Normal Sleep

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One of the most pervasive misconceptions about sleep is that sleep is just a matter of our bodies "turning off" for several hours, followed by our bodies "turning back on" when we awake. In short, most of us think of sleep as a passive and relatively constant and unchanging process. In fact, sleep is a very active state.[1]

Sleep can be distinguished by using three basic electrophysiological signals recorded from surface electrodes. Electroencephalogram (EEG) is used to measure brain activity and is recorded from electrodes placed on the head overlying the cortex. Separate electrodes placed beside each eye are used to record the electrooculogram (EOG), a marker of eye movements. Electromyogram (EMG) is used to monitor muscle tone by surface electrodes placed under the chin.[2,3]

From recordings of these electrodes, two major sleep states have been identified, namely: rapid eye movement (REM) and non rapid eye movement (NREM) sleep[2,4]. They will be described in more detail later.

Shown here are some good points regarding of EEG. The raw EEG has usually been described in terms of frequency bands: **BETA** (β; 13-30Hz), **ALPHA** (α; 8-12 Hz), **THETA** (θ; 4-7 Hz), and **DELTA** (δ; 0.5- 4 Hz) (Fig 1). Each frequency has a characteristic blueprint and produces a distinctive state of consciousness. BETA waves dominate the normal waking state of consciousness when attention is directed towards the outside world. During a day we experience all the brainwave patterns with a predominance of BETA. ALPHA waves are present during relaxed states when the eyes are closed. They also occur in manipulated-relaxed states such as meditation and under hypnosis. ALPHA waves are indicative of lack of visual processing and lack of focus, the less visual processing and the more unfocused, generally the stronger alpha waves. If you close your eyes and do not do any deep thinking or concentrating on vivid imagery, your ALPHA waves will usually be quite strong. THETA waves occur in sleep and are dominate in the highest state of mediation. In deep sleep, DELTA waves are predominantly present.

In brief, EEG of awake and alert state display rapid and irregular low-amplitude waves or BETA waves. When you close your eyes and become drowsy, the activity becomes regular and rhythmic, with a frequency of ALPHA waves. THETA waves appear as consciousness slips toward drowsiness while DELTA waves are primarily associated with deep sleep.

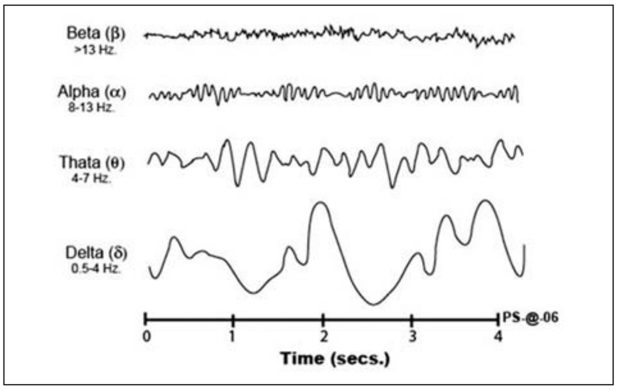

Fig 1. FOUR categories of brain wave patterns [© 2006: Physiology Dept., Siriraj].

REM sleep

REM sleep occupies 20% of the total sleep time. REM sleep is also associated with generalized heightened brain activity and periodic intense eye movements that give this sleep state its name. REM sleep is also associated with dreaming and periods of widely fluctuating respiratory and cardiovascular activities.

It is not known whether these latter phenomena are correlated with the heightened brain arousal of REM sleep or with the context of the dream. Many of the neurophysiological features of REM sleep are mirrored in the brain during alert wakefulness, and for this reason, this state is also termed "active" or "paradoxical" sleep. Despite the internal state of heightened brain arousal in REM sleep, responsiveness to external arousing stimuli such as noise, and even internal signals related to physiological stress such as hypoxia, are markedly reduced in REM sleep compared with NREM sleep. Postural muscle tone is almost completely suppressed in REM sleep apart from occasional muscle twitches. This absence of skeletal muscle tone in REM sleep is due mainly to processes of motor inhibition resulting in what is commonly likened to sleep "paralysis." A small region of the brain stem in the pons is responsible for this generalized muscle inhibition, and lesions at this site lead to brain electrophysiological signs of REM sleep but without motor inhibition.

NREM sleep

NREM sleep is also not a homogenous state and is composed of four subdivisions, labeled 1 to 4 in humans. Stage 3 and 4 NREM sleep are commonly referred to as

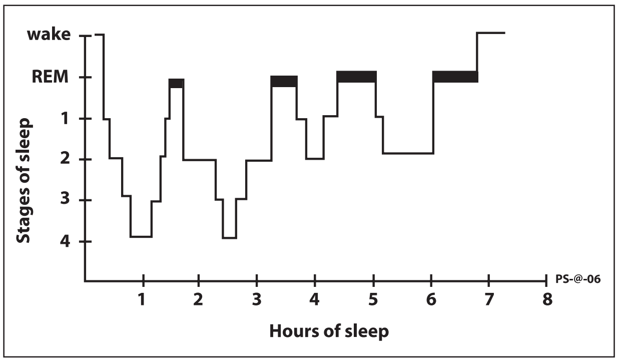

Fig 2. Normal "hypnogram" of sleep stage changes over the night in young human adults [© 2006: Physiology Dept., Siriraj].

