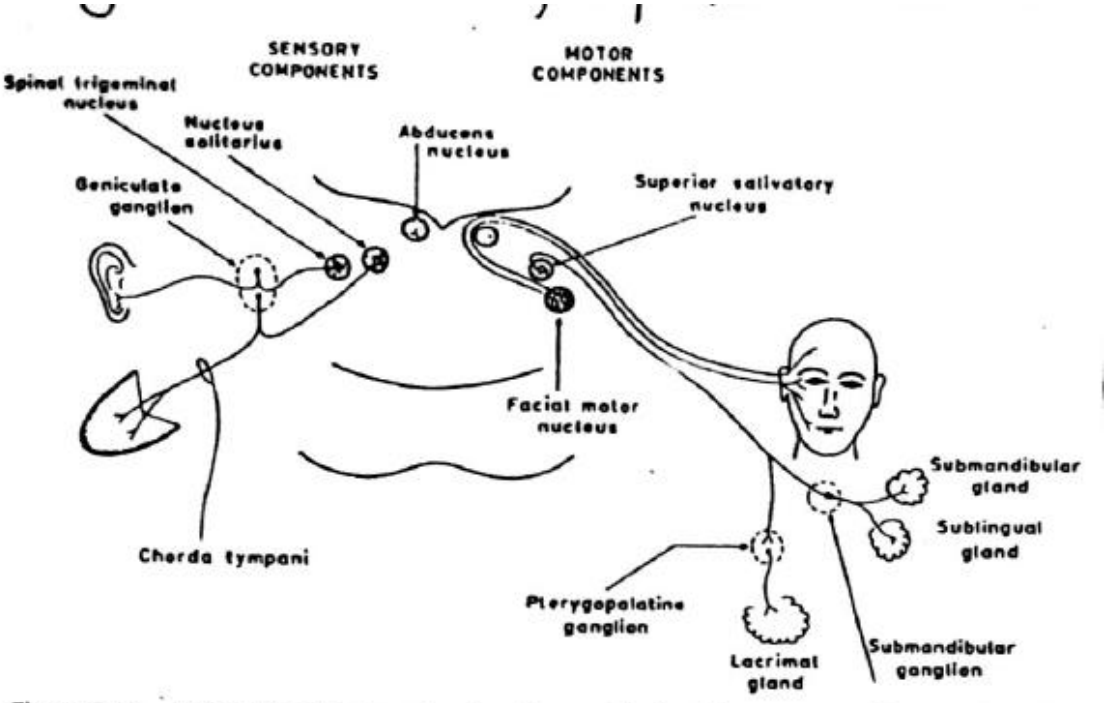


Figure 7.14. Schematic diagram showing the nuclei of origin, course, and areas of supply of the facial (CN VII) nerve.

Facial/Bell's Palsy:

In this condition, the facial nerve itself is affected. The upper and lower muscles of the face are affected. Take a look at the ear on the same side of the paralysis; if you find eruptions, then the most likely cause of paralysis is the herpes zoster virus. This is called the Ramsay Hunt syndrome (RHS). Inside the geniculate ganglion (ganglion of facial nerve which contains sensory and motor), the virus destroys the motor fibers and causes paralysis. The virus also runs in the sensory fibers until it reaches the external ear and causes eruptions.

And or the millionth time: IT'S IMPRTANT TO DIFFERENTIATE BETWEEN THE INJURTY OF THE NERVE/ITS NUCLEUS AND AN UMNL (stroke).

Nervus Intermedius:

The facial nerve runs next to the vestibulocochlear nerve. Nervus intermedius is a nerve running between the facial and vestibulocochlear nerves. It is part of the facial nerve. It was believed that it was made up of only sensory fibers. Now we know that it contains sensory and parasympathetic fibers. Two branches of the facial nerve run within nervus intermedius, carrying taste and parasympathetic signals: chorda tympani and the greater petrosal. Each one contains both parasympathetic fibers headed to the glands and sensory taste fibers.

If we look at the parasympathetic fibers from both chorda tympani and the greater petrosal, they both synapse in a parasympathetic ganglion before reaching the affected organ.

RULE: Any parasympathetic or sympathetic fibers must synapse in a ganglion before reaching their effector organ.

The pterygopalatine ganglion lies in the pterygopalatine fossa. Its post ganglionic fibers go to the lacrimal and nasal glands.

The parasympathetic ganglion of chorda tympani is attached to the lingual nerve under the jaw and is called the submandibular ganglion. Postganglionic fibers in the chorda tympani go to the submandibular, sublingual, and intralingual salivary glands. In addition, chorda tympani carries taste from the anterior 2/3 of the tongue, while the greater petrosal carries taste from the soft palate.

Allergic Rhinitis/Hay Fever:

Commonly, you see some people during a certain time of the year complaining of a runny nose, lacrimation, and sneezing. Those are all symptoms of allergic rhinitis (hay fever; the old name).

Allergic rhinitis could arise due to pollution, pollen, or other antigens found in the environment. The antigen enters the blood and stimulates the pterygopalatine ganglion. Impulses are carried to the lacrimal and nasal glands leading to a lacrimation, runny nose and sneezing.

Anti-histamines are used to treat allergic rhinitis. Nowadays, cortisone is also given. It is a very common condition and its time of manifestation differs from individual to another depending on the type of antigen that causes allergic rhinitis in each individual.

Lesions to the facial nerve:

Once the facial nerve leaves the cranial cavity via the stylomastoid foramen and enters the parotid gland, it is made up of only motor fibers. Taste, sensory and parasympathetic fibers are distributed before that. So, once it leaves the cranial cavity, it's only motor.

