بسم الله الرحمن الرحيم

Before the lecture has been started there were a long discussion about the syllabus & the Order of giving the material & the Doctor said that he will do his best to come up with the most suitable solution depending on the circumstances.

Now we will start our lecture:

* Conduction speed:

-We have two somatosensory pathways:

1) Antero-lateral system **(ALS)** or Spinothalamic pathway: which is slower.

* We'll note later in this sheet that "spinothalamic pathway" is actually one of several tracks of ALS, i.e. not the same as ALS, but rather part of it.

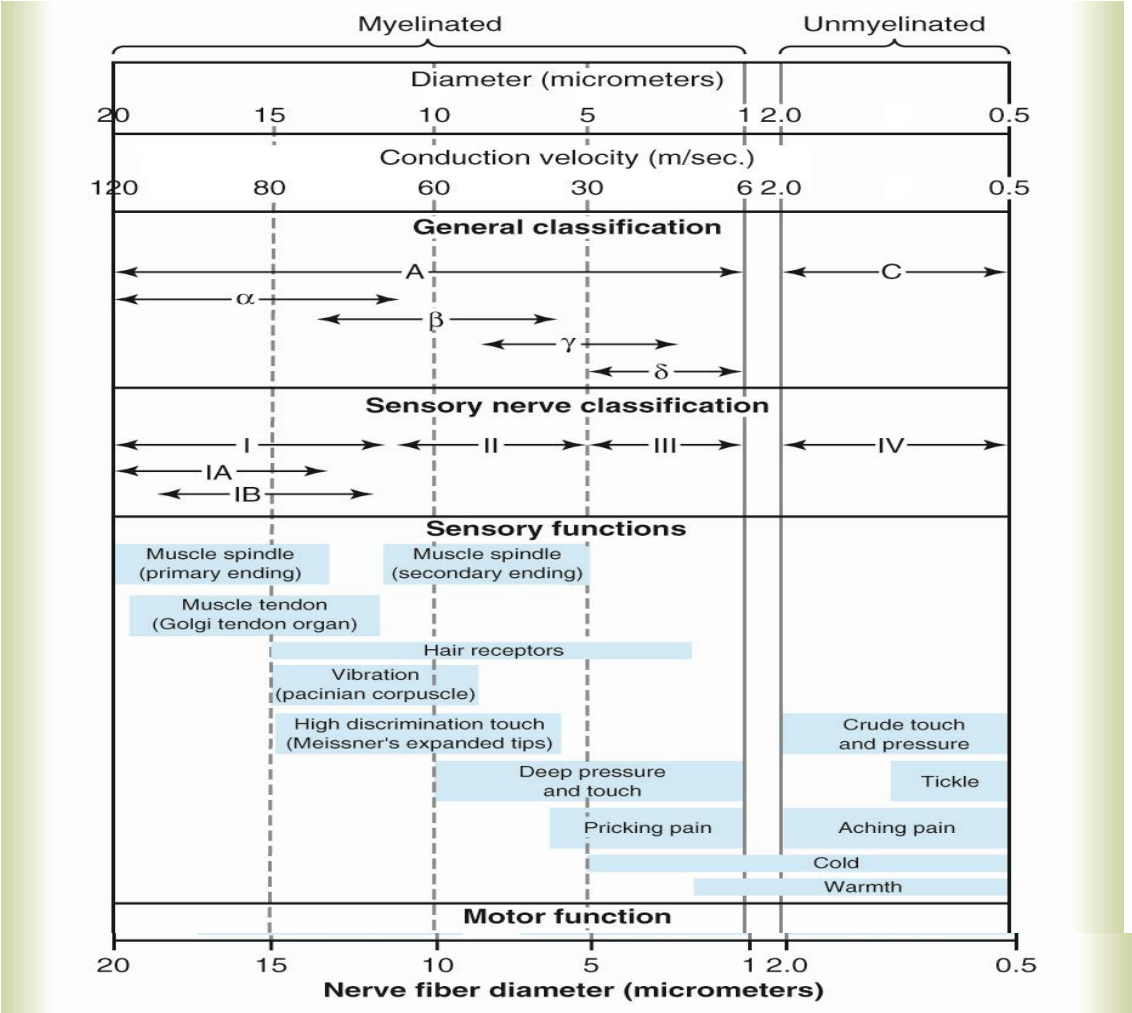
2) Posterior Column-Medial lemniscus Pathway **(PCML)**: which is faster.

