

6 Physiology of pain

CNS



**Sources:
Female slides**

Objectives

- Pain receptors (nociceptors)
- Effects associated with pain sensation
- Mechanism of stimulation of pain receptors
- Qualities of pain
- Types of pain
- Somatic pain (superficial & deep pain).
- Visceral pain.
- Referred pain
- Pathway of pain
- The neospinothalamic pathway
- The paleospinothalamic pathway

Terms

Free nerve endings:
Microscopic sensory nerve endings in the skin that are not connected to any specific sensory receptor

Topognosis: a sensation localized on the skin

Arousal: state of being awake or reactive to stimuli.

Pain : Pain is unpleasant sensation and emotional experience associated with actual or potential tissue damage.

pain properties

- ✓ It has a **protective** function.
- ✓ All pain receptors are free nerve endings of **unmyelinated C fibers** & small diameter **myelinated A delta δ fibers**.
- ✓ Pain receptors are the most **widely** distributed.
- ✓ Pain sensation can be produced by **various** types of stimuli i.e. mechanical, thermal & chemical, hence the existence of mechanoreceptors, thermoreceptors, & polymodal pain receptors (nociceptors).
- ✓ 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** i.e. painful stimuli must be strong & noxious to produce tissue damage.
- ✓ Pain is perceived at both **the cortical & thalamic levels**

EFFECT ASSOCIATION WITH PAIN :

1- Motor reactions

These may take the form of:-

- * Reflexes e.g. withdrawal reflex.
- * Muscle rigidity (stiffness).

2- Autonomic reactions

- * **Mild pain** stimulates post. hypothalamic nucleus→ **sympathetic changes e.g. tachycardia.**
- * **Severe pain** stimulates ant. hypothalamic nucleus→ **parasympathetic changes e.g. bradycardia.**

3- Emotional reactions as anxiety, crying , etc.

MECHANISM OF STIMULATION OF PAIN RECEPTORS (NOCICEPTORS):

- Pain receptors are depolarized “activated” either :
 - directly
 - through the production of **pain producing substances** that are produced from damaged tissues as a result of inflammation (**also called inflammatory mediators**) e.g. bradykinin, serotonin, histamine, interleukins, substance P, K+, Ach, proteolytic enzymes.
- Prostaglandins & interleukins will **lower threshold** of pain receptors

QUALITIES OF PAIN

	Fast pain (immediate, first)	Slow pain (delayed or second)
Called	pricking, acute, sharp or electric pain.	burning, aching or chronic pain.
Occurs	mainly in skin	skin, deep tissues & viscera
Transmitted by	type A delta fibers	type C fibers
Conduction velocity	3-30m/s	< 2m/s
Percentage	20% of nociceptors primary afferents	80% of nociceptors primary afferents
Arise from	all types of nociceptors.	polymodal nociceptors
Appearance and duration	It appears very rapidly within 0.1 sec. , and lasts for short time	It appears slowly, after one sec. or more, and lasts for longer duration
Localization	well localized	poorly localized
Neurotransmitter	glutamate	substance P
Example	sensation felt when skin is cut with a knife.	

Types of Pain: according to the site of stimulation into

	1. Somatic Pain		2. Visceral Pain
	Superficial	Deep	
Arises from	Skin or other superficial structures	<ul style="list-style-type: none"> ▪ Muscles ▪ joints, ▪ Periosteum ▪ tendons & ligaments. 	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
Quality	It occurs in 2 phase <ul style="list-style-type: none"> ▪ fast pricking ▪ slow burning pain 	slow prolonged conducted by type C fibers	It is slow pain conducted by C fibers . (pain arising from parietal peritoneum, pleura and pericardium is sharp, pricking type).
Localization	Well localized.	poorly localized (diffuse).	poorly localized (diffuse). the patient feels pain arising from inside but he cannot pinpoint it exactly.
Associations	Associated with motor, autonomic, emotional reactions.	can initiate reflex contraction of nearby muscles	<ul style="list-style-type: none"> •It is often associated with autonomic reactions. •It can be associated with rigidity of nearby muscles
Referred Pain	Cutaneous pain is not a referred.	referred to other sites	referred to other sites
Cause		trauma, bone fracture & inflammation, arthritis, muscle spasm & ischemia.	<ul style="list-style-type: none"> •Distension of a hollow organs. •Inflammation of an organ. •Ischemia e.g. pain due to myocardial ischemia.

Referred pain

What is the meaning of referred pain ?

It is the pain that felt away from its original site

Where can we see this type of pain?

With visceral organs and deep somatic structures BUT never can happens with cutaneous tissue

This type of pain follows which rule to referred ?

Follows Dermatomal rule

Examples:-

Cardiac pain is referred to left shoulder & inner side of left arm.

Pain of **appendicitis** is referred to umbilical region.

