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Sleep Stages

- Awake stage.
- Stage 1.
- Stage 2.
- Stage 3.
- Stage 4.

Slow Wave Sleep (NREM)

- Rapid eye movement (REM) Sleep.

We can't look at a patient and say he's in stage 3 for example; usually these stages are detected by **EEG** or **OEG** (ocular electrography), or sometimes with the help of the patient's vital signs.

EEG (Electro Encephalogram)

- ✓ There's a recording from electrode on the surface of the brain, it will give an indication of electrical activity from the brain, the main diagnosis of this activity is the clinical one; from which we can know if we have electrical activity, seizure or not, other than that whatever the information we get by eye, it's useful.
- ✓ Other clinical uses; that if the frequency changes too much (like in case of sleep), this differentiate certain types of waves and gives indication to certain activity on EEG, so sleep waves are now classified into 4 types of waves.

Remember that this classification depends on the frequency; we have high frequency waves, means that there is high activity, but going more and more in sleep will result in slower and slower waves of activity.

Classification

1. **Delta Waves**:
   - very slow activity and usually the sleep waves are slow in which their frequency is (1-3)Hz
   - because it has very slow activity , then it will happen during deep sleep , dreamless sleep.

2. **Theta Waves:**
   - The activity has a little bit more frequency than delta waves (4-8) Hz
   - Happens in state between wakefulness and sleep, before meditation, sub consciousness, also it might occur in sleep with dreaming, or the period before you enter full sleep.

Now we'll come to a faster wave which is:

3. **Alpha Waves:**
   - Have a frequency of (8-13)Hz.
   - Usually it happens when the brain is working and receives stimuli but doesn't do so much processing (e.g. if you're sitting and looking forward, the occipital lobe receives sensory stimuli from the eye **and that's why it will be mainly alpha waves** , and because most of the time our eyes are open and moving, we'll see that the occipital lobe has alpha waves more than other lobes.

4. **Beta Waves:**
   - Indicate high processing and solving problems, especially when we are talking about frontal lobe , when you're sitting and thinking a lot and also thinking what you'll do in future , you're doing association with sensory and multisensory and with decision making .
     So we can say that during thinking, processing or decision making, beta waves are more dominant in frontal lobe.

- When we look to an EEG, it's very difficult (expect for an expert) to say that this is an Alpha waves or to know the frequency like saying it's 8Hz.
- That's why the clinical use of EEG nowadays especially in Jordan is only when we see seizure activity or to see stages of sleep when the waves become more and more slow.

- Despite we say that when someone is thinking the dominant is beta not alpha, still there's a percentage of alpha (12-15%), but that can't be recognized by eye, instead we use computer analysis; we introduce EEG to a computer, it filters certain wave lengths or it separates all the waves and say that the dominant wave is for example beta, alpha, theta ……etc.
- Recently, we started using the computer in processing and getting more and more information from EEG and this process acquire a different name which is **qEEG (quantitative electroencephalography).**
- In autistic patients, temporal lobe doesn't communicate well with parietal lobe and there's decrease in connectivity or coherence that is seen on EEG, this is recognized due to the help of computer testing the connectivity between two areas of the brain (the aid of computers in analysis allow medical fields to diagnose more and more diseases).
- Still in Jordan we don't have any **qEEG**, the dr. then said that we have 8 qEEGs but they use them in wrong way and not in hospitals.

☒ Let's get back to the Waves:

In wakefulness, the electrical activity is very high and of course it differs according to the type of activity the person does, when we start sleeping:

- **Stage 1:** when you start relaxing, you're drowsy and want to sleep, if someone is talking to you, you can hear him and you're alert what he is talking about and you can complete the conversation , also in this stage it's very easy for you to wake up if there's any stimulus. In this case we can see **that the EEG starts to become a little bit slower**, but you can't differentiate the type of wave, instead, you are able to see that slow waves begin to emerge randomly.

- **Stage 2:** when you go more in deep sleep, more slow waves will appear and sometimes there will very short activity in the cortex seen on EEG, we call it **sleep spindle** and also there's one slow big wave called **K complex.** In this stage you're more drowsy, start to go to sleep and it's more difficult for you to wake up if there's any stimulus, and if anybody wakes you, you won't be able to know what happened in the last (1-2) minutes (you're not alert and you don't know what he said) .

