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1. PHYSIOLOGY OF SLEEP

DEFINITION: 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.

**SLEEP REQUIREMENT**: Sleep requirement is not constant. However, average sleep requirement per day at different age groups is:

1. Newborn infants : 18 to 20 hours

2. Growing children : 12 to 14 hours

3. Adults : 7 to 9 hours

4. Old persons : 5 to 7 hours.

Some physiological changes are observed during sleep such as changes in the plasma volume, cvs, respiratory system, GIT, excretory system, sweat secretion, lacrimal secretion, muscle tone, reflexes and the brain.

**TYPES OF SLEEP**

Sleep is of two types:

1. Rapid eye movement sleep or REM sleep

2. Non-rapid eye movement sleep, NREM sleep or non-REM sleep.

RAPID EYE MOVEMENT SLEEP – REM SLEEP Rapid eye movement sleep is the type of sleep associated with rapid conjugate movements of the eyeballs, which occurs frequently. Though the eyeballs move, the sleep is deep. So, it is also called paradoxical sleep. It occupies about 20% to 30% of sleeping period. Functionally, REM sleep is very important because, it plays an important role in consolidation of memory. Dreams occur during this period.

NON-RAPID EYE MOVEMENT SLEEP – NREM OR NON-REM SLEEP Non-rapid eye movement (NREM) sleep is the type of sleep without the movements of eyeballs. It is also called slow-wave sleep. Dreams do not occur in this type of sleep and it occupies about 70% to 80% of total sleeping period. Non-REM sleep is followed by REM sleep.

**STAGES OF SLEEP AND EEG PATTERN**

**RAPID EYE MOVEMENT SLEEP**: During REM sleep, electroencephalogram (EEG) shows irregular waves with high frequency and low amplitude. These waves are desynchronized waves.

**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 brainstem: 1. Raphe nucleus 2. 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.

1**. 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.

2**. 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.

1. ROLE OF THE BASAL GANLIA IN COORDINATING MOVEMENT

Basal ganglia are the scattered masses of gray matter submerged in subcortical substance of cerebral hemisphere. Basal ganglia form the part of extra pyramidal system, which is concerned with motor activities.

COMPONENTS OF BASAL GANGLIA

Basal ganglia include three primary components:

1. Corpus striatum

2. Substantia nigra

3. Subthalamic nucleus of Luys

CONTROL OF MOTOR ACTIVITY

* 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:

1. Premotor area
2. Primary motor area
3. 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.

* 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.
* 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.

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.

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.