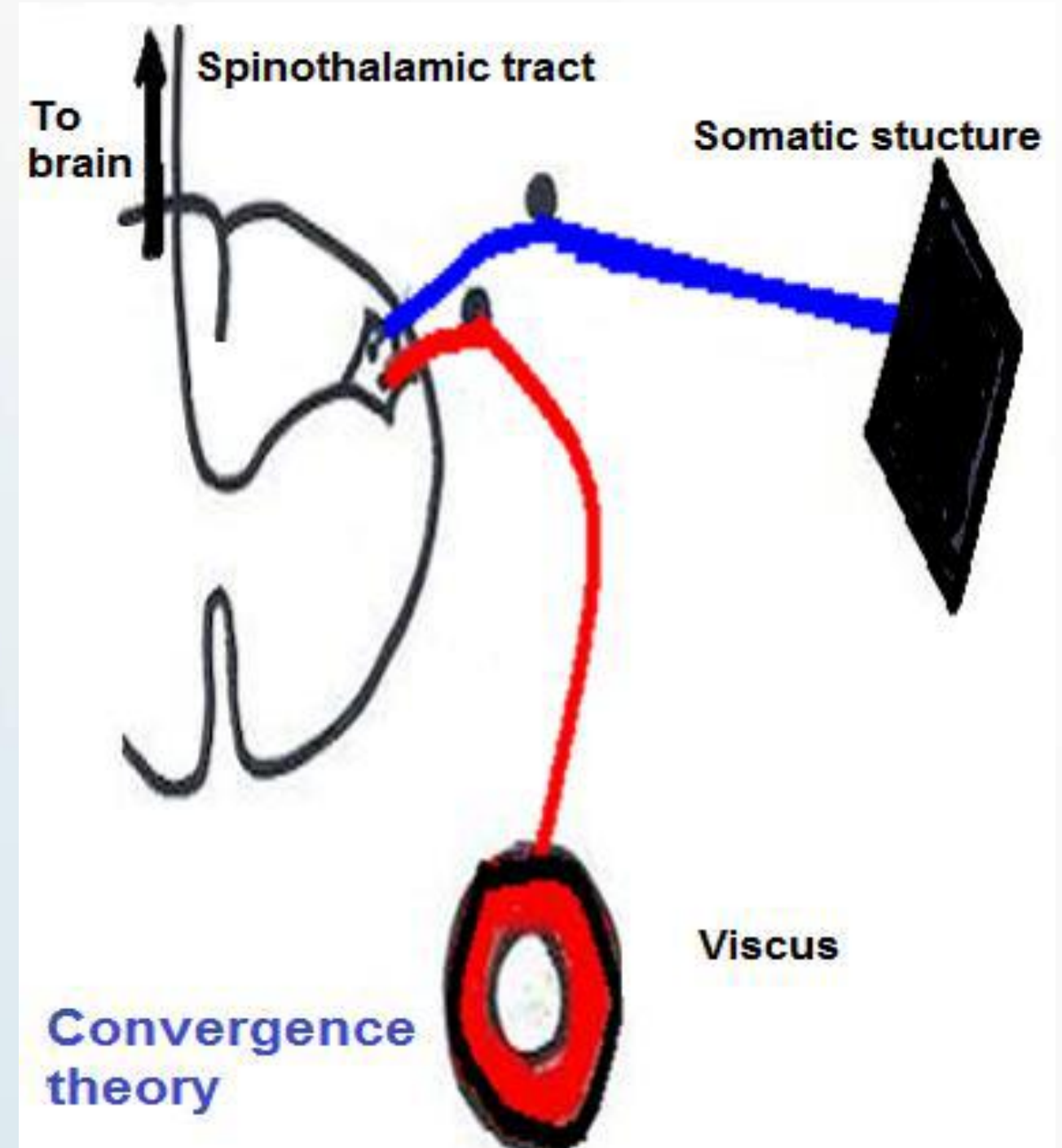
Pain from the **ureter** is referred to testicular region.

Mechanism of referred pain

1-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.

