

# Physiology of Pain

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# ● Objectives

- Define pain and identify its characters.
- Appreciate pain receptors & pain producing substances as serotonin & substance-P.
- Differentiate between acute sharp pain & dull aching pain concerning pathways & brain centers.
- Differentiate the types of pain & their causes as superficial skin pain, deep muscle pain , visceral pain & referred pain.
- Describe the mechanism of referred pain of visceral origin.
- Explain pain pathway in spinal cord.
- Explain the role of cerebral cortex in pain perception.

# *Pain*

- Pain is unpleasant sensation that is characterized by the following:-
- It has a **protective function**.
- All pain receptors are **free nerve endings** of unmyelinated **C fibers** & small diameter myelinated **A $\delta$  fibers**.
- Pain receptors are the most **widely distributed**.

- Pain sensation can be produced by **various types of stimuli** i.e. mechanical, thermal & chemical,
- Pain receptors **adapt very little**, if not at all.

- Localization of pain stimuli is less exact than that of other modalities.
- Pain receptors are high threshold receptors.
- Pain is perceived at both the cortical & thalamic levels.

# ***Effects associated with pain sensation***

- 1- Motor reactions.**
- 2- Autonomic reactions.**
- 3- Emotional.**

# Mechanism of stimulation of pain receptors (nociceptors)

- Pain receptors are depolarized either directly or through the production of **pain producing substances**.
- Prostaglandins & interleukins lower threshold of pain receptors.

# Qualities of pain

## *Fast pain (immediate, first)*

- It is also called pricking, acute, sharp or electric pain.
- It occurs mainly in **skin** by mechanical or thermal stimuli.
- It is transmitted via type **A $\delta$  fibers**.
- It appears **very rapidly** within 0.1 sec., and lasts for short time.
- It is usually **well localized**.
- e.g. The type of sensation felt when skin is cut with a knife.



## 2- Slow pain (delayed or second)

- \* It is also called **burning**, aching or chronic pain.
- \* It occurs in **skin, deep tissues & viscera**.
- \* It is transmitted via **type C**.
- \* It appears **slowly**, after one sec. or more, and lasts for longer duration.
- \* It is diffused (**poorly localized**).

# Types of pain

- Pain can be classified according to the site of stimulation into:-

1- **Somatic pain** ( superficial & deep pain).

2- **Visceral pain.**

## ● *Superficial pain*

- It arises from skin or other superficial structures.
- It occurs in 2 phase of **fast** pricking followed by slow **burning** pain.
- It can be **well localized**.
- It may be associated with motor, autonomic, emotional reactions.

# Deep pain

- It originates from muscles, joints, periosteum, tendons & ligaments
- It is **slow** prolonged conducted by type **C fibers**.
- It is **diffuse** (i.e. poorly localized).

# Deep pain (cont.)

- It can initiate **reflex contraction** of nearby muscles.
- It may be **referred** to other sites.
- It is caused by, **trauma, bone fracture & inflammation, arthritis, muscle spasm & ischemia.**

# Visceral pain

- There are few pain receptors in most viscera, some viscera are pain insensitive e.g. **liver parenchyma**, **lung alveoli**, **brain tissue**, **visceral layer** of peritoneum, **pleura** and **pericardium**.

# Characters of visceral pain

- It is **slow** pain conducted by **C fibers** ( pain arising from parietal peritoneum, pleura and pericardium is sharp, pricking type).
- It is **diffuse**.
- It is often associated with **autonomic reactions**.
- It can be associated with **rigidity** of nearby muscles.
- It may be **referred** to other sites.

# Causes of visceral pain:-

- **Distension** of a hollow organs
- **Inflammation** of an organ.
- **Ischemia** e.g. pain due to myocardial ischemia.



# *Referred pain*

- This is pain that is felt away from its original site.
- It is most frequent with visceral pain & deep somatic pain but **cutaneous pain is not referred.**
- Pain is referred according to dermatomal rule.

