Central Nervous System

Sheet 3

Subject | Anatomy

Done by | Dima Batarseh

Correction | ...

Doctor | Mohammad Al-Salem

This sheet includes the following subjects:

1) major symptoms of IVD herniation

2) cross section in spinal cord

3) physiology stuff that already taken in physiology lectures

4) PCML

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major symptoms of IVD herniation

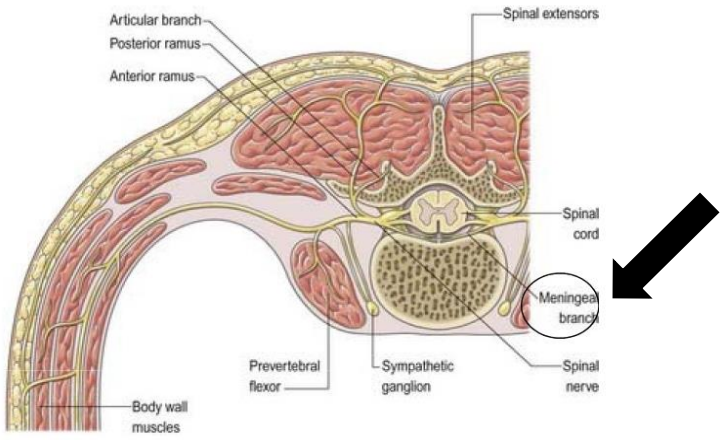
- As you know, IVD herniation commonly happen on the posterior lateral part of the disk affecting in 95% of the cases IVD between L4-L5, L5-S1. This bulge compresses on the root of spinal nerve that is near to it . So that, the part of skin and muscles that are supplied by the affected spinal nerve are affected too leading to loss of sensation of that part of skin and weakness in muscle movement respectively.

- One of the major symptoms of IVD herniation is low back pain. REMEMBER THAT LOW BACK PAIN IS A SYMPTOM OF MANY OTHER DESEASES AND IVD HERNIATION IS ONE OF THEM.

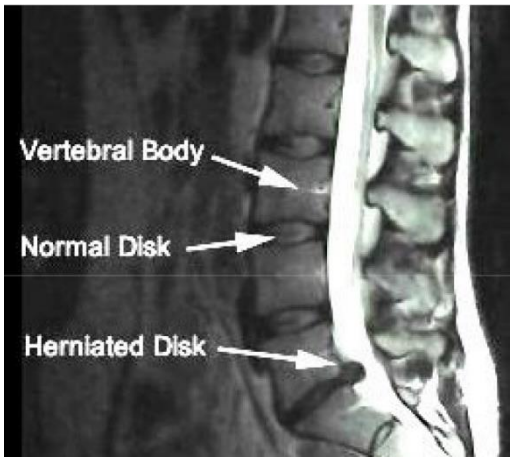
- This pain is diffused due to the overlapping dermatomes. It radiates to the gluteal region, the back of the thigh and the back of the leg.

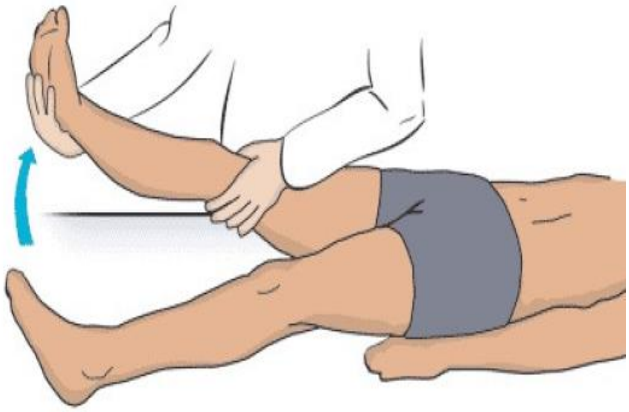
And now, let's understand the reason behind this:

spinal nerve after leaving the spinal canal gives one of its branches called the meningeal branch. This branch is called recurrent branch since it is originated outside the vertebral canal from spinal nerve and then pass by certain foramen and go back to spinal canal to give supply (sensation) to the Dura which is sensitive to stretch.



So, when the dura is stretched, nerve impulses are transported through this nerve.





