ADEBAYO BLESSING OMOLOLA

17/MHS01/013

MEDICINE AND SURGERY

300 LEVEL

NEUROPHYSIOLOGY

1. Discuss the physiology of sleep
2. Discuss the role of basal ganglia in coordinating movement

ANSWERS

1. PHYSIOLOGY OF SLEEP

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.

Two Types of Sleep: During each night, a person goes through stages of two types of sleep that alternate with each other. They are called

i. **Slow-wave sleep:** Because in this type of sleep the brain waves are very strong and very low frequency. This sleep is exceedingly restful and is associated with decrease in both peripheral vascular tone and many other vegetative functions of the body. For instance, there are 10 to 30 per cent decreases 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, and the dreams of slow-wave sleep usually are not remembered. That is, during slow-wave sleep, consolidation of the dreams in memory does not occur.

ii. **Rapid eye movement (REM) sleep (Paradoxical Sleep, Desynchronized Sleep):** Because in this type of sleep the eyes undergo rapid movements despite the fact that the person is still asleep.

- It is usually associated with active dreaming and active bodily muscle movements.

- 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.
- Muscle tone throughout the body is exceedingly depressed, indicating strong inhibition of the spinal muscle control areas.
- Heart rate and respiratory rate usually become irregular, which is characteristic of the dream state.
- Despite the extreme inhibition of the peripheral muscles, irregular muscle movements do occur. These are in addition to the rapid movements of the eyes.
- The brain is highly active in REM sleep, and overall brain metabolism may be increased as much as 20 percent. The 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 marked activity in the brain.

  In summary, REM sleep is a type of sleep in which the brain is quite active. However, the brain activity is not channelled in the proper direction for the person to be fully aware of his or her surroundings, and therefore the person is truly asleep.

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:

- **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.
- **Locus ceruleus of pons**: Activation of this center produces REM sleep. Noradrenaline released by the nerve fibers arising from locus ceruleus induces REM sleep.

- Recently, many more areas that induce sleep are identified in the brain of animals. Inhibition of ascending reticular activating system also results in sleep. 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.

PHYSIOLOGICAL CHANGES DURING SLEEP

During sleep, most of the body functions are reduced to basal level. Following are important changes in the body during sleep:

- Plasma Volume: Plasma volume decreases by about 10% during sleep.
- Heart Rate: During sleep, the heart rate reduces. It varies between 45 and 60 beats per minute.
- Blood Pressure: Systolic pressure falls to about 90 to 110 mm Hg. 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.
- Rate and force of respiration are decreased. Respiration becomes irregular and Cheyne-Stokes type of periodic breathing may develop.
- Reflexes: Certain reflexes particularly knee jerk, are abolished. Babinski sign becomes positive during deep sleep. Threshold for most of the reflexes increases. Pupils are constricted. Light reflex is retained. Eyeballs move up and down.
- Brain: Brain is not inactive during sleep. There is a characteristic cycle of brain wave activity during sleep with irregular intervals of dreams. Electrical activity in the brain varies with stages of sleep.

SLEEP DISORDERS

- **Insomnia:** 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.
- **Hypersomnia:** Hypersomnia is the excess sleep or excess need to sleep. It occurs because of lesion in the floor of the third ventricle,

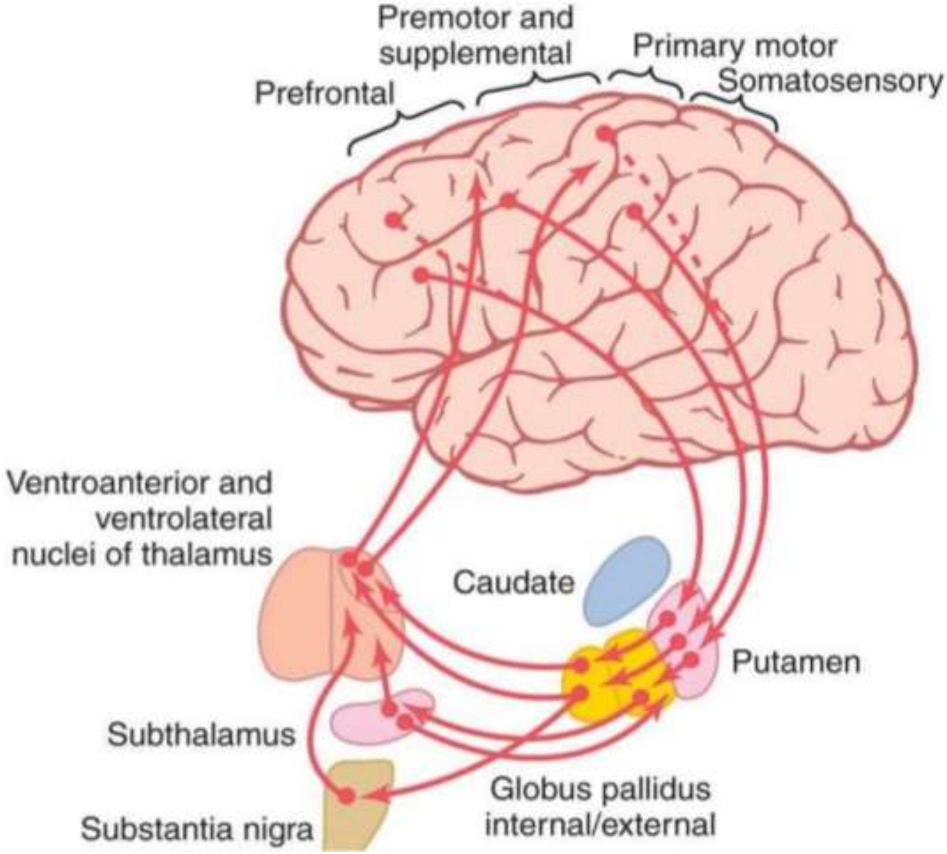
brain tumors, encephalitis, chronic bronchitis and disease of muscles. Hypersomnia also occurs in endocrine disorders such as myxedema and diabetes insipidus.