- **Stage 3:** the brain starts to turn off, different brain areas start to stop their activity (turning off), waves become more and more slow, there's theta and a little of delta but mainly theta rhythm predominate, also in this stage when we start sleeping, vital signs start to decrease (heart rate decreases, there's more and more relaxation of the muscles, etc).

  - ✓ Remember that many areas have turned off, but there's one area still working and doing activity that will appear above background noise and dreaming will happen
  - ✓ **The most common stage in which dreaming happens is stage 3.**
  - ✓ In some cases we turn down the areas of consciousness and control but forgot to turn down areas of walking or movement, because of that sleep walking will happen.

- **Stage 4:** all the brain areas are now off (cortical areas), the activity is very low, delta waves are dominant (actually there's no other waves than delta), there's much relaxation of muscles also vital signs are more declined, and arousal is very difficult.

  Now we turned off most of the brain areas but don't forget that during sleep we need activities and we need to do some work, which is reconsolidation of memories or re-jumping through the circuits again and retesting and making connections, and all of these processes occur during sleep! Actually we sleep to do that; we sleep for REM to happen!!

  Still we didn't start these processes; we are now going more deep in sleep and turning off most of the areas then we will start working **and this is the function of REM sleep**.

REM Sleep: the most important stage of sleep

- ✓ Connections will be activated and this will increase the activity of the brain and that's why the activity will return back to beta wave (the fastest one), beta waves here are more active than any stage in which the person is awake.
- ✓ Because the brain is now active and the connections are reactivated, we don't want these activities to be interpreted as movement or as a behavior, so I need to turn off all the outputs, as a result we do inhibition to all the motor centers in brain stem and spinal cord and in this case the muscle is in complete relaxation or atonia.
- ✓ Before REM sleep, I was in stage 4 in which I was going deep in sleep and vital centers are decreased. Now in REM sleep, the brain is active so I need more blood supply and more oxygen so the heart rate will increase and the breathing become more irregular and more rapid.

- ✓ **So again what happens when you go to sleep?**
  - ❖ First you are awake then stages 1,2,3,4 and brain is now off, then block the sensations, then start to make reconsolidation of memory in term of synapses and it results in REM sleep, then we turn down motor centers to prevent any motor effect, then we increase respiration and the heart rate increases, then after the mission is completed we return to stages 1, 2, or 3 but rarely we return to stage 4, then again we go to another area and progress through the stages and REM sleep then when it's completed we return back to stage 1, 2 , 3 again , then other area and activate connections again then REM then back, this is done until the person wakes up.
  - ❖ Why do we go to different areas when we want to do memory consolidation?
    Because when we want to do memory, it's sub-cortical and involves different regions, and in different researches you can see switching of activity from one area to other, but usually the majority of activities are in association and sub-cortical.

- ✓ A normal person sleeping 8 hours will have 4-5 REM sleep stages, and each level from stage 1 to REM sleep is called one sleep cycle. So if we sleep 8 hours, we take 4 cycles, that doesn't mean each cycle take 2 hours, each cycle differs in its length and period from the other, even the REM differs in length and period from one cycle to another

  Look at slide 12: each red bar represents REM sleep

- ✓ Early in life, the individual needs to make more and more memories, more and more connections, also he is learning more and more, so this will make the period of REM and the period of sleep in total more than in old age in which there's not much new memories.
  So, with increasing age, less and less percentage (period) of REM stage will happen.

- ✓ When you're studying and remembering more and more or you're so tired that day, the percentage of REM sleep at night will be more than a normal usual night.

- ✓ When you stay awake for 2 days, the brain didn't work and make memories (in REM), the first night you sleep after these 2 days, the percentage of REM in it will be higher and the first REM will happen faster (for example if the first REM usually happens after 1 hour, at that night it will happen after 25 minutes).

- ✓ So, in sleep deprivation, the person becomes distracted and memory starts to disappear then other deficits are seen.