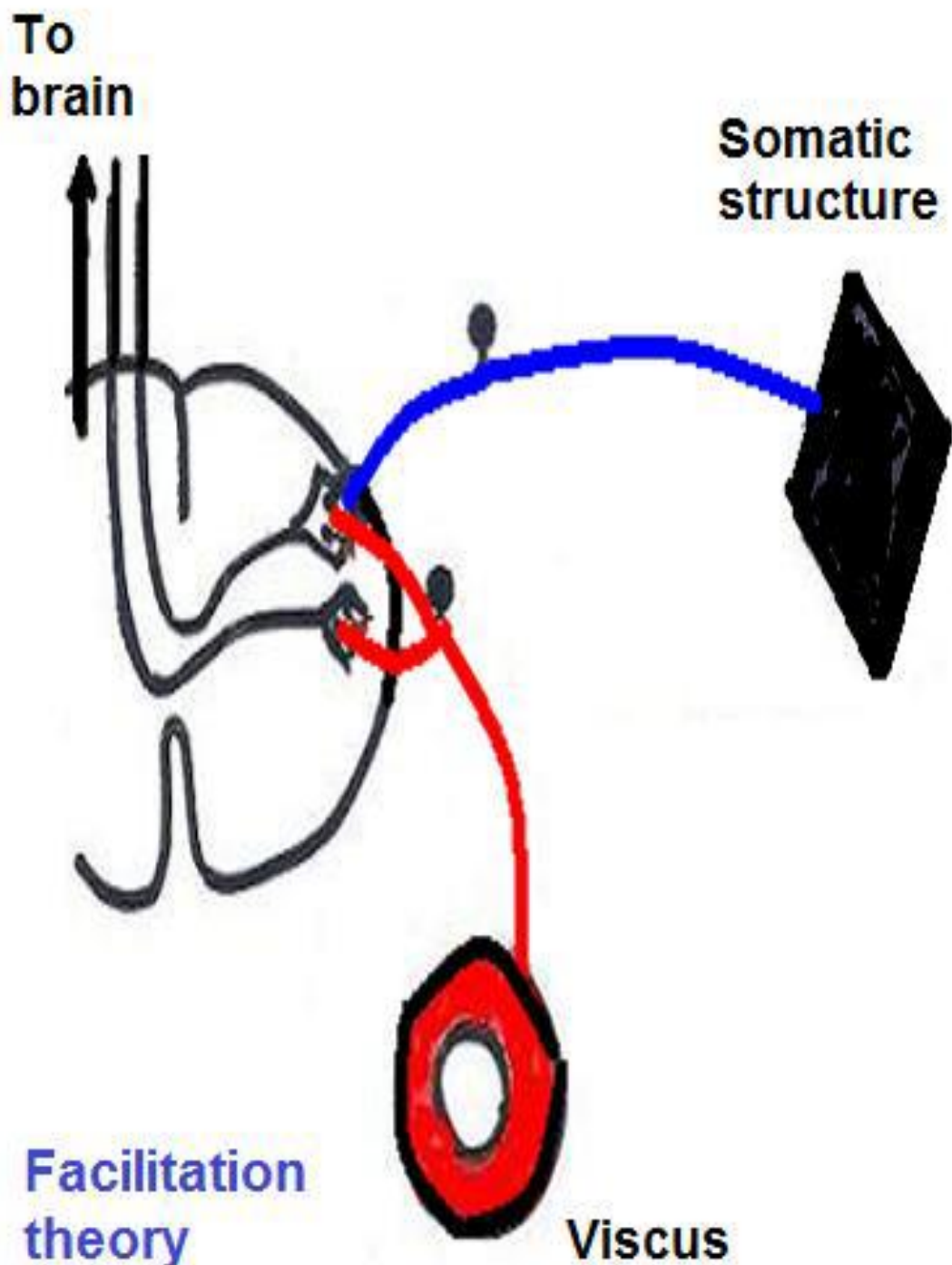
هذي النظرية تنص على ان هناك مناطق بالجسم *سواء اراديه او غير اراديه* لها نفس الاعصاب الحسيه والعقل متعود يستقبل نبضات من الجلد اكثر من اي عضو ثاني !! ف بالتالي اذا حسينا بالـ من عضو يوصل هذا الاحساس للـ *spinothalamic tract* على ان الالم جاء من الجلد مو من العضو وبكذا يحصل انتشار الالم



Mechanism of referred pain

2-Facilitation theory

Pain fibers from skin are always carrying impulses, 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



النظريه الثانيه تنص على ان هناك نبضات مستمره تطلع من الجلد للاعصاب الحسيه لكن لم تصل لل * threshold level* ومع العضو المصاب تطلع نبضات للاعصاب الحسيه لتحفز النبضات الي جايه من الجلد ف بالتالي العقل يعتقد ان هذي النبضات جايه فقط من الجلد وبكذا يصير الانتشار

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

Pathway of pain

Good to know that the pain sensation is carried by the **lateral spinothalamic tracts** which includes 2 separate pathways:-

	First order neurons	Second order neurons	Third order neurons
1)The neospinothalamic Pathway This transmits fast pain & thermoceptive sensation.	Are mainly A δ afferent nerves. They ascend few segments in Lissauer' tract & terminate at lamina I & V of Dorsal horn.	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.	These start at thalamus & project to somatosensory cortex.

Pathway of pain

	First order neurons	Second order neurons*	Third order neurons
<p>2)The paleospinothalamic pathway</p> <p>This transmit slow pain sensation & thermoceptive sensation.</p>	<p>They are mainly type C fibers. They enter spinal cord via dorsal roots, ascend a few segments in Lissauer' tract & terminate at substantia gelatinosa in laminae II & III of dorsal horn.</p>	<p>They start at SGR, cross to opposite side in front of central canal, ascend in lateral column of SC & terminate at:-</p> <ul style="list-style-type: none"> Reticular formation of brain stem. Intralaminar nuclei of thalamus. Hypothalamus & adjacent region of basal brain. 	<p>These start at thalamus & Project to all parts of cerebral cortex.</p>

*Impulses arriving these regions have strong arousal effects and can be perceived.

Role of cerebral cortex in pain perception

Full perception of pain occurs when signals enter

1) Reticular Formation of brain stem

2) thalamus

3) basal regions. **(1&2&3 together)**

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 all to somatosensory cortex, while a small proportion of paleospinothalamic pathway reach there ((because they also terminate at Reticular Formation of brain stem, thalamus and basal brain))

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