YU - MEDICINE
PASSION ACADEMIC TEAM

Central Nervous System

Sheet# 10 - Physiology

Lec. Title : Sleep & Brain Waves

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brain waves and sleep-wake cycle

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Brain waves

- Electrical recordings from the surface of the brain or from the outer surface of the head demonstrate that there is continuous electrical activity in the brain.

Up and Down ripples

- The undulations in the recorded electrical potentials are called *brain waves*, and the entire record is called an EEG (electroencephalogram).

- The character of the waves is dependent on the degree of activity in respective parts of the cerebral cortex, and the waves change markedly between the states of wakefulness and sleep and coma.

These waves are changeable in illness states so we can use them in diagnosis of diseases and medical tests

Brain waves

There are 4 different types of brain waves as shown in the diagram below

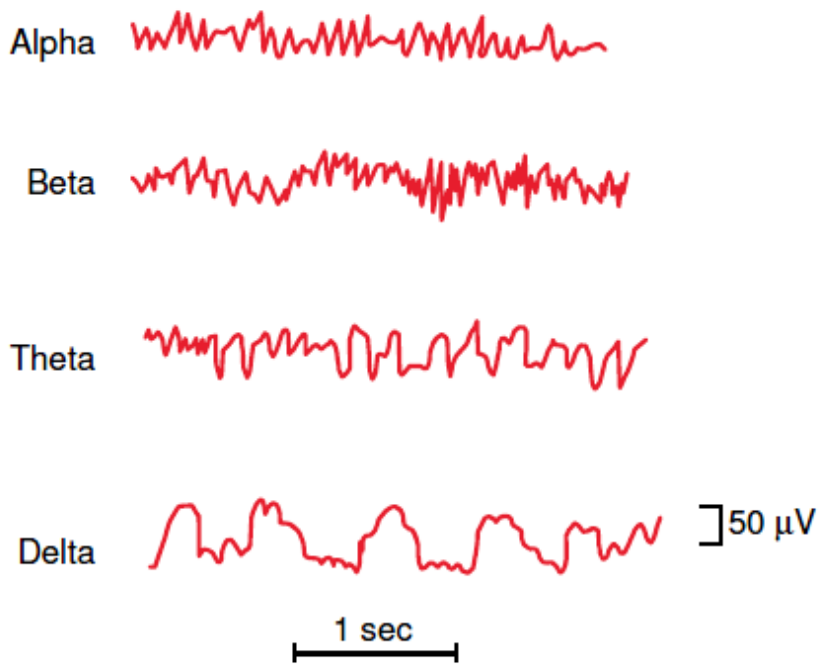


Figure 59-1 Different types of *brain waves* in the normal electroencephalogram.

- ***Alpha waves***:
  - Found in EEGs of normal awake adults and in a quiet, resting state.
  - Mostly intense in the occipital region.
  - Disappear during deep sleep.

- ***Beta waves:***
- Beta waves are produced when an external stimulus induces logical thinking, computation, and reasoning during consciousness.
  - Mainly recorded from parietal and frontal regions.

Brain waves

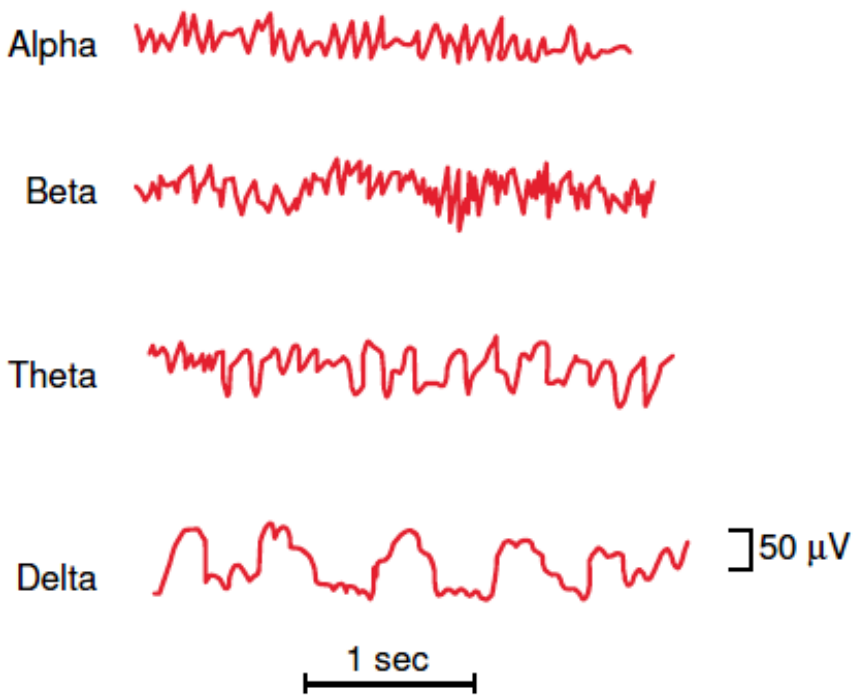


Figure 59-1 Different types of *brain waves* in the normal electroencephalogram.