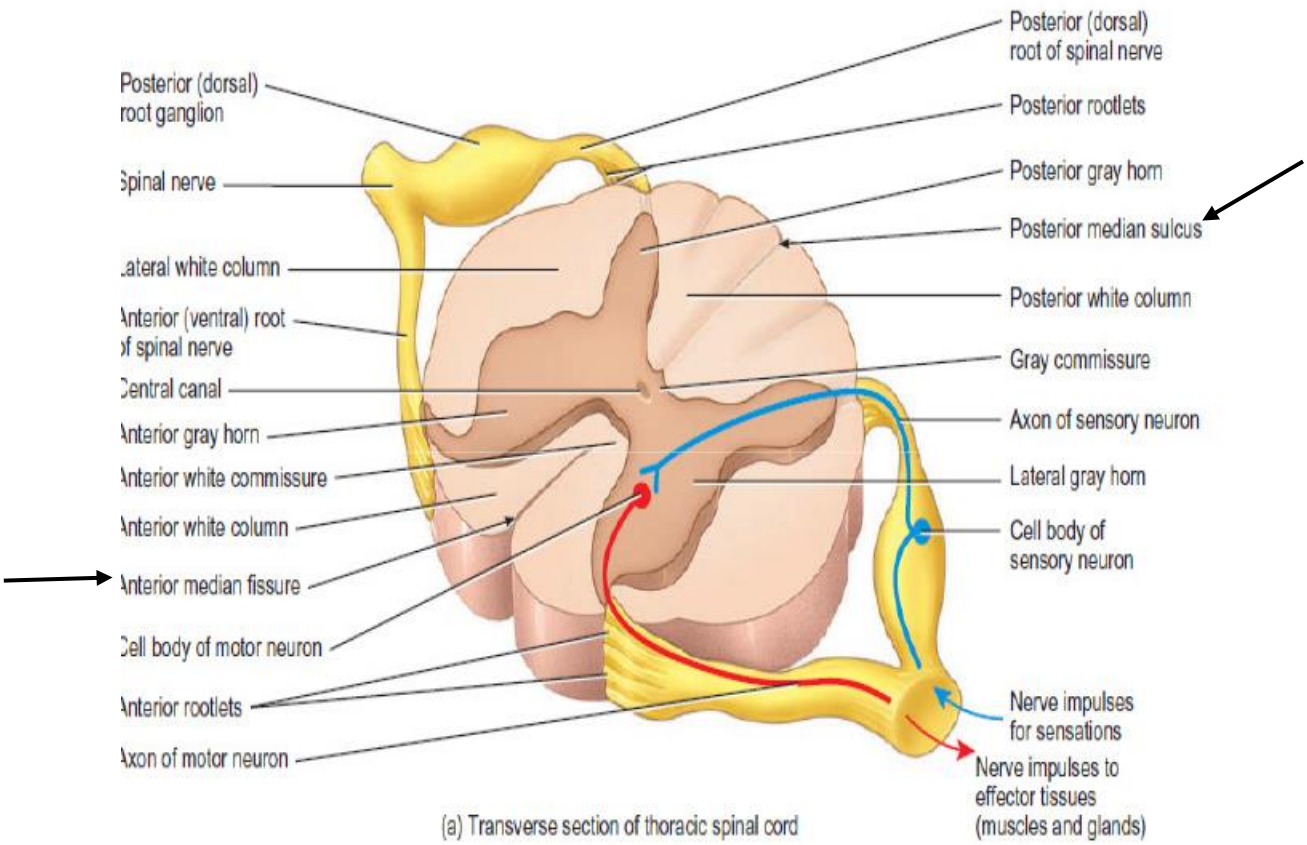
Raised straight leg test : In this test, the patient is lying on his/her back . The doctor raise his/her fully straight leg in order to flex hip joint and stretch Sciatic nerve and its root (very big root from L4 to S3) . Patient feels back pain during this test as a symptom of many diseases including the one we are studying.

Note that , the patient might feel back pain after raising his leg for just few cms . And other patient might feel back pain after raising his leg to a higher level . The earlier the pain is felt , the worse the situation is . Usually, IVD herniation patients feel back pain when the angle between the raised leg and floor/ bed = 30-70

-MRI is usually used to aid in making the diagnosis of IVD herniation

Cross section in spinal cord

We will Discuss this part of the lecture by viewing some pictures and adding some notes to them.



