

Trigeminal, Gustatory, and Visceral Sensory Systems

Objective

- To learn the trigeminal somatic sensory system and understand the anatomical and functional parallels with the spinal somatic sensory pathways.
- To learn the various cranial nerve sensory nuclei
- To learn the pathways for taste and visceral sensory functions (e.g., blood pressure regulation)
- To be able to use changes in facial somatic sense and taste to help localize site of CNS damage
- NTA Ch 8, pgs. 223-234
- Key Figs: 8-1; 8-3; 8-7
- NTA Ch 12, pgs 362-362; 368-370 (section on Separate sensory roots...); 374-375 (section on Occlusion of the posterior...)
- Key Figures: 12-5a, 12-6, 12-7, 12-10
Clinical Case
- #10 Shaking spells; CC10-1

Self evaluation

- Be able to identify all structures listed in key terms and describe briefly their principal functions
- Use neuroanatomy on the web to test your understanding

List of media

F-1 Ventral surface of brain stem

Review the exit points and general function of each of the cranial nerves.

F-2 Location of cranial nerve nuclei within the brain stem

The position of the cranial nerve nuclei within the brain stem is shown as viewed from the dorsal surface. Motor nuclei (somatic and special visceral) are shaded red; sensory nuclei are shaded blue; parasympathetic (general visceral efferent) nuclei are shaded green; and cranial nerves and tracts are shaded yellow. Note that the nuclei giving rise to particular fiber types are organized generally in longitudinal columns.

F-3 Central connections of the sensory component of the trigeminal nerve

Examine this slide of the 3-D organization of the trigeminal system from the perspective of the three trigeminal sensory nuclei constituting three functional subsystems.

1. Spinal trigeminal nucleus. Small diameter afferent fibers, which mediate pain and temperature senses, enter the pons and descend in the spinal trigeminal tract. (Where are the cell bodies of the primary afferent fibers located?) These afferents synapse on second-order neurons in the spinal trigeminal nucleus – both interneurons and ascending projection neurons. The trigeminothalamic and trigeminothalamic neurons are primarily located in the marginal zone. Trigeminothalamic neurons are located in the deeper portions of the nucleus. The axons of ascending projection neurons decussate and ascend primarily with the fibers of the anterolateral system. These axons terminate in the reticular formation, tectum, and thalamus (medial and intralaminar nuclei as well as the ventral posterior medial nucleus).

2. Main (also termed the principal) trigeminal sensory nucleus. Large diameter fibers, which mediate tactile sensation, enter the pons and terminate in the main trigeminal sensory nucleus. (Where are the cell bodies of the primary afferent fibers located?) The axons of second-order projection neurons decussate and ascend in the trigeminal lemniscus, along with the medial lemniscus. The trigeminal lemniscus terminates in the ventral posterior medial nucleus. A second pathway is thought to ascend from the main trigeminal sensory nucleus on the ipsilateral side – termed the dorsal trigeminothalamic tract – and terminates in the ventral posterior medial nucleus. However, there is little modern evidence for the existence of this pathway.

3. Trigeminal mesencephalic nucleus. The trigeminal mesencephalic nucleus is equivalent to a peripheral sensory ganglion because it contains the cell bodies of primary afferent fibers. These afferent fibers innervate stretch receptors in jaw muscles. Two key central connections of these afferent fibers are: 1) monosynaptic contacts with trigeminal (jaw) motor neurons, and 2) multisynaptic contacts with neurons in the trigeminal sensory nuclei and the reticular formation.

trigeminothal Trigeminothalamic tract (movie)

Key:

Trigeminal nerve=gray

Spinal trigeminal tract=white

Spinal trigeminal nucleus=aqua

Decussating trigeminothalamic fibers, trigeminothalamic tract=green

Spinothalamic tract=yellow

Thalamus (including VP)=brown

trigemlemniscus Trigeminal lemniscus (movie)

Key:

Principal (main) trigeminal nucleus, cuneate nucleus=aqua

Trigeminal lemniscus=green

Medial lemniscus=white (leg) and yellow (arm)

F-4 Visceral afferent systems

The visceral afferent system is composed of two portions. Special visceral afferents conveying taste information via cranial nerves VII, IX and X converge in the solitary tract and terminate in the rostral portion of the solitary nucleus. Cells in this portion of the solitary nucleus project to VPM of the thalamus via the central tegmental tract. What is the peripheral distribution of taste fibers in cranial nerves VII and IX? General visceral afferents terminate in the caudal portion of the solitary nucleus which is interconnected with the visceral motor nuclei (nucleus ambiguus and dorsal motor nucleus of X). The caudal portion of the solitary nucleus is also interconnected with other brain stem nuclei and hypothalamus and mediates various visceral reflexes (not shown on image). These projections mediate visceral sensations and visceral reflexes.

X-10 Spinal cord-medulla junction (pyramidal decussation)

Identify the spinal trigeminal nucleus and tract. Are the axons of primary sensory neurons or ascending projection neurons located in the spinal trigeminal tract? Nucleus caudalis is located at this level; this nucleus plays a key role in facial pain mechanisms. Note the similarity between the shape of the nucleus caudalis and the spinal cord dorsal horn. Two regions can clearly be distinguished within nucleus caudalis. Identify the substantia gelatinosa (comparable to Rexed's lamina II) of nucleus caudalis. This is the lightly-stained region spanning most of the nucleus. The trigeminal equivalent to the nucleus proprius (Rexed's lamina III) is located immediately beneath the substantia gelatinosa. The marginal zone (Rexed's lamina I) is very thin and, as in the spinal cord dorsal horn, it is located along the rim of the nucleus caudalis. Trigeminothalamic neurons are located primarily in the marginal zone.