-Conduction speed for any pathway depends on 3 factors:

1) Myelination

2) Nerve axon size or diameter

3) Number of the synapses



-In the above figure we classify nerve fibers **anatomically** (depending on the shape) & **physiologically** (depending on the function).

1) Anatomically: "Sensory **&** motor classification – general classification"

A) Unmyelinated **(C)**

B) Myelinated **(A)**

-Myelinated axons are so many & they are subdivided based on the size from the biggest to the smallest as the following:

Aα (the biggest) **> Aβ > Aγ > Aδ** (the smallest)

2) Physiologically: "Sensory nerve classification"

Based on the **speed** (which affects the function), classified into: **I, II, III, IV**

I is the fastest (big & myelinated axon) while **IV is the slowest** (small & unmyelinated axon).

-We have to memorize each classification & the sensory information carried through each type of nerve fibers (distribution) (for example, to know what sensation is carried through Aα nerve fiber, Aβ, Aγ & so on):

1) All the unmyelinated axons are **ALS** fibers except for some types of pain which may be carried through **Aδ.**

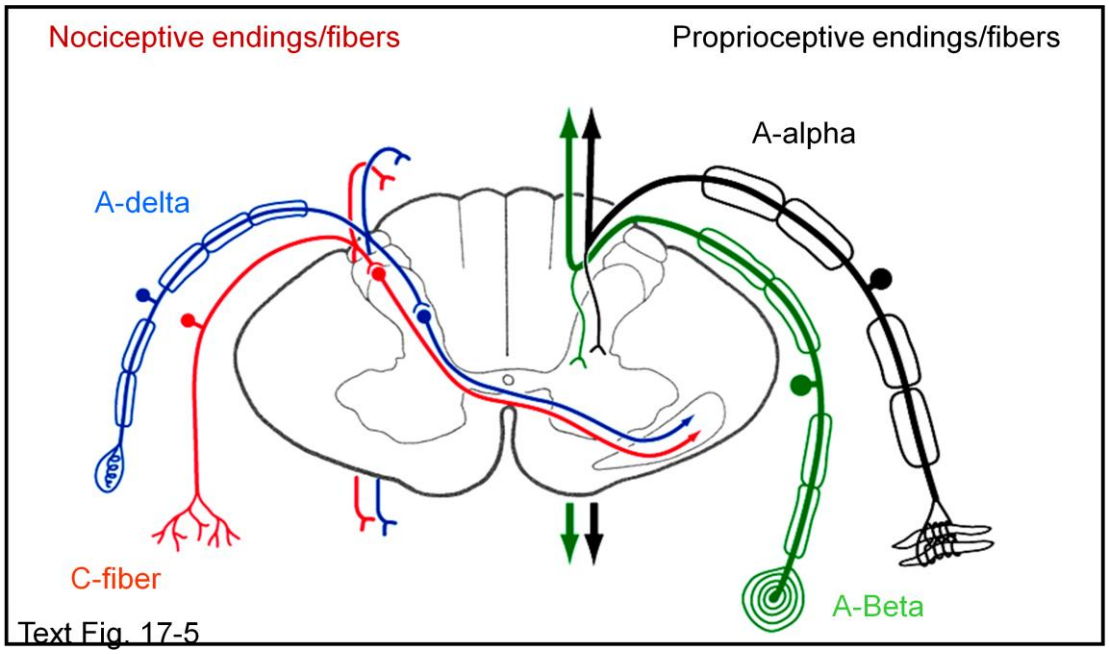
2) The proprioception is carried faster than 2-point discrimination & Vibration, so it is **Aα.**

3) **Aβ**: the other modalities of **PCML** (like 2-point discrimination & Vibration).

