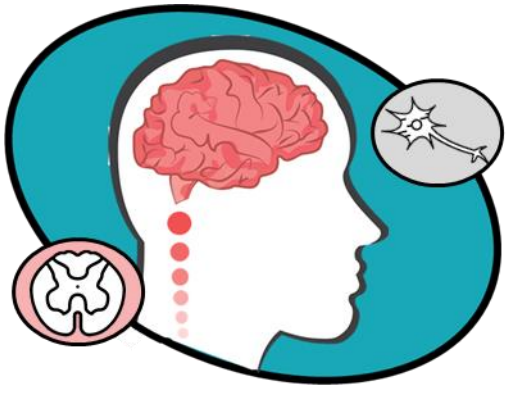

CNS

Physiology

Sheet Slide

Number

-11

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بسم الله الرحمن الرحيم

*This lecture was made from section 3 and corrected from section 1 records

-The **most important phase** of sleep -which the CNS puts us to sleep because of it- is the **REM sleep** .so if we don't get REM sleep it is like that we haven't slept at all.

- (REM) stands for rapid eye movement.

- # Common sleeping problems:

1-**Narcolepsy**: which is **excessive sleep**.

2-**Insomnia**: which is **lack of sleep** either decreased sleep hours or decreased sleep quality and one of the most important forms is sleep apnea –which is discussed below-

3- Sleep apnea: (0:47-5:40)

-Apnea means cessation of breathing

-Normally: During the NREM stages of sleep, breathing decreases and the tidal volume decreases(decreased vital signs). When reaching the REM sleep, the cortex increases its consumption of oxygen and glucose. So, the tidal volume and breathing increase in this stage.

-**How sleep apnea happens**: If a patient has a **problem in breathing**, the respiratory system will not get enough amount of oxygen and will not reach the amount demanded by the cortex in the REM sleep. So**, the cortex will not get enough oxygen**. This causes the cortex to assume that there is a problem with the sleeping position. So the cortex stops the REM sleep and awakens that person up in order to change the position he is sleeping in. The patient sleeps again, reaches stage 3 and 4 again and everything is alright. When reaching the REM stage, the same thing happens again .so those patients sleep for 7-8 hours with no benefit ..

-The outcome of this is that the patient **gets a little amount of REM sleep**. This will affect the brain and its functions. So even if he sleeps for a long time, he will be tired and will have problems in attention and

cognition when he wakes up. {it is not necessary that you are aware when the cortex wakes you up to change the sleeping position}

-All people may experience this case especially when they have a cold or flu. When you have a cold, you may notice that you may sleep for 8 hours and still wake up tired. This is because you didn't get enough REM sleep.

-Be aware that sleep apnea doesn't interrupt the 4 stages of sleep; it only interrupts the REM sleep.

4- Sleep talking/walking: (5:45-7:15)

-**How sleep talking/walking happen**: this happens if the person sleeps and the **cortex didn't turn off** as it is supposed to do during sleeping (In stage three, the awareness is shut down but the motor is still working). This causes the person to walk or talk during sleeping.

-Most people will experience sleep talking/walking during their teenage years or their late childhood. Some people may have this problem in adulthood. It is not considered a problem if it is not dangerous. It could be dangerous if the person for example wakes up hungry and doesn't find food in the fridge so he takes out a knife and starts cooking.

- **Dangerous sleepwalking** has another name: **Somnambulism**

5-Parasomnia: (7:15-17:40)

-This condition is usually a side effect for some medications.

-It is a condition associated **with abnormal movement, abnormal emotions, abnormal behaviour or abnormal perception during sleep or due to sleep interruption.**

-Sleep walking is one of the Parasomnias.

-**The following is what happens normally**: As we know, there are two phases of sleep. The first one is the non-REM sleep phase when the RAS (reticular activating system) is turned off and the GABA is increased. This will turn the cortex off which means that there will be less activity and less processing. In the REM phase, the brain needs to do processing so the cortex needs to be active. So during the REM sleep, we need the RAS to start working again to turn on the cortex. One of the important

components of the RAS is the **acetylcholine which is useful in sustaining attention**. Another important component is the **norepinephrine, which helps the prefrontal cortex in selective attention (it starts the attention)**. Another less important component is the serotonin which helps in processing. During sleep, the cortex during the REM will select something you have been through during the day and arrange it (process it) through the whole REM stage (every REM is about 20 minutes). This needs selective and sustained attention. So you need norepinephrine at the beginning of the REM for selective attention and acetylcholine during the REM for sustained attention and we also need serotonin.

-the RAS activity during sleep is almost the same as its activity during waking hours.