# *Referred pain*

## Examples of referred pain:-

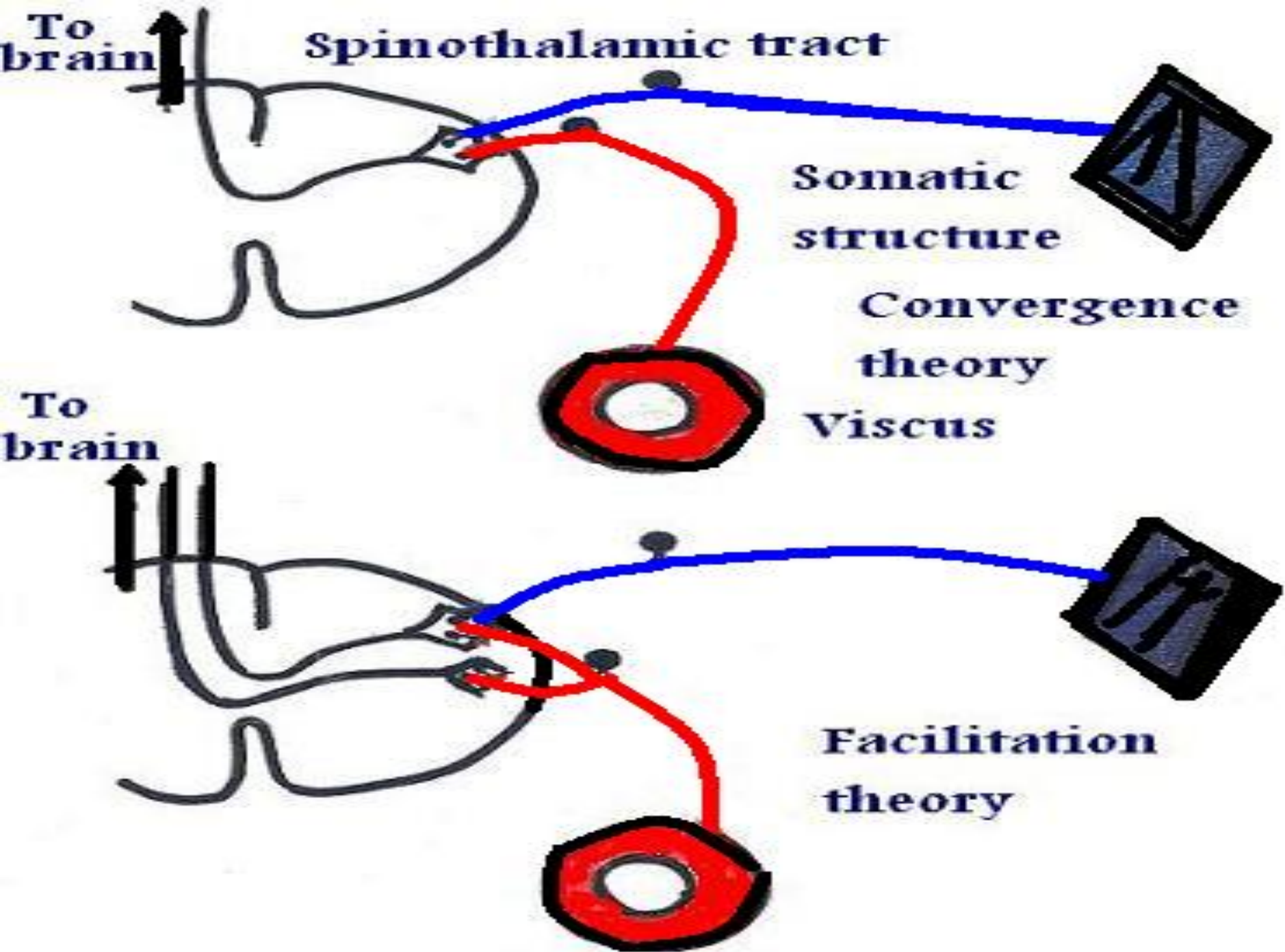
- Cardiac pain is referred to left shoulder & inner side of left arm.
- Pain of appendicitis is referred to umbilical region.
- Pain from the ureter is referred to testicular region.

| <b>● <u>Organ</u></b>     | <b><u>Site of referred pain</u></b> |
|---------------------------|-------------------------------------|
| <b>Meninges</b>           | <b>Back of head &amp; neck</b>      |
| <b>Heart</b>              | <b>Central chest, left arm</b>      |
| <b>Diaphragm</b>          | <b>Shoulder tip</b>                 |
| <b>Esophagus</b>          | <b>Behind sternum</b>               |
| <b>Stomach, duodenum</b>  | <b>Epigastrium</b>                  |
| <b>Kidney</b>             | <b>Loin</b>                         |
| <b>Ureter</b>             | <b>Testicles</b>                    |
| <b>Trigone of bladder</b> | <b>Tip of penis</b>                 |
| <b>Hip</b>                | <b>Knee</b>                         |
| <b>Appendix</b>           | <b>Umbilicus</b>                    |
| <b>Uterus</b>             | <b>Low back</b>                     |

# Mechanism of referred pain

## Convergence theory

- Afferent nerves from somatic structure & viscera that develop from same embryonic segment converge on **same spinothalamic tract**.
- Since brain is accustomed to receiving impulses from skin than viscera, so pain impulses carried to cortex along spinothalamic neurons shared by afferents from skin & other from diseased viscus are **misinterpreted** by the brain as coming from 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 ST neurons receiving pain fibers from skin. As a result, ST 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

# Pathway of pain

- Pain sensation is carried by **lateral spinothalamic tracts** which includes 2 separate pathways:-

## The neospinothalamic pathway:-

- This transmits fast pain & thermoceptive sensation.
- First order neurons
- Are mainly **A $\delta$**  afferent nerves. They ascend few segments in Lissauer' tract & terminate at lamina I & V of D. horn.<sup>32</sup>

- Second order neurons
- These constitute the tract. They start at dorsal horn, cross to opposite side and ascend in lateral column of spinal cord. The fibers ascend in brain stem to terminate in ventrobasal complex of thalamus.
- Third order neurons
- These start at thalamus & project to somatosensory cortex.



# The paleospinothalamic pathway:-

- This transmit slow pain sensation & thermoceptive sensation.

## First order neurons

- They are mainly **type C fibers**. They enter spinal cord via dorsal roots, ascend a few segments in Lissauer's tract & terminate at substantia gelatinosa in laminae II & III of dorsal horn.

## Second order neurons

- They start at SGR, cross to opposite side in front of central canal, ascend in lateral column of SC & terminate at:-
- Reticular formation of brain stem.
- Intralaminar nuclei of thalamus.
- Hypothalamus & adjacent region of basal brain.
- Impulses arriving these regions have strong arousal effects and can be perceived.

# Third order neurons

- These start at thalamus, project to all parts of cerebral cortex.

## *Role of cerebral cortex in pain perception*

- Full perception of pain occurs when signals enter RF of brain stem, thalamus & basal regions.
- Somatosensory cortex plays important role in topognosis i.e. **localization & interpretation of pain quality**.
- Fast pain is localized better than slow pain because signals carried in neospinothalamic tract reach somatosensory cortex, while a small propotion of paleospinothalamic pathway reach there.