NOTES :

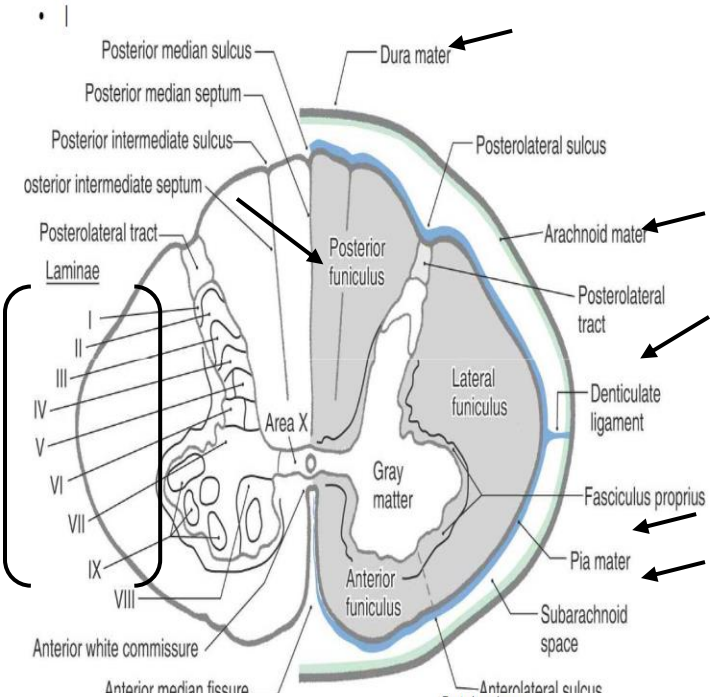
1) Gray matter is surrounded by white matter in spinal cord
2) Gray matter is divided into 3 horns :
   A. Posterior – dorsal : cell bodies of sensory neurons
   B. Anterior –ventral : cell bodies of motor neurons
   C. Lateral : cell bodies of autonomic preganglionic neurons and exists only in spinal segments that give raise to autonomic nerve fibers
3) White matter is divided into posterior – lateral – anterior columns
4) Sometimes both anterior column and lateral column are called anterolateral column because they are similar each other.

- Anterior median fissure: wide groove on the Anterior aspec
- posterior median sulcus: Narrow groove on the posterior

Sulcus = اخدود fissure= اخدود اكبر و مفتوح للداخل

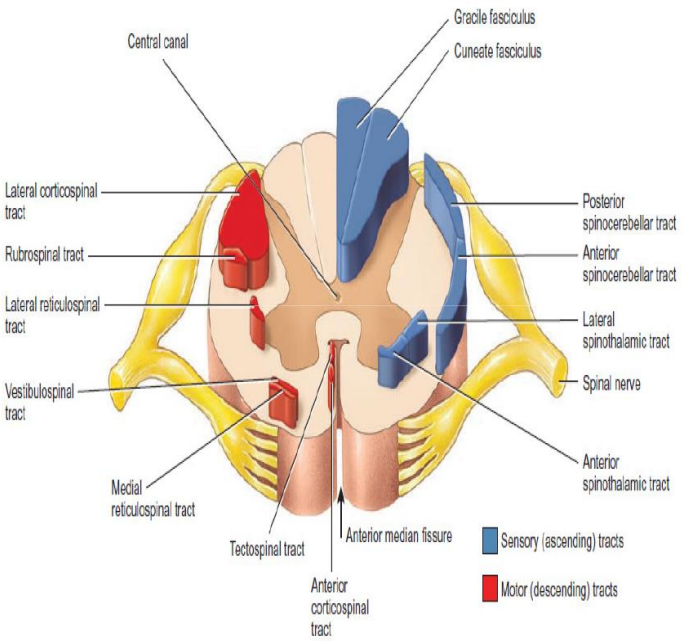
NOTES :

1) Here the white matter is filled with gray color so don't be confused.
2) Note that 'funiculus' means column
3) Here you can see the 3 meninges and the denticulate ligament that were discussed in the previous lect.
4) Rexed classified the white Matter into laminae (I-VII)



NOTES :

1) Here you can differentiate between anterior median fissure which is wider than the posterior median groove
2) Those colored with red and blue are examples of tracts in the white matter. Red tracts (left) are motor and blue tracts (right)are sensory .
3) Note that from each tract name you can understand where it begins and ends and whether it is sensory or motor.