What is the rostro-caudal somatotopic organization of the nucleus caudalis?
Where is dental pain represented?

X-15 Caudal medulla

Identify the following nuclei: gracile nucleus; cuneate nucleus; spinal trigeminal nucleus. Identify the following fiber tracts: spinal trigeminal tract; anterolateral system; medial lemniscus; pyramidal tract. Which sensory modalities are processed by the gracile, cuneate and spinal trigeminal nucleus?

X-20 Mid-medulla just rostral to the obex

Identify the following nuclei: solitary nucleus; spinal trigeminal nucleus; inferior olivary nucleus; reticular formation. At this level, the medial and inferior vestibular nuclei are located dorsal to the solitary nucleus. Identify the following fiber tracts: solitary tract; spinal trigeminal tract; anterolateral systems; medial lemniscus; pyramidal tract. Which cranial nerves project afferents through the solitary tract? What sensory signs would you expect to observe in a patient with an infarction of PICA? The motor signs will be considered in Laboratory IX.

X-25 Rostral medulla

Identify the following nuclei: dorsal and ventral cochlear nuclei, medial and inferior vestibular nuclei; cochlear nuclei; spinal trigeminal nucleus; inferior olivary nucleus. Identify the following fiber tracts: spinal trigeminal tract; inferior cerebellar peduncle; medial lemniscus; MLF, pyramid.

X-30 Pons at the level of the facial colliculus

Identify the following nuclei: spinal trigeminal nucleus, superior olivary nucleus, pontine reticular formation, and pontine nuclei. Identify the following fiber tracts: MLF, spinal trigeminal tract, and trapezoid body.

X-35 Rostral pons at level of the sensory and motor trigeminal nuclei.

Identify the following nuclei: main trigeminal nucleus; trigeminal motor nucleus (located medial to the sensory nucleus and separated from it by fibers of the trigeminal nerve); pontine nuclei. Identify the following fiber tracts: MLF; medial lemniscus; lateral lemniscus; middle cerebellar peduncle; central tegmental tract; corticospinal and corticobulbar tracts. What sensory modalities are conveyed in the lateral and medial lemniscus?

At this level, the trigeminal lemniscus is located dorsomedial to the medial lemniscus. However, the trigeminal fibers cannot be distinguished from the fibers of the dorsal column nuclei. The trigeminothalamic fibers are located laterally, with the anterolateral system (spinothalamic, spinoreticular, and spinotectal fibers).

Paramedian branches of the basilar artery supply blood to the medial portion of the pons, whereas the anterior inferior cerebellar artery (or the lateral circumferential branches of the basilar artery, depending on the rostrocaudal level) irrigate the lateral pons.

X-37 Pons-midbrain junction

Identify the general location of the parabrachial nucleus. This nucleus is important for transmitting viscerosensory information to the diencephalon and cerebral hemispheres. It also plays a role in regulating autonomic function, such as blood pressure control.

X-40 Midbrain at level of the inferior colliculus

Identify the mesencephalic trigeminal nucleus and tract. What is the principal neuron type in the mesencephalic trigeminal nucleus? What is the major decussation on this slide? Also identify the MLF, medial lemniscus, basis pendunculi, and central tegmental tract. What are the key constituents in each of these tracts?

X-45 Midbrain at level of the superior colliculus

Identify the trigeminal mesencephalic nucleus and tract. Identify the red nucleus, periaqueductal gray matter, and the substantia nigra. Which midbrain structure is important in pain regulation?

As in the pons, the trigeminal lemniscus is located dorsomedial to the medial lemniscus. The trigeminothalamic axons are located with the ascending spinothalamic fibers dorsal and lateral to the medial lemniscus.

X-70 Ventral posterior nucleus

The ventral posterior medial nucleus consists of a small-celled division (the parvocellular division of the ventral posterior medial nucleus) located medially and a division with larger sized neurons (simply termed the ventral posterior medial nucleus), located laterally. The trigeminal lemniscus terminates laterally in the ventral posterior medial nucleus, whereas the medially-located parvocellular division receives gustatory input from the solitary nucleus. By what brain stem pathway does gustatory information reach the parvocellular division of the ventral posterior medial nucleus?

AN01 Thalamo-cortical relations (Animations)

Identify the trigeminal projection zone on the postcentral gyrus. While not shown on either slide, where do the thalamic gustatory neurons project?

Key Structures and Terms

Trigeminal system:

Trigeminal ganglion

Spinal trigeminal tract

Trigeminal nuclei:

Spinal

 Caudal nucleus

 Interpolar nucleus

 Oral nucleus

Main

Mesencephalic

Motor

Trigeminal lemniscus

Ventral posterior medial nucleus

Primary somatic sensory cortex

Gustatory and Viscerosensory Systems:

Solitary tract

Solitary nucleus

Facial nerve

Intermediate nerve

Glossopharyngeal nerve

Vagus nerve

Gustatory nucleus

Cardiorespiratory nucleus

Central tegmental tract

Reticular formation

Sulcus limitans

IVth ventricle

Cerebral aqueduct

Brain stem vasculature