4) **Aδ**: pain (pricking pain).

5) **C**: modalities of **ALS** (crude touch, temperature, aching pain, pressure, tickle)

-The physiologic distribution of type **IV** sensory nerves is the same as the sensory distribution of type **C** sensory nerves, whereas the physiologic distribution of **I (IA & IB)** is related to/ coming from the **muscle spindle & golgi tendon argan, respectively.**



Text Fig. 17-5

-As shown in the previous figure:

-The proprioception (**Aα**) is the most lateral one & as we go medially we will find other PCML modalities' fibers (**Aβ**), pain fibers (fast pain , **Aδ**) & the most medial one is the unmyelinated fiber (**C-fiber**) .

-So when the spinal nerve enters the spinal cord, **the large & myelinated fibers are located laterally whereas the smaller & unmyelinated fibers are located medially** & this is important in clinical cases.

*Somatosensory from the face:

-As we said, we have **PCML** & **ALS** sensory pathways coming from different receptors in the body, which enter the spinal cord through spinal nerves.

-However, we can note that PCML pathway fibers decussate in medulla oblongata not in the spinal cord, whereas ALS pathway fibers decussate at the level of the spinal cord in the dorsal horn.

-So, as somatosensory pathaways' fibers enter the brain stem, **PCML** pathway fibers haven't yet synapsed, but **ALS** fibers have already synapsed & decussated (at the spinal cord level). However, by reaching the medulla level, all somatosensory pathways' fibers have now made synapses & crossed the midline since PCML fibers synapsed & crossed the midline in the medulla.

Now let's talk about the face:

-The face has somatosensory sensation: thermal, pain, 2-point discrimination, vibration & proprioception like any other part of the body.

-Synapses of somatosensory fibers coming from the face don't occur in the spinal cord (why bother & go down), instead, the fibers go directly to the brain stem.

-The somatosensory pathways (both PCML & ALS) that come from the face travel through the **trigeminal nerve** through its 3 divisions (ophthalmic, maxillary & mandibular) & go directly to the brain stem.

- As the trigeminal nerve fibers enter above the medulla (in the pons, since this nerve –trigeminal- is the 5th cranial nerve), the sensory fibers make synapses at different levels (there is no place to ascend without synapse).

Following the general rule that defines 3 stages (3 order neurons) for any sensory pathway; the first order neurons here are pseudo-unipolar neurons that are present in one of the ganglia, those first order neurons enter the brain stem –above the medulla- then make synapses with the 2nd order neurons at different levels of the trigeminal complex –to be further explained later-.

- The fibers of this nerve enter the brain stem as almost one unit as "the trigeminal nerve" -حزمة وحدة– , however, when they enter the brain stem, the fibers separate on the bases of modalities; for example, fibers conducting modalities of **ALS** go to the nucleus (which is situated caudally in relation to the site of entry of the trigeminal nerve to the brain stem) & centre which are specialized in **ALS.**

- Note: the name of the nuclei & their exact location will be taken in the anatomical part of the course, but we have to know which is caudal & which is rostral.

-So again, ALS fibers of the trigeminal nerve go to the caudal part of the trigeminal complex & there, they make synapses with 2nd order neurons inside the nucleus present there (known as spinal trigeminal nucleus), crossing & go to the other thalamus & cortex.

- Most of **PCML** pathway fibers / **PCML** modalities enter a specialised nucleus in the centre of the trigeminal complex (known as the principle nucleus), making synapses with 2nd order neurons there, and crossing to the other thalamus and cortex, although there are other PCML fibers that synapse in the principle nucleus but DON'T cross the midline (Note: we will not talk about the uncrossed fibers).

