

Welcome to Clinical anatomy of the head, neck and neuronal pathways
Lecture #10

Alemeh Zamani, Ph.D.
Department of Anatomy
MUNI, MED

Today's lecture will cover:

- 1- Somatosensory and Viscerosensory Pathways
- 2- Pain Pathways and Stress-Induced Analgesia

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Somatosensory Pathways

- o Inform about objects around us through touch
- o Inform about position and movements of our body parts (proprioception)
- o Monitor the temperature
- o Inform about painful, itchy and tickling stimuli

Somatosensory Pathway

- o Most somatosensory receptors are not specialized receptor cells and are formed by the terminal endings of the somatosensory 1st afferents.

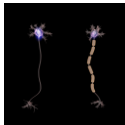
1st order somatosensory afferent neurons: pseudounipolar neuron located in DRG

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Somatosensory Receptor Types

Peripheral Somatosensory Axons

1 st Axon to skin	A α	A β	A δ	C
1 st Axon to muscle	Group I	Group II	Group III	Group IV
Diameter (um)	12-20	6-12	1-5	0.2-1.5
Speed(m/sec)	75-170	33-70	3-30	0.5-2
Sensory receptors	Proprioceptors of skeletal muscle	Mechanoreceptors of skin	Pain, temperature	Temp, pain, itch



o Faster propagation of an action potential in myelinated neurons than that of unmyelinated neurons.



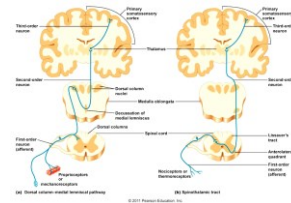
Somatosensory Pathways

Lemniscal system
Medial Lemniscal Pathway

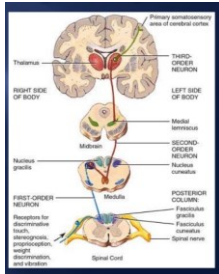
- o perception with high discrimination ability
- o discriminative touch, proprioception

Anterolateral system
Spinothalamic pathway

- o perception with low discrimination ability
- o crude touch, pain and temperature



Medial Lemniscal Pathway

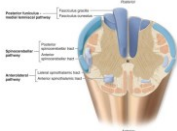


2nd order neurons:

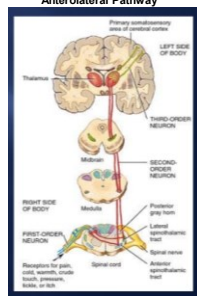
- o Nucleus Gracilis (below T6)
- o Nucleus Cuneatus (above T6)

3rd order neurons:

Ventroposterior lateral nucleus of thalamus



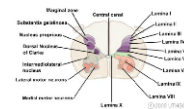
Anterolateral Pathway



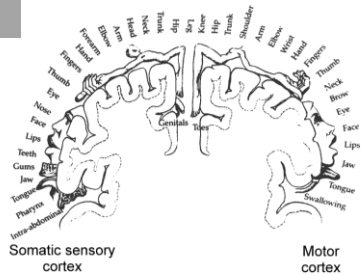
- o Anterior spinothalamic tract
- o Lateral spinothalamic tract
- o Spinotectal tract
- o Spinohypothalamic tract

2nd order neuron: Lamina I to V

3rd order neurons: Ventroposterior lateral nucleus of thalamus



Sensory Homunculus

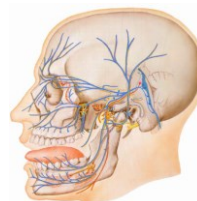


Trigeminal Systems

Somatic sensory representation for most of head and all of face

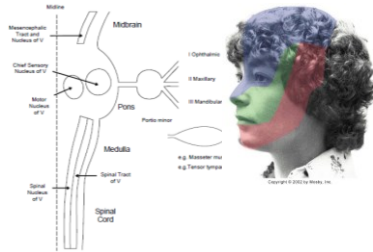
Somatic sensory pathways:

- o Lemniscal system
- o Antrolateral system
- o Trigeminal system



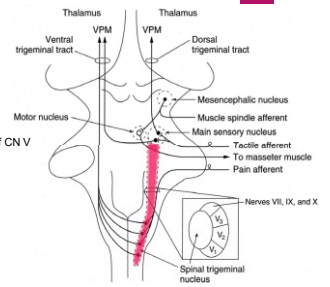
Sensory Inputs to Trigeminal Nuclei:
Somatic sensory; tactile, pain and temperature

Trigeminal Nerve (CN V)



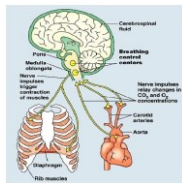
Trigeminal Pathways

- 1st order neurons: Trigeminal Ganglion cell
- 2nd order neurons: Spinal nucleus of CN V & central sensory nucleus of CN V
- 3rd order neurons: Ventral posterior medial nucleus of thalamus (VPM)



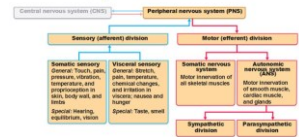
Viscerosensory Pathways

- o Carry information from the thoracic, abdominal and pelvic cavities, and from the cardiovascular system
- o Utilize autonomic pathways to reach the CNS
- o Participate in important reflexes
- o Mostly end in the hypothalamus



Viscerosensory fibres go together with sympathetic and parasympathetic nerves.