- **Nightmare:** Nightmare is a condition during sleep that is characterized by a sense of extreme uneasiness or discomfort or by frightful dreams. Discomfort is felt as of some heavy weight on the stomach or chest or as uncontrolled movement of the body. After a period of extreme anxiety, the subject wakes with a troubled state of mind. It occurs mostly during REM sleep. Nightmare occurs due to improper food intake, digestive disorders or nervous disorders. It also occurs during drug withdrawal or alcohol withdrawal.
- **Somnabulism:** Somnambulism is getting up from bed and walking in the state of sleep. It is also called walking during sleep or sleep walking (somnus = sleep; ambulare = to walk). It varies from just sitting up in the bed to walking around with eyes open and performing some major complex task. The episode lasts for few minutes to half an hour. It occurs during non-REM sleep. In children, it is associated with bedwetting or night terror without any psychological disturbance. However, in adults it is associated with psychoneurosis.

2. ROLE OF BASAL GANGLIA IN COORDINATING MOVEMENT

One of the principal roles of the basal ganglia in motor control is to function in association with the corticospinal system to control complex patterns of motor activity. An example is the writing of letters of the alphabet. When there is serious damage to the basal ganglia, the cortical system of motor control can no longer provide these patterns. Instead, one's writing becomes crude, as if one were learning for the first time how to write. Other patterns that require the basal ganglia are cutting paper with scissors, hammering nails, shooting a basketball through a hoop, passing a football, throwing a baseball, the movements of shovelling dirt, most aspects of vocalization, controlled movements of the eyes, and virtually any other of our skilled movements, most of them performed subconsciously.

Neural Pathways of the Putamen Circuit: Shows the principal pathways through the basal ganglia for executing learned patterns of movement. They begin mainly in the premotor and supplementary areas of the motor cortex and in the somatosensory areas of the sensory cortex. Next they pass to the putamen (mainly bypassing the caudate nucleus), then to the internal portion of the globus pallidus, next to the ventroanterior and ventrolateral relay nuclei of the thalamus,and finally return to the cerebral primary motor cortex and to portions of the premotor and supplementary cerebral areas closely associated with the primary motor cortex. Thus, the putamen circuit has its inputs mainly from those parts of the brain adjacent to the primary motor cortex but not much from the primary motor cortex itself. Then its outputs do go mainly back to the primary motor cortex or closely associated premotor and supplementary cortex. Functioning in close association with this primary putamen circuit are ancillary circuits that pass from the putamen through the external globus pallidus, the subthalamus, and the substantia nigra-finally returning to the motor cortex by way of the thalamus.



Role of the Basal Ganglia for Cognitive Control of Sequences of Motor Patterns- The Caudate Circuit:

The term cognition means the thinking processes of the brain, using both sensory input to the brain plus information already stored in memory. Most of our motor actions occur as a consequence of thoughts generated in the mind, a process called cognitive control of motor activity. The caudate nucleus plays a major role in this cognitive control of motor activity. The neural connections between the caudate nucleus and the corticospinal motor control system are somewhat different from those of the putamen circuit. Part of the reason for this is that the caudate nucleus extends into all lobes of the cerebrum, beginning anteriorly in the frontal lobes, then passing posteriorly through the parietal and occipital lobes, and finally curving forward again like the letter “C” into the temporal lobes. Furthermore, the caudate nucleus receives large amounts of its input from the association areas of the cerebral cortex overlying the caudate nucleus, mainly areas that also integrate the different types of sensory and motor information into usable thought patterns. After the signals pass from the cerebral cortex to the caudate nucleus, they are next transmitted to the internal globus pallidus, then to the relay nuclei of the ventroanterior and ventrolateral thalamus, and finally back to the prefrontal, premotor, and supplementary motor areas of the cerebral cortex, but with almost none of the returning signals passing directly to the primary motor cortex. Instead, the returning signals go to those accessory motor regions in the premotor and supplementary motor areas that are concerned with putting together sequential patterns of movement lasting 5 or more seconds instead of exciting individual muscle movements. A good example of this would be a person seeing a lion approach and then responding instantaneously and automatically by (1) turning away from the lion, (2) beginning to run, and (3) even attempting to climb a tree. Without the cognitive functions, the person might not have the instinctive knowledge, without thinking for too long a time, to respond quickly and appropriately. Thus, cognitive control of motor activity determines subconsciously, and within seconds, which patterns of movement will be used together to achieve a complex goal that might itself last for many seconds.