Ex : lateral spinothalamic : starts in spinal cord and ends in thalamus which means that it is sensory tract

Ex: corticospinal : starts in brain cortex and ends in spinal cord which means that it is motor tract

4) You can also see the central canal inside the spinal cord which is opened to the forth ventricle in the brain and filled with CSF
5) Commissural tracts connect corresponding cortical areas in the two hemispheres. They cross from one cerebral hemisphere to the other through bridges called commissures. Wikipedia

Sensory receptors

- Note that first order neuron that transmits signal from peripheral tissues to CNS is called receptor and on its surface there are specialized proteins that are able to detect certain type of energy and convert it to other form of energy which is electrical energy. Those proteins are called receptors too.
- Thermoreceptors and nociceptors are free nerve endings (free= not capsulated) that has membrane protein channels(TRP CHANNELS) that opens when stimulated by heat .
- Nociceptors are pain receptors and there are 2 types of pain :
  1. Chronic pain : detected due to the action of cytokines released after tissue damage
  2. Acute pain : there is no type of energy called pain , unlike heat. Pain is an exaggeration of energy . EX, normal amount of heat is sensed as heat. High level of heat is sensed as pain .

❑ Mechanoreceptors

- **Meissner's corpuscle**
  - Respond to touch, pressure and low frequency vibration (low frequency)
  - rapidly adapting
- **Merkel's disc (Tactile Disc)**
  - Discriminative touch
  - Slowly adapting
- **End organ of Ruffini**
  - sensitive to skin stretch
  - Slowly adapting
- **Pacinian corpuscles**
  - Vibrations (high frequency)
  - rapidly adapting

➢**Rapidly adapting**: signals fade away after stimulus exposure
➢**Slow adaptation:** signals is transmitted as long as the stimulus is present

❑ Thermoreceptors

- Free nerve endings
- Detect change in temperature
- TRP channels

❑ Nociceptors

- Free nerve endings
- Detect damage (pain receptors)
- Multimodal

NOTE : no need to memorize this table. You just should understand that nerve axons that transmit the signal differs in diameter (higher diameter →higher velocity) .

Aα in the highest → Aβ→ Aδ→C

TABLE 25.1 Summary of Primary Afferent Fibers and Their Roles

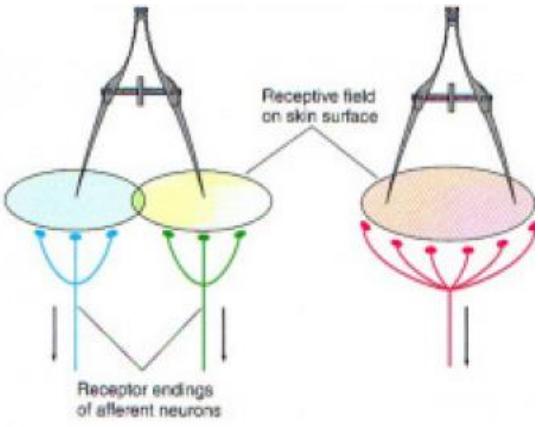
Modality	Submodality	Receptor	Fiber type	Conduction velocity ($m\,s^{-1}$)	Role in perception
Mechanoreception	SAI	Merkel cell	Aβ	42-72	Pressure, form, texture
	RA	Meissner corpuscle	Aβ	42-72	Flutter, motion
	SAII	Ruffini corpuscle	Aβ	42-72	Unknown, possibly skin stretch
	PC	Pacinian corpuscle	Aβ	42-72	Vibration
Thermoreception	Warm	Bare nerve endings	C	0.5-1.2	Warmth
	Cold	Bare nerve endings	Aδ	12-36	Cold
Nociception	Small, myelinated	Bare nerve endings	Aδ	12-36	Sharp pain
	Unmyelinated	Bare nerve endings	C	0.5-1.2	Burning pain
Propioception	Joint afferents	Ruffini-like and paciniform-like endings, bare nerve	Aβ	42-72	Protective function against hyperextention
	Golgi tendon organs	Golgi endings	Aα	72-120	Muscle tension
	Muscle spindles	Type I	Aα	72-120	Muscle length and velocity
		Type II	Aβ	42-72	Muscle length
	SAII	Ruffini corpuscle	Aβ	42-72	Joint angle?