Dreaming

a. We said before that dreaming happens in stage 3, dreaming occurs when one area is more active and other areas are not active, due to that its activity rises above background noise then dreaming occurs.

b. Most of the dreams are NREM dreaming in stage 3, it happens when there's an area still make connections but sleeping centers turned down all the cortex around it, the activity of this area rises and dreaming occurs, then immediately it's turned off by brain centers and that's why NREM dreaming is short, it's an activity of a **real connection** and that's why it's realistic and sometimes it recalls something happened in real life or resembles something that will happen in real life, also dreaming sometimes seems like you're thinking.

NREM Dreaming:
- ✓ Just thinking.
- ✓ Shorter, less active.
- ✓ Logical, realistic.

c. In REM sleep, we're trying to do different connections between different areas, so if we do one connection and make an activity or if we turn circuits in a particular direction (which is what happens in REM sleep), then there's a higher chance for us to dream in REM sleep more than in NREM sleep.

d. We said previously that an individual usually sleeps (4-5) cycles, during that there's a probability to have (3-4) REM dreaming (2-3) NREM dreaming every night. In other words, we dream each night (6-7) times, more than half (60%) is REM and the rest (40%) is NREM.

e. In REM sleep, we are trying new connections (for example ; imagining a horse with a head of a duck or fighting in a war), so it's non-realistic, also the centers responsible for relations are not working properly (I am trying connections and see what is the effect), that's why we feel that REM dreaming is longer.

REM Dreaming:
- ✓ Longer, more detailed.
- ✓ Non-realistic and fantasy (if fantasy increase to something non pleasant, it becomes nightmares).
- ✓ Nightmares.

❖ We dream every night (6-7) times, why can't we remember them??
Actually in 99%, what determines if memory will happen or not and if we will be able to remember the dreams or not is the blood flow at that stage.
If there was very good blood flow, I will be able to remember that dream, if not then I can't remember it and that's why most of the dreams can't be recalled.

Sleep Disorders

1. **Insomnia:**

If someone sleeps 3 hours a day and within each hour he only sleeps 30 minutes, this is considered as insomnia, because we didn't take our needs from REM sleep. We don't measure insomnia as a quantitative (how much time), instead we depend on the quality of sleep that's based on REM.

2. **Sleep Apnea:**

As we said, there will be slowing in vital signs when we sleep, but once reaching REM state there will be an increase in them and high activity resulting in good breathing and good heart rate, but if there is any problem by which we can't accomplish this increase in activity and increase in oxygen supplementation, then the demand will be higher than the supplement, the brain feels that there's a danger, it will switch off the REM resulting in improved breathing and the supply is more than the demand. The person might wake up, either fully awake or he's just back to stages 1 or 2. After breathing is improved, the brain will go back to REM again, if REM again increases the demand, the brain will go back again to stage 1 or 2 and the cycle is repeated.

So the person might wake up and he is also aware but sometimes instead of going to stage 1 or 2, he goes back to stage 3 or 2, and in this case he is not aware that he has sleep apnea (because he doesn't wake up at night having problems in breathing)

3. **Nightmares:** mentioned previously in REM dreaming.

4. **Night Terrors.**

5. **Somnambulism (Sleepwalking):**

In stage 3 where the conscious centers are turned off but motor and reflex centers were not turned off completely, so the person might walk, eat, or do anything without being aware and while he is asleep

- ✓ This is found in 40% of children and adolescents. This condition is usually benign and ends when the patient becomes older.
- ✓ If this persists in older age, it's treated by neurotransmitters.

Note: About neurotransmitters, the most important in REM sleep is acetylcholine followed by norepinephrine, because these neurotransmitters have a role in regulation of REM sleep and regulation of brain activity during REM sleep. Therefore, beta-blockers and anti-cholinergics are associated with nightmares.

Coma and Death

- There are two pathways for the Reticular Activating System: Ventral pathway (the larger and the most important), and Dorsal pathway (mainly for REM induction, but it can supplement if the ventral pathway is damaged).
- If the RAS pathways are damaged: there will be absent activity in the cortex because there's no activation coming from RAS, and this is called Coma.
- If the coma is partial (only damage to the ventral pathway), there might be regeneration in which dorsal pathway might supplement and the patient wakes up.
- If the coma is complete, there's little or no chance to regenerate.

Sorry for any mistake.

Your colleague; Alaa' Shqeirat.