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**MATRIC NUMBER: 17/MHS01/190**

**DEPARTEMENT: MEDICINE AND SURGERY**

**COURSE: NEUROPHYSIOLOGY**

**COURSE CODE: PHS 305**

**QUESTION ONE: Discuss the physiology of sleep**

**Answer:** Sleep is the natural periodic state of rest for mind and body with closed eyes characterized by partial or complete loss of consciousness. Loss of consciousness leads to decreased response to external stimuli and decreased body movements. Depth of sleep is not constant throughout the sleeping period. It varies in different stages of sleep.

**TYPES OF SLEEP** Sleep is of two types: 1. Rapid eye movement sleep or REM sleep. 2. Non rapid eye movement sleep or NREM sleep.

**1. Rapid eye movement sleep (REM Sleep):**

In a normal night of sleep, bouts of REM sleep lasting 5 to 30 minutes usually appear on average, every 90 minutes in young adults. When a person is extremely sleepy, each bout of REM sleep is short and may even be absent. As the person becomes more rested through the night, the durations of the REM bouts increase. REM sleep has several important characteristics: 1. It is an active form of sleep usually associated with dreaming and active bodily muscle movements. 2. The person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep, and yet people usually awaken spontaneously in the morning during an episode of REM sleep. 3. Muscle tone throughout the body is exceedingly depressed, indicating strong inhibition of the spinal muscle control areas. 4. Heart rate and respiratory rate usually becomes irregular, which is characteristic of the dream state. 5. Despite the extreme inhibition of the peripheral muscles, irregular muscle movements do occur in addition to the rapid movements of the eyes. 6. The brain is highly active in REM sleep, and overall brain metabolism may be increased as much as 20 percent. An electroencephalogram (EEG) shows a pattern of brain waves similar to those that occur during wakefulness. This type of sleep is also called paradoxical sleep because it is a paradox that a person can still be asleep despite the presence of marked activity in the brain. In summary, REM sleep is a type of sleep in which the brain is quite active. However, the person is not fully aware of his or her surroundings, and therefore he or she is truly asleep.

**2. Non rapid eye movement sleep (slow-wave sleep):**

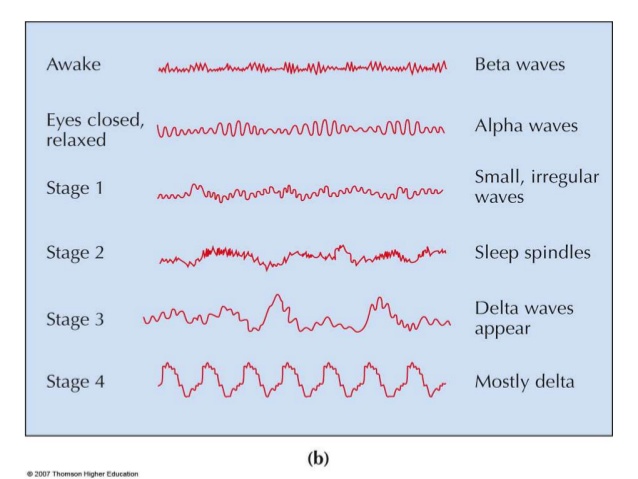
This sleep is exceedingly restful and is associated with decreases in both peripheral vascular tone and many other vegetative functions of the body. For instance, 10 to 30 percent decreases occur in blood pressure, respiratory rate, and basal metabolic rate. Although slow-wave sleep is frequently called “dreamless sleep,” dreams and sometimes even nightmares do occur during slow-wave sleep. The difference between the dreams that occur in slow-wave sleep and those that occur in REM sleep is that those of REM sleep are associated with more bodily muscle activity. Also, the dreams of slow-wave sleep are usually not remembered because consolidation of the dreams in memory does not occur.

**PHYSIOLOGICAL CHANGES DURING SLEEP**: During sleep, most of the body functions are reduced to basal level. Below are important changes in the body during sleep: 1) Plasma volume: plasma volume decreases by about 10% during sleep. 2) Cardiovascular system: during sleep, the heart rate reduces. It varies between 45 and 60 beats per minute. Systolic pressure falls to about 90 to 110 mmhg. Lowest level is reached about 4th hour of sleep and remains at this level till a short time before waking up. Then, the pressure commences to rise. If sleep is disturbed by exciting dreams, the pressure is elevated above 130 mm hg. 3) Respiratory system: rate and force of respiration are decreased. Respiration becomes irregular and **cheyne-stokes type** of periodic breathing may develop. 4) Gastrointestinal tract: salivary secretion decreases during sleep. Gastric secretion is not altered or may be increased slightly. Contraction of empty stomach is more vigorous. 5) Excretory system: formation of urine decreases and specific gravity of urine increases. 6) Brain: Brain is not inactive during sleep. There is a characteristic cycle of brain wave activity during sleep with irregular intervals of dreams.

**STAGES OF SLEEP**

**1) Rapid eye movement sleep** During REM sleep, electroencephalogram (EEG) shows irregular waves with high frequency and low amplitude. These waves are desynchronized waves. **2) Non-rapid eye movement sleep** The NREM sleep is divided into four stages, based on the EEG pattern. During the stage of wakefulness, i.e. while lying down with closed eyes and relaxed mind, the alpha waves of EEG appear. When the person proceeds to drowsy state, the alpha waves diminish

Stage I (Stage of Drowsiness): Alpha waves are diminished and abolished. EEG shows only low voltage fluctuations and infrequent delta waves. Stage II (Stage of Light Sleep): Stage II is characterized by spindle bursts at a frequency of 14 per second, superimposed by low voltage delta waves. Stage III (Stage of Medium Sleep): During this stage, the spindle bursts disappear. Frequency of delta waves decreases to 1 or 2 per second and amplitude increases to about 100 µV. State IV (Stage of Deep Sleep): Delta waves become more prominent with low frequency and high amplitude.