- ***Theta waves***:

  Strong during internal focus, meditation, prayer, and spiritual awareness. It reflects the state between wakefulness and sleep and relates to the subconscious mind.

  It is abnormal in awake adults but is perfectly normal in children up to 13 years old. It is also normal during sleep.

Delta waves:

the slowest recorded brain waves in human beings. They are found most often in infants and young children, and are associated with the deepest levels of relaxation and restorative, healing sleep. Delta is prominently seen in brain injuries, learning problems, inability to think

Origin of Brain waves

- Many thousands or even millions of neurons or fibers *must fire synchronously* so that potentials from the individual neurons or fibers summate enough to be recorded all the way through the skull.

This resembles the recording of action potential of cardiac myocytes in Electrocardiogram through the chest

Sleep

- Sleep is defined as unconsciousness from which the person can be aroused by sensory or other stimuli.

- The Electroencephalogram (EEG) is a recording of neuronal electrical activity that can be made from the cerebral cortex via electrodes placed on the skull, used for determining the stages of sleep-wake cycle

By this we can know the differences in sensation between sleeping and awake person as well as determining the stages of sleep-wake cycle

Types of sleep

There are two major types of sleep

1.Slow-wave sleep (Non-REM)

Lasts about 30 to 45 minutes in usual and it can extend up to 90 minutes

- The brain waves are strong and of low frequency
- Deep, restful sleep during the first hours of sleep
- Associated with decreased peripheral vascular tone, BP, RR and BMR.(Respiratory Rate Basal Metabolic Rate Blood Pressure)
- Dreams may happen, but are not associated with bodily muscle activity and usually are not remembered.
- Most sleep during each night.

Most of sleep relaxation is in this period

EEG characteristics of Non-REM sleep

falling asleep passes sequentially through four stages of **slow-wave sleep** (called stages 1 through 4) over a period of 30 to 45 minutes (Fig. 10-5). In stage 1, alpha waves are interspersed with lower-frequency waves (3 to 7 Hz) called **theta waves.** In stage 2, the EEG slows further, but the slow-wave activity is interrupted by **sleep spindles,** which are bursts of activity at 12 to 14 Hz, and by large **K complexes** (large, slow potentials). Stage 3 sleep is associated with **delta waves,** which occur at frequencies of 0.5 to 2 Hz, and with occasional sleep spindles. Stage 4 is characterized by delta waves.

Sleep spindles during stage 2 are Spikes that give an indication of slight activation of brain meaning it is not fully sleep

Stage 4 characterized completely by delta waves meaning that the person is fully relaxed with no activity of his brain

Types of sleep

2. **Rapid eye movement sleep** *(REM* sleep)

It has this name because of phasic movement of eye muscle in this stage

- In which the eyes undergo rapid movements.
- Occupies about 25% of the sleep time / 5-30 minute episodes recurring every 90 minutes.
- Not restful; associated with vivid dreaming and active irregular bodily movements.

Very strong dreaming that can be memorized later

- Person more difficult to arouse by stimuli, but people usually wake up spontaneously during a REM episode.
- Muscle tone depressed.
- HR and RR become irregular.
- Brain highly active (20% increase in metabolic rate) → *Paradoxical sleep*.

Because this stage shows some activity like a person when he is awake

-Why does REM Sleep contains Beta and Theta waves ?
-Because in REM Sleep there are some brain activities, and even in subconscious stage the person may think about some issues that happened in the previous days

- In REM sleep, the EEG again becomes desynchronized. The low-voltage, fast activity of REM sleep resembles that seen in the EEG from an aroused subject (the EEG proposed to show beta (15–35 Hz) and theta (3–7 Hz) waves oscillations).
- The similarity of the EEG to that of an awake individual and the difficulty awaking the person have suggested the term paradoxical sleep for this type of sleep.
- Muscle tone is completely lost, but phasic contractions occur in a number of muscles, most notably the eye muscles. The resulting rapid eye movements are basis of the name for this type of sleep. Many autonomic changes also take place.

Basic theories of sleep

And sleep purpose as well

- The mechanism of sleep is incompletely understood.
- Stimulation in the brainstem reticular formation in a large region known as the reticular activating/**exciting** system causes arousal and low-voltage, fast EEG activity.
- Sleep was once thought to be caused by a reduced level of activity in the reticular activating system.