-Some of the proprioception carried through PCML pathway fibers actually goes to a special area in the most rostral part of the trigeminal complex, more specifically; to the "mesencephalic nucleus" there, where these fibers DON'T synapse; since these fibers' cell bodies are actually present in this nucleus, unlike other discussed pathways' fibers, where their cell bodies are present in one of the ganglia (so this mesencephalic nucleus is actually a sensory ganglion, i.e. no synapses occur inside it), also, the fibers coming out from this nucleus go to the same side as well as giving branches that cross the midline to the other side – bilateral - to control some motor functions (the fibers do not ascend to the thalamus or cortex), pls note that this nucleus takes some proprioception **to control mastication & reflexes** (that's why the fibers don't ascend to thalamus or cortex).

- Note regarding mesencephalic nucleus: this nucleus resembles the gray matter of the spinal cord, how is that?

As we said, there are neurones that bring sensations to laminae in gray matter of the spinal cord & don't ascend upwards to the brain stem & cortex, they just do their function in the spinal cord (as in reflexes) & when we talk about mesencephalic nucleus, it's actually a gray matter but with no laminae, that receives primary afferents that don't further ascend to the thalamus or cortex, instead, they go & control some motor functions (reflexes & mastication) "same concept/ principle".

- Note: the mesencephalic nucleus is present in the midbrain.

- Note: The trigeminal system/ complex is distributed over a large part of the brain stem, i.e through all brain stem sections we can find the trigeminal nucleus, which are the spinal (in the caudal part), principle (in the centre) & mesencephalic (in the rostral part) nuclei & each one of them has its own function (all of this will become clear when we take sectional anatomy).

-Reflex means localised circuit that doesn't send information upwards.

- Note: some proprioceptive information are conveyed to mesencephalon & other proprioceptive information are conveyed to the principle nucleus (these proprioceptive information are the ones that will be sent further to thalamus & cortex), also, mesencephalic nucleus may send information to the principle nucleus & from there, these information ascend upwards to the thalamus.

-The **principle nucleus** resembles cuneate & gracile in the dorsal coloumn of white matter of the spinal cord; since most of the modalities of **PCML** go there, and then continue to thalamus and cortex.

-In the **PCML pathway,** we have fibers that arrive at gracilis & cuneatus fasciculi in the spinal cord; these fibers do not synapse & only ascend upwards, however, they give off collateral branches that go to the gray matter of the spinal cord & synapse there for reflexes (like stretch reflex).

- Stretch reflex is a local circuit.

- Jaw reflex: not fairly explained by the dr, however this is from Wikipedia:

(The jaw jerk reflex can be classified as a dynamic stretch reflex. As with most other reflexes, the response to the stimulus is monosynaptic, with sensory neurons of the trigeminal mesencephalic nucleus* sending axons to the trigeminal motor nucleus, which in turn innervates the masseter.)

*Remember that trigeminal mesencephalic nucleus has to do with reflexes.

-In the spinal cord we have complex circuits that are controlled by higher centres.

-When we reach the thalamus, all somatic sensations go to the **ventro-posterior complex/ nucleus of the thalamus (ventral posterior complex of the thalamus)**.

- Note: The ventral posterior nucleus is the somato-sensory relay nucleus in **thalamus** of the brain (Wikipedia).

- As we go laterally in this complex towards **the lateral part of the ventro-posterior nucleus**, the somato-sensation received will be from the body and the body is represented there "down to up", while **the medial part** will receive somato-sensation from the face, from there (lateral & medial parts), all sensory modalities/ information will go to the primary sensory cortex 3,1,2 (where the somatosensory cortex organization is the same as motor somatotopic organization; lower limbs presented more medially, then trunk, then upper limb, face, internal of the mouth & larynx).