**MECHANISM OF SLEEP**

Sleep occurs due to the activity of some sleep-inducing centers in brain. Stimulation of these centers induces sleep. Damage of sleep centers results in sleeplessness or persistent wakefulness called insomnia **Sleep centers:** Complex pathways between the reticular formation of brainstem, diencephalon and cerebral cortex are involved in the onset and maintenance of sleep. However, two centers which induce sleep are located in the brainstem which are: Raphe nucleus and Locus ceruleus of pons. Recently, many more areas that induce sleep are identified in the brain of animals. Inhibition of ascending reticular activating system also results in sleep. **i) Role of Raphe Nucleus:**  Raphe nucleus is situated in lower pons and medulla. Activation of this nucleus results in non-REM sleep. It is due to release of serotonin by the nerve fibers arising from this nucleus. Serotonin induces non-REM sleep. ii) **Role of Locus Ceruleus of Pons**: Activation of this center produces REM sleep. Noradrenaline released by the nerve fibers arising from locus ceruleus induces REM sleep.

**Inhibition of Ascending Reticular Activating System**: Ascending reticular activating system (ARAS) is responsible for wakefulness because of its afferent and efferent connections with cerebral cortex. Inhibition of ARAS induces sleep. Lesion of ARAS leads to permanent somnolence, i.e. coma.

**APPLIED PHYSIOLOGY**

1) Insomnia: is the inability to sleep or abnormal wakefulness. It is the most common sleep disorder. It occurs due to systemic illness or mental conditions such as psychiatric problems, alcoholic addiction and drug addiction.

ii) Sleep apnea syndrome: is the temporary stoppage of breathing repeatedly during sleep. Sleep apnea syndrome is the disorder that involves fluctuations in the rate and force of respiration during REM sleep with short apneic episode. Apnea is due to decreased stimulation of respiratory centers, arrest of diaphragmatic movements, airway obstruction or the combination of all these factors. When breathing stops, the resultant hypercapnia and hypoxia stimulate respiration.

iii) Narcolepsy and cataplexy: Narcolepsy is the sudden attack of uncontrollable sleep. Cataplexy is sudden outburst of emotion. Both the diseases are due to hypothalamic disorders.

**QUESTION TWO: Discuss the role of basal ganglia in coordinating movement.**

**Answer:**

Basal ganglia form part of the extrapyramidal system, which is concerned with integration and regulation of motor activities. Below are the roles of basal ganglia in coordinating movement:

1**) Regulation of Voluntary Movements**: Movements during voluntary motor activity are initiated by cerebral cortex. However, these movements are controlled by basal ganglia, which are in close association with cerebral cortex. During lesions of basal ganglia, the control mechanism is lost and so the movements become inaccurate and awkward. Basal ganglia control the motor activities because of the nervous (neuronal) circuits between basal ganglia and other parts of the brain involved in motor activity. Neuronal circuits arise from three areas of the cerebral cortex: a. Premotor area b. Primary motor area c. Supplementary motor area. All these nerve fibers from cerebral cortex reach the caudate nucleus. From here, the fibers go to putamen. Some of the fibers from cerebral cortex go directly to putamen also. Putamen sends fibers to globus pallidus. Fibers from here run towards the thalamus, subthalamic nucleus of Luys and substantia nigra. Subthalamic nucleus and substantia nigra are in turn, projected into thalamus. Now, the fibers from thalamus are projected back into primary motor area and other two motor areas, i.e. premotor area and supplementary motor area.

2**) Regulation of Conscious Movements**: Fibers between cerebral cortex and caudate nucleus are concerned with regulation of conscious movements. This function of basal ganglia is also known as the cognitive control of activity. For example, when a stray dog barks at a man, immediately the person understands the situation, turns away and starts running.

**3) Regulation of Subconscious Movements**: Cortical fibers reaching putamen are directly concerned with regulation of some subconscious movements, which take place during trained motor activities, i.e. skilled activities such as writing the learnt alphabet, paper cutting, nail hammering, etc.

**4) Control of automatic associated movements**: Automatic associated movements are the movements in the body, which take place along with some motor activities. Examples are the swing of the arms while walking, appropriate facial expressions while talking or doing any work. Basal ganglia are responsible for the automatic associated movements. Lesion in basal ganglia causes absence of these automatic associated movements, resulting in poverty of movements. Face without appropriate expressions while doing any work is called mask-like face. Body without associated movements is called statue-like body.

**5) Control of reflex muscular activity**: Some reflex muscular activities, particularly visual and labyrinthine reflexes are important in maintaining the posture. Basal ganglia are responsible for the coordination and integration of impulses for these reflex activities. During lesion of basal ganglia, the postural movements, especially the visual and labyrinthine reflexes become abnormal. These abnormal movements are associated with rigidity. Rigidity is because of the loss of inhibitory influence from the cerebral cortex on spinal cord via basal ganglia.