-the acetylcholine is active during all the REM stage while Norepinephrine is active at the beginning and the end of the REM sleep.

-**How Parasomnia happens**: **If the activity of norepinephrine, acetylcholine or serotonin was not right,** when you go to sleep you will not be able to sustain the attention on one thing during REM to process it. This will affect dreams and may affect the person emotionally. So there will be no sustained attention during REM. Because of that, the **REM is interrupted** and the person will wake up during dreaming and aware of the dream instead of just being deleted from the memory. This will affect the person as he will wake up every day remembering his dreams and wondering if it had really happened or not. This may cause cognitive problems, emotional problems. If not, the least effect is not getting the full REM session which is the Parasomnia.

This is extra: you may be confused on what is Parasomnia. A definition from the internet: The term Parasomnia refers to any sleep-related problem that cannot be classified as sleep apnea. So it is a name for a group of disorders and they include sleepwalking for example. The last point I talked about (the RAS problem) is one of the disorders under the category of Parasomnia. The cognitive and emotional problems that emerge from this problem are not Parasomnia as they are not affecting the sleep. The last effect (not getting the full REM) is the effect that affects the sleep so we can call it a sleeping problem.

-Be aware that the RAS also works while awake and a problem in it may lead to hallucination or a cognitive problem.

*Other problems associated with neurotransmitters imbalance:

-**Lack of norepinephrine causes ADHD(Attention Deficit/Hyperactivity Disorder) and excess of it causes anxiety**. Both cases may affect the REM sleep and people with these problems may be associated with Parasomnia.

-A person with ADHD may be treated with norepinephrine and as **a side effect he will have Parasomnia.**

-One of the side **effects of beta blockers is 'Nightmares'** as they interrupt norepinephrine entrance during the REM

-Drugs **affecting acetylcholine may give Parasomnia** effect(as antiparkinson drugs and Alzheimer drugs)

-depression which is characterized by decreased levels of biogenic amines will affect the REM sleep causing parasomnia.

-**Drugs that increase serotonin will increase waking up**. This may cause insomnia or Parasomnia. A person with depression treated with SSRI (Selective serotonin reuptake inhibitor) may cause insomnia(by increasing serotonin levels) or at least Parasomnia.

6- Nightmares and night terrors: (17:58-22:00)

-Nightmares are also considered Parasomnia(-if you experience nightmares too much then this is parasomnia)

-**How nightmares happen**: as we know, during the **REM sleep there is non realistic dreaming**. If the dream was **scary it is called a nightmare**. Sometimes the dream is so intense that the cortex will think that you are actually in a dangerous or a scary situation so it will wake you up to stop the nightmare.

-In some cases after a nightmare, the cortex will shut down the REM and wake you up without gaining the activity of the muscles. So you will wake up but the brain still has some residual thoughts from the dream and you can't move your muscles since there is complete muscle

relaxation and we can consider it parasomnia . This case is called **night terror**(**Sleep paralysis**)

-An example is when you dream that something is following you and you can't run away. You will wake up but the muscles are still off and because of that you can't run away.

Somatosensation: (22:00-the end)

-It can also be called **general sensation**: it is the sensation that comes from the body **(skin and muscles).**

-There is a **variety of receptors** (most of them are mechanoreceptors)to detect **different stimuli**, and because of this, the person gets **different sensations.**

-**Processing of the sensation** through its pathway can give **two completely different sensations** (as in the two point discriminative touch and crude touch or touch and pressure), or **it can increase the resolution of** sensation (as in lateral inhibition).

- the same receptor may send fibres to two pathways resulting in two different sensations .

-Because there are different receptors and different pathways, we can divide the sensation into two main pathways :

A) posterior column medial lemniscal pathway (PCML)

which is responsible for :

1- discriminative touch (two point discrimination).

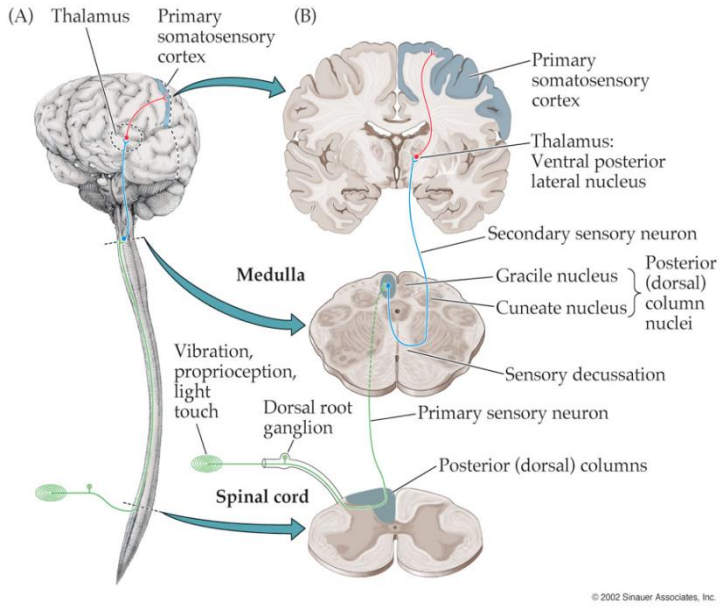
2 -feeling vibration.