- Organization of somatosensory cortex (how big is the representation of a part of your body) depends on the number of neurons arriving to the cortex from each part of the body; for example, the hand has lots of sensory nerve endings which do not converge, i.e. each neuron will send its **own** axon in the sensory pathway to the cortex, that's why representation of hands, lips & face are more than the trunk, back & legs in the primary sensory cortex.

*Pain:

-This table contains terminology about pain and the doctor said that we should know them:

TERM	DESCRIPTION
ALLODYNIA	PERCEPTION OF NON-NOXIOUS STIMULUS AS PAIN
ANALGESIA	ABSENCE OF PAIN PERCEPTION
ANESTHESIA	ABSENCE OF ALL SENSATIONS
ANESTHESIA DOLOROSA	PAIN IN AN AREA THAT LACKS SENSATION

DYSESTHESIA	UNPLEASANT SENSATION WITH OR WITHOUT STIMULUS
HYPOALGESIA	DIMINISHED RESPONSE TO NOXIOUS STIMULUS
HYPERALGESIA	INCREASED RESPONSE TO NOXIOUS STIMULUS
HYPERASTHESIA	INCREASED RESPONSE TO MILD STIMULUS
HYPOASTHESIA	REDUCED CUTANEOUS SENSATION
NEURALGIA	PAIN IN THE DISTRIBUTION OF A NERVE
PARASTHESIA	ABNORMAL SENSATION PERCEIVED WITHOUT AN APPARENT STIMULUS
RADICULOPATHY	FUNCTIONAL ABNORMALITY OF NERVE ROOTS

-Pain is one of the alarming modalities which is very important.

-Pain will start at the periphery in free nerve endings, so when we have trauma or tissue damage by inflammation or through needle or cut, etc., there will be release of certain molecules – chemicals- that will stimulate free nerve endings, which in turn will send impulses through **ALS** pathway up to the brain through the spinal cord.

-Some of these chemicals are:

Bradykinin, Histamine, Serotonin, Prostaglandin, substance B

-**ALS** is a group of tracts, one of them is spinothalamic tract, that starts from the spinal cord (don't forget that it actually starts from receptors then go to the spinal cord) to the thalamus then to the cortex.

- ALS old classification was into 2 main tracts, neospinothalamic tract and paleospinothalamic tract, neospinothalamic tract conducts ALS modalities from the periphery to the thalamus to the cortex, whereas paleospinothalamic tract conducts from periphery to subthalamic areas without reaching the thalamus & VP complex/ nucleus, except for few of its fibers that actually ascend to the thalamus.

*__Neo__ for localised & sharp pain, usually through **Aδ** fibers; since fast conduction transmits localised pain, whereas other fibers will conduct the suffering type of pain "AS THE DR SAID" *** pls refer to him about this point for further explanation.

- The newly named tracts of ALS are:

Spinothalamic tract

Spinoreticular tract: goes to the reticular formation

Spinohypothalamic tract: goes to the hypothalamus (that controls our emotions)

Spinomesencephalic tract: goes to the midbrain to a specialized area there, called periaqueductal gray.

-Descending control of pain: upper regions control lower regions:

*the cortex controls all areas that receive pain impulses; whether hypothalamus, midbrain, reticular formation & even spinal cord, for example, corticospinal tract that descends from cortex & modulates sensation through modulation of sensory pathways.

*hypothalamus: controls areas that receive pain but only at the level of the brain stem (i.e. doesn't send descending fibers to the spinal cord) like locus coeruleus, raphe nucleus –serotonin system- & periaqueductal gray "AS THE DR SAID"

*periaqueductal gray: sends descending controlling fibers down to the spinal cord (to control & eliminate pain)

*locus coeruleus: "was" part of the reticular formation, sends descending inhibitory fibers to the axons conducting pain, also inhibits the ascending pathway at postsynaptic regions.

Sorry for any mistakes

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