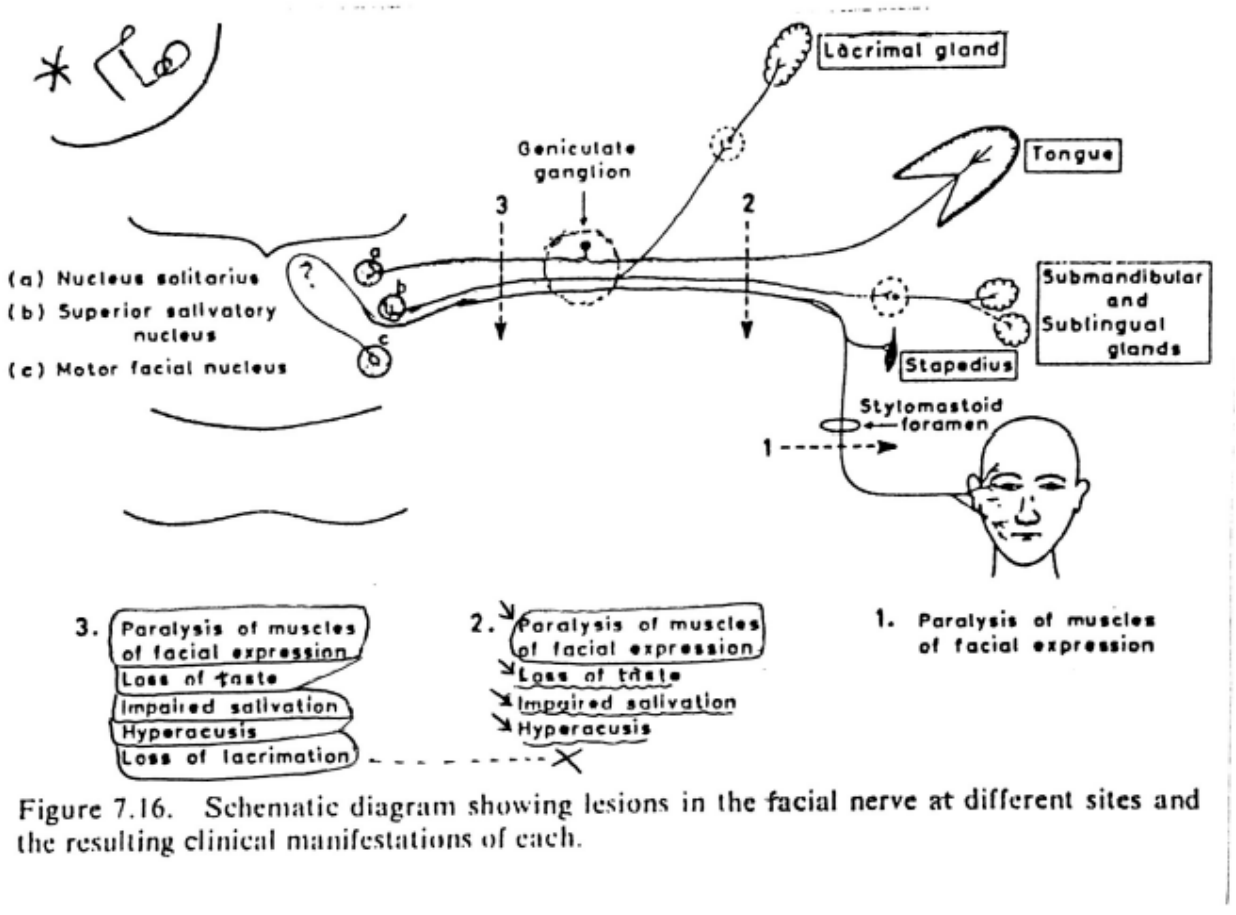


Figure 7.16. Schematic diagram showing lesions in the facial nerve at different sites and the resulting clinical manifestations of each.

Loss of lacrimation is NOT due to injury of the facial nerve outside the cranium. It doesn't contain parasympathetic fibers at that point!

Facial palsy does NOT lead to loss in lacrimation or salivation.

A lesion proximal to the geniculate ganglion affects all components of the facial nerve. Paralysis of the muscles of upper and lower facial expression (SVE), loss of taste (chorda tympani and greater petrosal), *impaired* salivation (parotid still functions so salvation is not completely lost), and **hyperacusis***.

***The middle ear contains a muscle called the stapedius. It limits the movement of stapes (bone in middle ear). If the stapes bone is pushed strongly, it makes a weak noise really loud. Paralysis of the stapedius muscle leads to **hyperacusis** (hypersensitivity to sound).

A lesion distal to the geniculate ganglion causes all of the above, except lacrimation would still be functional.

A lesion under stylomasoid foramen only leads to loss of motor fibers and thus cause paralysis of the upper and lower face.

Paralysis of the upper facial muscles means the patient is unable to close his eyelid because of paralysis of palpebral part of orbicularis oculi, which leads to dryness of the corneas. This is the most dangerous thing about facial palsy. In this case, the patient would need eye drops and should keep his eyes closed with band-aids at night.

Remember:

- UMN lesion (supranuclear lesion) → lower face will be affected contralaterally.

- Lesion in the nerve itself → upper and lower face will be affected ipsilaterally. For example, a patient is unable to close his right eye, so the lesion is on the right side and the deviation of the angle of the mouth is to the left.

THE END

Author's Note: I apologize for the lengthy sheet, but Dr. Faraj had a lot to say. Good job for sticking around and congratulations on finishing this monster of a sheet.