3-Sensations from the muscles and joints: muscle tension, muscle length and the position and movement of the joint. This group of sensations is called Propriosensation or proprioception .

B) **Anterolateral system (ALS) or The Spinothalamic pathway** : This pathway will take information from pain receptors(nociceptors), temperature receptors (thermal receptors) and some mechanical receptors (that sense itching and rubbing=crude touch) .

Anatomy of the PCML

-The doctor explained the anatomy of the PCML pathway quickly and said that we took them in anatomy: We start with peripheral receptors that will enter a level or more than a level in the spinal cord. These fibers will gather in **the posterior column**. These axons will continue upward to reach the 2nd order neurons and **synapse with them in the lower part of the brain stem (the medulla) in either one of the two nuclei called *the Cuneate* or *the Gracile* nucleus. {**the Gracile is medial and the Cuneate is lateral}. In these nuclei processing will happen. At the level of the lower part of medulla oblongata **the fibres of the 2nd order neurons will cross** and continue to reach the **ventral posterior lateral (VPL)** nucleus in the thalamus. Then 3rd order neurons will continue to reach the **primary somatosensory area** in the cortex (the postcentral gyrus according to anatomical name or number 312 according to Broadmann classification).



Somatotopic organization of the PCML

-The posterior column receives fibers from the lower part of the body, the trunk and the upper part of the body(all parts of the body). **The first to enter the spinal cord are from the lower limbs**, **then the trunk and in the end the upper limbs enter**. Fibers that enter first (lower extremities) are put in the midline and next fibers (the trunk) are put at the lateral side of them and the most lateral fibers are from the upper extremities.

-**Their organization in the brain stem is different as they *do a counter-clockwise shifting***. So, the lower limbs become anterior and the upper limbs become posterior.

-They continue their **counter-clockwise shifting in the thalamus as the lower limbs fibers become lateral and the upper limbs fibers become medial.**

-In the **somatosensory cortex they will *come back* to their arrangement in the spinal cord** as the lower limbs are medial and the trunk and upper limbs are lateral.

-It is important to know these fibers arrangements to know what is affected in case of a lesion. (The doctor said that would be another lecture).

-Functions of the PCML:

1- It gives the two point discrimination function

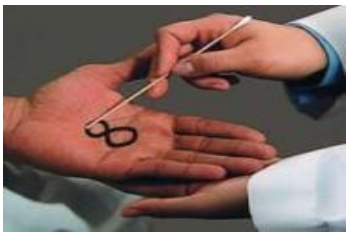
2-Vibration

3-Propriosensation

-This allows us to know the feeling of things (rough or soft).

-It also allows us to know the shape of anything you are holding while your eyes are closed. The functions that help in this are the touch and propriosensation. This ability is called **Stereognosis**.

-There is another ability provided by the PCML called **Graphesthesia**. It is the ability to feel the direction of touch and know what is being written on your hand based on touch only.



-One of the functions of the cerebellum is the coordination between the sensation and the motor. The discoordination between the motor and the sensation is called Ataxia. **The PCML role in the function of the cerebellum is that it gives us the sensation needed to give the appropriate motor order**. For example, if you want to take something off the table, you already know the position of your joints and muscles before making the movement. Because of that information provided by

the PCML, you can make the appropriate movement needed to take that thing off the table.

-PCML also helps in **knowing the power of the movement needed (It helps in weight sensation)**. For example, if you want to pick up a cup of coffee, you know through the PCML modalities that the cup is light in weight. Because of that, you can pick up the cup with the appropriate power to avoid spilling the coffee. This weight sensation ability is called **Barognosis**

-If the PCML is damaged:

1-You lose the ability to identify things with touch only. This condition is called **Stereognosia or Astereognosis**.

2-You lose the ability to identify the direction of touch so you cannot tell what letter is being written on your hand for example. This condition is called **Agraphesthesia**.

3-You lose the ability to give the appropriate movement because you lost the joint position sensation

4-You lose the ability to sense weight and give the appropriate amount of power needed for a movement. This condition is called **Abarognosis**.