Functional Organization of the PNS



visceral organ

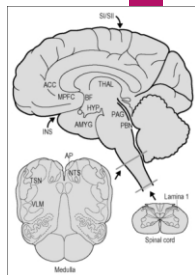
pseudounipolar neurons in ganglia

dorsal horn or brain stem sensory nuclei (the solitary nucleus)

Visceral Pathways

- 1st order neurons: Ganglion cell of spinal cord or inferior ganglion of CN IX or CN X
- 2nd order neurons: Lamina I of dorsal horn or solitary nucleus in medulla

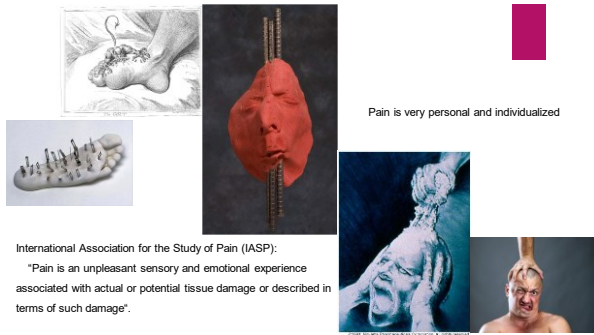
Signals are transmitted to reticular formation, hypothalamus and thalamus.



Today's lecture will cover:

- 1- Somatosensory and Viscerosensory Pathways
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Pain is very personal and individualized

International Association for the Study of Pain (IASP):
 "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage".

Noceptors

Noxious, adj.
 from classical Latin noxious harmful, injurious, guilty (from noxa; harm, injury + -ius)
 Noxious stimulus: A stimulus which is damaging to normal tissues

Noceptor:
 A sensory receptor neuron preferentially sensitive to a noxious stimulus or to a stimulus which would become noxious if prolonged.



Noceptors

- o noceptors of Aδ fibres (5-30 meters/sec)
 - o Aδ mechanical noceptors
 - o Aδ thermal noceptors
- o noceptors of C fibres (0.2-2.0 meters/sec)
 - o C polymodal noceptors – react to thermal, mechanical and chemical stimuli
- o silent noceptors (MIA = mechanically insensitive afferents)
 - responsive after inflammation and tissue injury

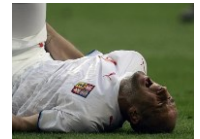
Axons from nociceptors	Aδ Group I	Aδ II	Aδ III	C
Diameter (µm)	1.5-2.5	0.5-1.2	1-1.5	0.2-1.5
Speed (m/sec)	80-120	30-70	0-30	0.5-2
Sensory receptors	Proprioceptors of skeletal muscle	Mechanoreceptors of skin	Pain, temperature (skin, 50°C)	Temperature (skin, 50°C)

Noception

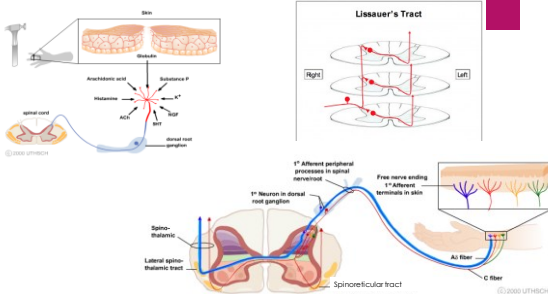


Noception: all events following damage, or threat of damage to tissue

1. Begins with detection of noxious event by noceptors
 - o influenced by non-neuronal cells (e.g. inflammatory and immune cells, keratinocytes)
2. Subsequent activity in CNS neurons and pathways
 - a. reflex and withdrawal behaviors
 - b. autonomic responses
 - c. activity of neurons in "pain" pathways and systems
 - d. activation of endogenous modulatory systems
3. Perception of pain

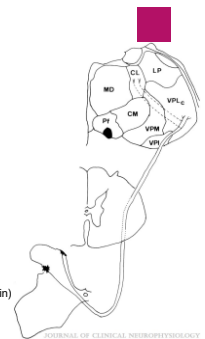


Factors that activate noceptors



A. Spinothalamic Tracts (STT)

- o neospinothalamic
- o most cells of synapse in laminae I and V
- o axons ascend contralateral
- o thalamic terminations
 - a) VPL: somatotopic projection
 - b) Central Lateral (CL)
 - c) Posterior nuclei (PO)
- o VPL projects primarily to primary somatosensory cortex
- o Major role pain and temperature sensation (sharp, well localized pain)