Note : the process of sensation is characterized by :

- Modality : to recognize the type of stimulus
- Locality : to recognize in which part or area in your body that signal came from
- Intensity : to recognize whether the stimulus is strong or not

- Receptive field : the certain area of skin that a specific neuron receives sensation from .

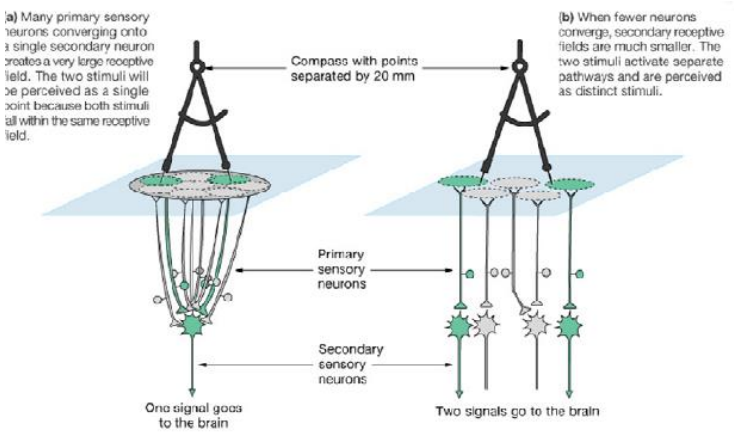
the one to the right will stimulate 2 points on skin and the signal is eventually transmitted through one neuron so you will feel those 2 stimuli as one. In other words, here the receptive field is bigger so all stimuli affecting this area at the same time will eventually transmit action potential that Is transmitted through the same axon and identified by your brain as one .



the one to the left will stimulate 2 points on skin and each signal is transmitted through different neuron so you will feel those 2 stimuli as 2 stimuli.

- Receptive field area for each neuron depends on the density of neurons distributed in that part of skin. Higher number of neurons means that receptive field for each one of them is smaller so sensation will be more accurate. Ex , your hand → low receptive field , your back → high receptive field

here the receptive field is the same. However , due to the difference in processing the sensation differs . in the one to the right each first order neuron synapse with a different second order neuron so 2 signals are transmitted in 2 pathways so 2 stimuli are sensed. in the one to the left, both first order neurons synapse to the same second order neuron so the signal from both of them is transmitted together within the same second neuron and eventually sensed as one stimulus .



labeled line theory

-inside the CNS , there are many pathways and each one of them carry a spesefic signal from a specific location in the body. By experience your brain can recognize the peripheral origin and the type of that stimulus detected once that pathway deliveres the signal to its final destination.

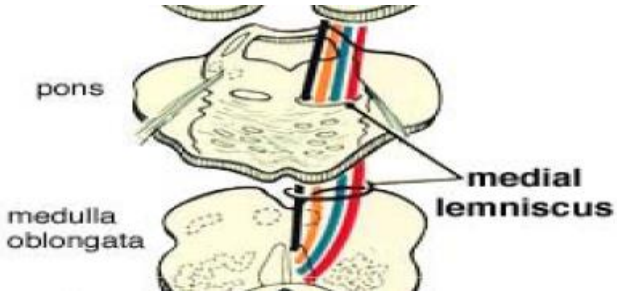
-Here are some points mentioned in the slides:

- ❑ individual receptors preferentially transduce information about an **adequate stimulus**
- ❑ individual primary afferent fibres carry information from a single type of receptor
- **Conclusion:**
- pathways carrying sensory information centrally are therefore also specific, forming a "labelled line" regarding a particular stimulus

