CNS Block

7th Lecture

Physiology of Pain

PHYSIOLOGY TEAM – 430

This Lecture is done by :

Lujyne Bukhari

Organized by : Sulaiman AlShammari

- **Pain**: is a protective mechanism

Pain receptors are free nerve endings of:

1- unmyelinated C fibers
2- small diameter myelinated Aδ

Pain receptors (nociceptors) are most widely distributed

- **Different stimuli that can excite pain receptors:**
  Mechanical - thermal – chemical

Pain receptors adapt very little and sometimes they don't adapt at all to their stimuli this allows the person to feel the pain and notice when there is persistent tissue damage.

- **Pain receptors are high threshold receptors:**

Stimuli must be very strong or noxious to cause tissue damage to reach the threshold and excite the pain receptor

Pain is perceived at both the cortical and thalamic levels

- **Effects associated with pain sensation :**

Motor reactions	• reflexes : withdrawal reflex • muscle rigidity : stiffness
Autonomic reactions	• mild pain stimulates post. hypothalamic nuclei which causes sympathetic changes e.g. tachycardia • severe pain stimulates anter. Hypothalamic nuclei which causes parasympathetic changes e.g. bradycardia
emotional reaction	

- **Mechanism of stimulation of pain receptors (nociceptors):**

There are two ways that can cause depolarization of the pain receptors:

1-directly

2-pain producing substances (inflammatory mediators) > bradykinin – serotonin – histamine – interleukins – substance P - K+ - Ach – proteolytic enzymes

Prostaglandin and interleukins lower the threshold of pain receptors (they make the pain receptors more sensitive to their stimuli)

- **Types of pain:**

  1-fast pain (immediate, first)
  2-slow pain (delayed, second)

	Fast pain	Slow pain
Called	Pricking – acute – sharp – electric pain	Burning - aching – chronic pain
Occurs in	the skin	Skin – deep tissue - viscera
Caused by	Mechanical – thermal stimuli	
Transmitted via	Type Aδ fibers	Type C fibers
Conduction velocity	3-30 m/s	<2 m/s
Accounts for	20% of nociceptors	80% of nociceptors
Primary afferents that arise from	All types of nociceptors	Polymodal nociceptors
Appears	Rapidly within 0.1 second and lasts for short time	Slowly after 1 second and lasts for longer duration
Localization	Well localized	Diffused (poorly localized)
e.g.	When skin is cut with a knife	

- **Types of pain according to the site of stimulation:**

  1-somatic pain : superficial + deep pain

  2-visceral pain

Some viscera are pain insensitive and other has few pain receptors

Pain insensitive viscera: liver – parenchyma – lung alveoli – brain tissue – visceral layer of peritoneum – pleura – pericardium

Superficial	Deep pain	Visceral pain
Arises from: Skin – other superficial structure	**Arises from:** Muscles – joints – periosteum – tendons – ligaments	
Fast pricking followed by slow burning pain	Slow and prolonged	Slow (sharp and pricking pain if it arises from parietal peritoneum – pleura – pericardium)
	Conducted by C fibers	**Conducted by** C fibers
Well localized	Diffuse (poorly localized)	Diffuse
-May be associated with: motor – autonomic – emotional reactions	-Can initiate reflex contraction of nearby muscles -Can be referred to other sites	-Often associated with: autonomic reactions – rigidity of nearby muscles -May be referred to other sites
	Caused by: trauma – bone fracture – inflammation – arthritis – muscle spasm – ischemia	**Caused by:** distension of hollow organs – inflammation of an organ – ischemia (e.g. due to myocardial infarction)

- **Referred pain:** feeling pain in a part of the body away from the tissue causing the pain

-Frequently occurs in visceral and deep somatic pain

-Does not occur in cutaneous pain

-**Examples:**

1-cardiac pain is referred to left shoulder – inner side of left arm
2-pain of appendicitis is referred to umbilical region
3-pain from ureter is referred to testicular region

Organ	Site of referred pain
Meninges	Back of head and neck
Heart	Central chest – left arm
Diaphragm	Shoulder tip
Esophagus	Behind sternum
Stomach – duodenum	Epigastrium
Kidney	Loin
Ureter	Testicles
Trigone of bladder	Tip of penis
Hip	Knee
Appendix	Umbilicus
Uterus	Low back

- **Mechanism of referred pain:**

- **Convergence theory:**

1-Brain is accustomed to receiving impulses from skin than viscera.
2-Some branches of visceral pain fibers synapse in the in the spinal cord on the same spinothalamic tract that receive pain signals from other somatic structures and viscera.
As a result, pain impulses from viscera are misinterpreted by the brain as coming from the skin

- **Facilitation theory:**

Pain fibers from skin are always carrying impulses, but they are not enough to produce pain. Impulses from diseased viscus pass through afferents which give collaterals to spinothalamic neurons receiving pain fibers from skin. As a result, spinothalamic neurons' excitability is raised (they are facilitated) to reach a threshold level. The signals reaching the brain are projected to skin area and pain is felt in skin dermatome

- **Pain impulses are transmitted to the brain by lateral spinothalamic tracts:**

  1-neospinothalamic pathway

  2-paleospinothalamic pathway

	Neospinothalamic pathway	**Paleospinothalamic pathway**
Transmit	Fast pain + thermoceptive sensation	Slow pain + thermoceptive sensation
First order neurons	**-Mainly Aδ** 1-Ascend a few segments in Lissauer tract 2-Terminate at Lamina I and V of the dorsal horn	**-Mainly C fibers** 1-Enter the spinal cord through the dorsal roots 2-Ascend a few segments in Lissauer tract 3-Terminate at substantia gelatinosa in laminae II & III of dorsal horn.
Second order neurons	-Constitute the tract -Start at the dorsal horn, cross to the opposite side and ascend in the lateral column of the spinal cord -Fibers ascend in the brain stem and terminate in the ventrobasal comlex of thalamus	-Start at SGR, cross to opposite side in front of central canal and ascend in the lateral column of the spinal cord **-Terminate at:** **a-**reticular formation of brain stem **b-**intralaminar nuclei of thalamus **c-**hypothalamus and adjacent region of basal brain -Impulses arriving in this region have strong arousal effect and can be perceived
Third order neurons	-Start at thalamus & project to somatosensory cortex	-Start at the thalamus and project to all parts of the cerebral cortex

- **Role of cerebral cortex in pain perception:**

Full perception of pain occurs when signals enter the RF of brain stem , thalamus and basal regions

Somatosensory cortex plays an important role in topognosis i.e. localization and interpretation of pain quality

Fast pain is localized better than slow pain because fast pain is carried in the neospinothalamic tracts which reach the somatosensory cortex but only a small proportion of the peleospinothalamic tracts which carries slow pain reach the cortex