B. Spinoreticular Tract System (SRT)

- o paleospinothalamic pathway
- o many cells in lamina I and deep dorsal horn
- o direct projections from spinal cord to reticular formation
- a) medulla, pons, and midbrain (multiple levels)
- o axons ascend contralateral (with STT)
- o project to multiple thalamic and cortical regions
- o Important in arousal and attention (diffuse, non-localized pain)



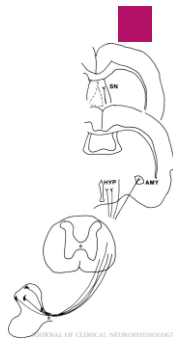
C. Spinoparabrachial Tract

- o many cells in lamina I
- o axons ascend through dorsal part of lateral funiculus
- o axons terminate parabrachial nn. in pons
- o parabrachial neurons project to thalamus
- also hypothalamus and amygdala
- o cognitive, emotional, affective responses to pain



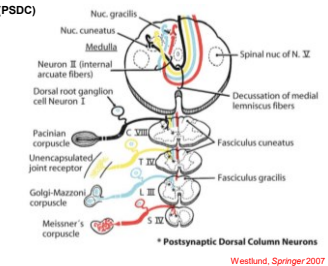
D. Direct spino-limbic Access

- spino-amygdaloid
- spino-hypothalamic
- spino-septal nuclei
- o cells of origin in dorsal and ventral horns
- o axons ascend through dorsal part of lateral funiculus
- o many bilateral projections to
- a. hypothalamus
- b. amygdala
- c. septal nuclei and nucleus accumbens
- o motivational aspects of pain



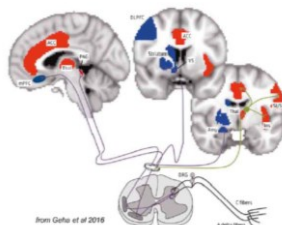
E. Postsynaptic Dorsal Column Tract System (PSDC)

- o most cells in laminae III-IV
- o many respond noxious visceral inputs
- o PSDC axons ascend ipsilaterally
- o axons terminate in dorsal column nuclei
- o DCN cells project to contralateral thalamus
- ventrobasal complex of the thalamus
- o Important ascending visceral system
- effective for relief of extreme visceral pain

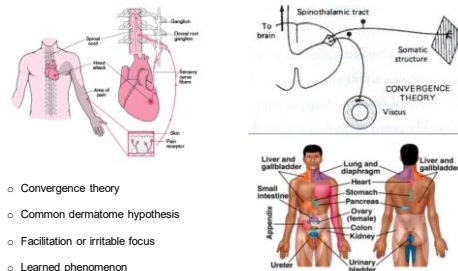


Forebrain Regions Related to Nociception (Nociception Matrix)

- A. Primary Somatic Sensory Cortex (SI)
- B. Secondary Somatic Sensory Cortex (SII)
- C. Insular Cortex
- D. Anterior Cingulate Gyrus
- E. Pre-frontal cortex
- F. Thalamus
- H. Amygdala



Referred Pain

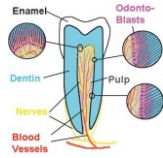
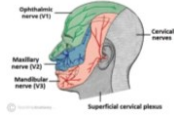


- o Convergence theory
- o Common dermatome hypothesis
- o Facilitation or irritable focus
- o Learned phenomenon



Dental Pain

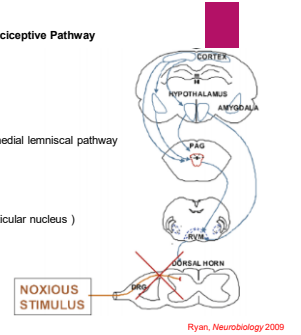
- o Aβ + Aδ fibres –first and sharp pain, easily stimulated by application of cold
- o C fibres – dull ache, sensitive to inflammatory mediators, changes in blood flow
- o pulp + dentin – enormous number of free nerve endings
- o Somatic pain: musculoskeletal pain and visceral pain
- o Neuropathic pain: inflamed pulp or periapex – peripheral and central sensitization hyperalgesia, allodynia and spontaneous pain
- o referred orofacial pain – both source and referral site



Modulating Systems of Nociceptive Pathway

Levels of modulation of nociceptive pathways

- o spinal cord ("gate control theory")- dorsal column medial lemniscal pathway
- o peri-aqueductal gray matter (PAG)
- o locus coeruleus
- o reticular formation of brain stem (gigantocellular reticular nucleus)
- o raphe magnus nuclei



Ryan, Neurobiology 2009

Anterior limbic brain
Hypothalamus
(stress)

Periaqueductal
gray matter

other nuclei of RF
locus coeruleus
ncl. gigantocel.
ncl. raphe magnus

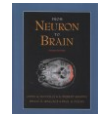
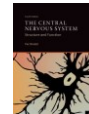
Dorsal spinal horns

Stress-Induced Analgesia

Pain suppression upon exposure to unconditioned or conditioned stressful stimuli.



Reading List



Thank you very much for your attention