+ Increase in function of reticular inhibitory area in the brain

- Investigators have tried to relate sleep mechanisms to brainstem networks that use particular neurotransmitters, including serotonin, norepinephrine, and acetylcholine, because manipulations of the levels of these transmitters in the brain can affect the sleep-wake cycle. However, a detailed neurochemical explanation of the neural mechanisms of sleep is not yet available.

Basic theories of sleep

1. The raphe nuclei in the lower half of the pons and in the medulla

This area is responsible for serotonin secretion, so it cold be involved in sleep induction

- Nerve fibers from these nuclei spread
  - locally in the brain stem reticular formation
  - upward into the thalamus, hypothalamus, most areas of the limbic system, and even the neocortex of the cerebrum.
  - downward into the dorsal dorsal horns of spinal cord.

- Many nerve endings of fibers from these raphe neurons secrete *serotonin*.

2. The nucleus of the tractus solitarius

- *This nucleus is the termination* in the medulla and pons for visceral sensory signals entering by way of the vagus and glossopharyngeal nerves.

Some researchers found that if I stimulate NTS with low frequency current that could resolve some sleep disturbances like insomnia

- Activation of NTS muscrainic receptors after low-frequency EA stimuli increases concentrations of β-endorphin,

Which: 1-give the feeling of relaxation, 2-reduce brain activity

3. Several regions in the diencephalon, including

a. the rostral part of the hypothalamus, mainly in the suprachiasmal area,

This area is responsible for circadian rhythm control

b. an occasional area in the diffuse nuclei of the thalamus.

Cycle between sleep and wakefulness

- When the sleep centers are *not activated* → reticular activating nuclei become spontaneously active → excite cerebral cortex and peripheral nervous system → positive feedback signals to nuclei.

As a result, continuation of cerebral cortex activity which inhibit sleeping

- After brain stays activated for many hours → neurons become fatigued → feedback mechanism fades → the sleep-promoting effects of the sleep centers take over → rapid transition from wakefulness back to sleep.

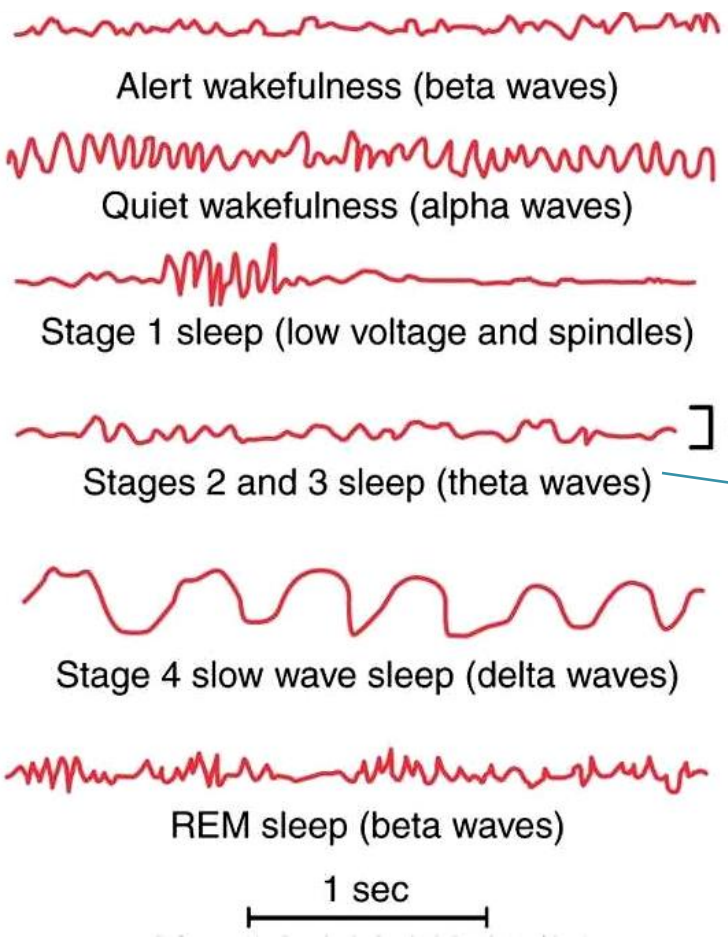
Physiologic functions of sleep

- Sleep has an essential role in homeostasis.
- Even mild sleep restriction over a few days may degrade cognitive and physical performance, overall productivity, and health of a person.

  As well as developing of certain chronic diseases

- Lack of sleep affects the functions of the CNS.
  - progressive malfunction of the thought processes and sometimes abnormal behavioral activities.
- Sleep restores both normal levels of brain activity and normal "balance" among the different functions of the CNS.

Changes in the EEG at Different Stages of Wakefulness and Sleep



Spindles could happen here too.