5-There will be ataxia. To differentiate between this ataxia caused by PCML damage and cerebellar ataxia, they called this ataxia **sensory ataxia.**

*Be aware that with PCML damage, you will still feel if there is an object in your hand through the ALS pathway but you can't tell what the object is.

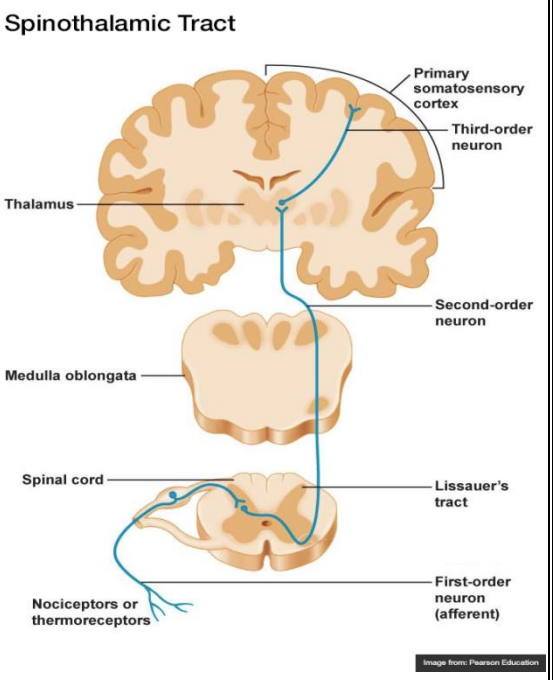
-If the PCML is damaged on the right side of the spinal cord: you will lose the ability to feel the PCML modalities **on the right side** but you will still feel them on the left(this is because crossing happens later in the pathway at the lower part of medulla oblongata so the right PCML carries information from the right side)

-If the PCML is damage at a certain level of the spinal cord **you will lose the PCML modalities below this level** but above it they will still exist.

Anterolateral system (Spinothalamic pathway)

-This pathway helps in some **crude touch, temperature and pain**.

-Pathway anatomy: we start with peripheral receptors that will enter different levels of the spinal cord. <u>The receptor fibers will synapse **with 2nd order neurons in the spinal cord.**</u> This is important to produce **reflexes** that generate from pain or temperature. So the processing happens in the spinal cord in the grey matter . The **2nd order neurons will cross obliquely in the spinal cord** and will reach the thalamus. In the thalamus they will synapse with **the 3rd order neurons in the same nucleus as the PCML (the VPL)** and then move to the same area in the cortex as PCML which is the **primary somatosensory area.**

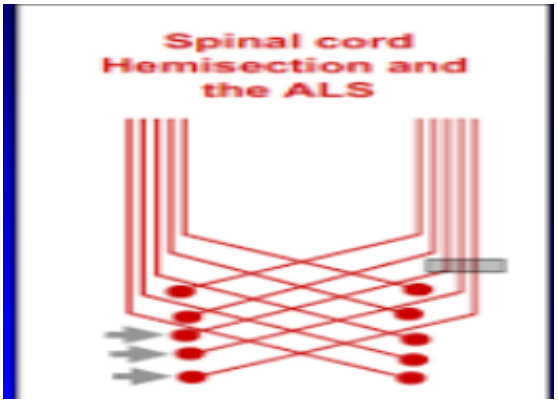


-Since **crossing happens in the spinal cord**, **damage to the right ALS will affect the sensation on the left side** (since the ALS crosses early then the right ALS represents the crossed fibres from the left side that carries information from the left)

-If there is **damage to the whole right side of the spinal cord (ALS+PCML):** you will lose the **PCML modalities on the right side** as they are ipsilateral because their fibers cross at the level of the medulla, and you **will lose the ALS modalities on the left side** of the body as they are contralateral because they cross in the spinal cord , this condition in which both PCML and ALS are damaged at the same side is known as **dissociative sensory syndrome** (you lose some sensations on the right and some on the left)

-Crossing in the ALS : axons of the 2nd order neurons synapse in the grey matter. After that they cross. But they don't cross in a straight line instead they cross obliquely in an ascending manner . They will reach the other side of the spinal cord **two levels** above the synapse level (if they enter spinal cord at X they will reach midline at X+1 then they will reach the contralateral at X+2).

-So imagine if the spinal cord is cut at the level of C5. You will not lose the sensations below this level as in PCML damage; instead you will lose it two levels below (C7) at the opposite side of the body as the result of crossing.



Lamination of the gray mater (Rexed laminae): the grey matter is divided into 10 laminae according to the shape of the neurons in each one and their function (processing).

The future belongs to those who believe in the beauty of their dreams