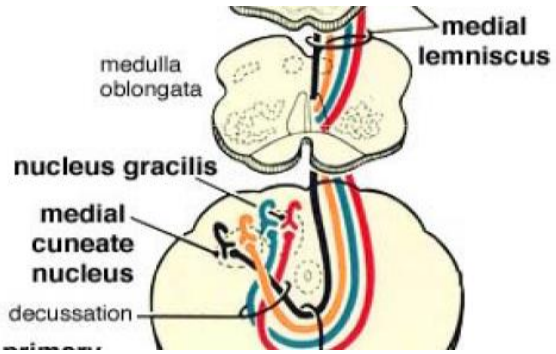
➢ **Note: The adequate stimulus is the amount and type of energy required to stimulate a specific sensory organ**

Posterior column medial lemniscus pathway *

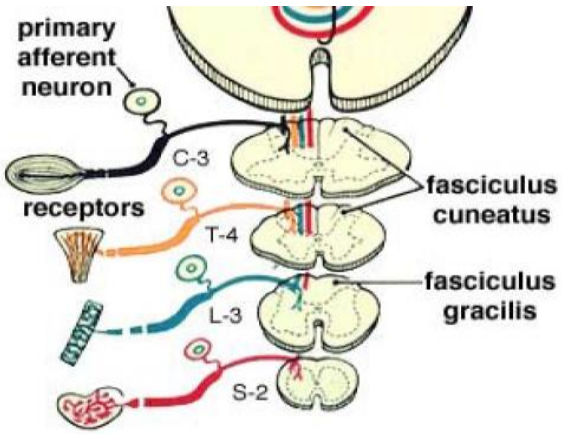
3) axons of 2nd order neuron become close to each other forming a structure called medial lemniscus. It is called so since it looks like new moon (هلال) when viewed in a cross section.



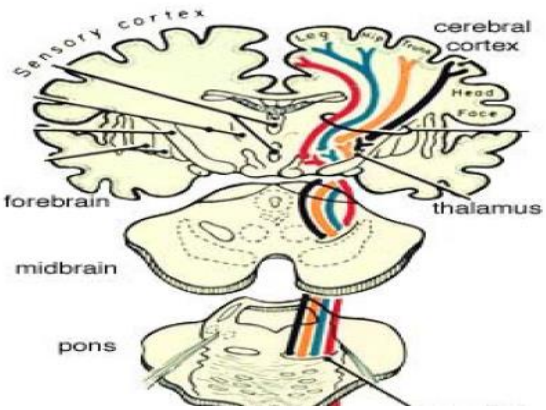
2)1st order neuron synapse with the cell bodies of 2nd order neurons in the nucleus in the lower part of medulla oblongata. Axons of 2nd order neuron go across the medulla to the other side (from right to the left and from left to the right) . this part appears like an arch , that is why it is called “internal arcuate fibers “



1) first, most types receptors (proteins) are included in this pathway except free nerve endings sense they are slow and included in other pathways related to the anterolateral column (posterior column is well developed and transports very fast signals). afferent sensory neurons or first order neurons transmit signals from peripheral neurons to the spinal cord through dorsal rout of spinal nerves. then their axons transmit the signal through spinal cord without making any synapse



Axons of 2nd neuron synapse with cell bodies pf 3rd neuron in the VPL nucleus in the hypothalamus. axons of 3rd neuron will go through the white matter toward primary somatosensory cortex . At some point those fibers pass through a very small area where there is no enough space so they get close to each other. Then, they distribute in a larger area reaching their final targets in the cortex . those fibers look like this thing in the picture bellow . that is why they form a structure that is called corona radiata .



Finallyyyyyyyyyy, here are some notes :

- 1st order neuron axons forms 2 bundles within the white matter. First one is located more medially called fasciculus gracilis that synapses with nucleus gracilis in medulla oblongata. the other one is located more laterally called fasciculus cuneatus that synapses with nucleus cuneatus in medulla oblongata.
- Modality of this pathway: discriminative touch and **conscious** proprioception
- proprioception : is the ability of your body to recognize its position in the space by processing the signals that come from muscle spindles and golgi tendons organs (receptors on muscle fibers and tendons that detect the tension in them) . mostly this process happen in a subconscious level by cerebellum.
- Cell body of first order neuron is in dorsal root ganglia

Sorry for any mistakes
GOOD LUCK