"deep" or "slow wave" sleep. The latter term is used in reference to the frequency of waves in the EEG signal that are of slowest frequency at this time (0.5-4 Hz compared with; 10-25 Hz in wakefulness) and of the highest amplitude (more than 75 μV compared with 20-40 μV in wakefulness). The body appears to be most silent during this stage of sleep and shows little postural muscle tone. Breathing, heart rate and blood pressure are in their most stable in slow wave sleep compared with REM sleep and wakefulness. Responses to external stimuli such as noise or internal arousing stimuli such as hypoxia are progressively reduced from stages 1 to 4 of NREM sleep.

The sleep cycle

Sleep is not a simple linear process in which an individual enters into stage 1 NREM sleep at the beginning of the night, progresses through to stage 4 NREM sleep, enters REM sleep, and then wakes up in the morning. Rather, repeated episodes of NREM and REM sleep alternate cyclically through the night.

During a night of sleep, the brain waves record by the EEG gradually slows down and becomes larger as the individual passes into deeper stages of slow wave sleep. After about an hour, the brain re-emerges through the same series of stages, and there is usually a brief period of REM sleep (Fig 2, on dark area of graph), during which the EEG is similar to wakefulness. The body is completely relaxed, the person is deeply unresponsive and is usually dreaming. The cycle repeats over the course of the night, with more REM sleep and less time spent in the deeper stages of slow wave sleep as the night progresses.

In humans, sleep begins with 80 min of NREM sleep followed by a REM period of 2-10 min. This 90-min NREM-to-REM sleep cycle is then repeated about three to six times during the night.[5] Hypnogram (Fig. 2) is a graphical display the sequences of sleep stage changes over the night.

Mechanisms of wakefulness and sleep

The following is a brief overview on wakefulness and sleep mechanisms. There are many books on this subject. *Principles and practice of sleep medicine*[3] and *Sleep disorders medicine: Basic science, technical considerations and clinical aspects*[6] are recommended.

It has been known for more than half a century that wakefulness and consciousness depend on the activity of the neurons within the brainstem reticular formation. These

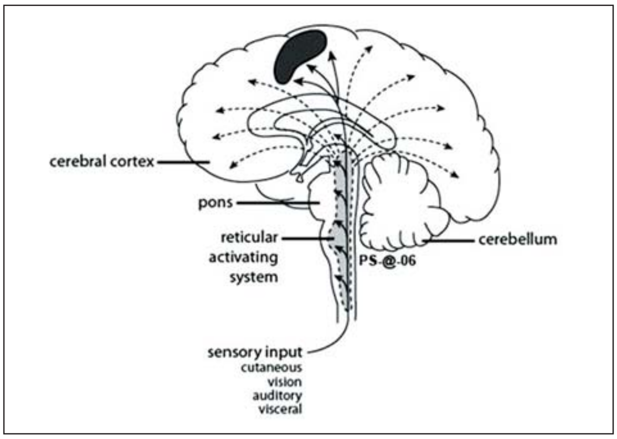

Fig 3. Sagittal view of human brain showing reticular activating system (RAS) [© 2006: Physiology Dept., Siriraj].

neurons form the ascending reticular activating system (RAS) (Fig 3). They receive collateral inputs from visceral, somatic and special sensory system and project via dorsal pathway to the thalamus and via ventral pathway to the basal forebrain. From both pathways, impulses are transmitted to widespread areas of the cerebral cortex to produce the cerebral cortical activation that occurs during wakefulness.

Sleep is a state of unconsciousness in which the brain is relatively more responsive to the internal than to the external stimuli. The predictable cycle of sleep and the reversal of relative external unresponsiveness are features that assist in distinguishing sleep from other states of unconsciousness.

There are also specific brain mechanisms that promote NREM sleep and others that are responsible for REM sleep. The old notion that sleep occurs as a result of the withdrawal of activity in systems that promote wakefulness is simply not true. Sleep is not a passively occurring state, but it is actively generated by activities in specific brain regions.

NREM sleep is controlled by complex initiating and maintenance mechanisms, the extent of which is not fully elaborated. Probably no single sleep-generating center exists. From animal studies, stimulation, recording and lesion data implicate more than one area is necessary in the control of NREM sleep. The anterior hypothalamus, preoptic area, basal forebrain and the lower brainstem, the solitary tract nucleus (NTS) in particular, are shown to be important in sleep-inducing system.

In an attempt to localize the neurons generating REM sleep, a number of investigations had been conducted (the details of which are not mentioned here). In the big picture they found that when the pons is connected to the mid brain and forebrain, most of the defining signs of REM sleep are observed in these rostral structures. When the pons is connected to the medulla and spinal cord, as in the midbrain transected animal, most of the defining signs of REM sleep are observed in the caudal structures. When a transection is made at the junction of the spinal cord and the medulla, all of the signs of REM sleep occur in all rostral brain areas, i.e., in the medulla, pons, midbrain and forebrain. From these results, the conclusion is that the pons is both necessary and sufficient to generate the basic phenomena of REM sleep.

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Sleep Hygiene

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Insomnia is a leading sleep complaint in general practice. It is defined as an inability to obtain ad equate sleep. The clinical presentation of insomnia varies from transient to chronic insomnia. The most important concept is that insomnia is a complaint and a symptom, but it is not a diagnosis, except for primary insomnia and sleep state misperception. This sleep symptom is always found secondary to a medical, psychiatric, circadian, sleep, behavioral, or environmental disorder. Detailed history taking including sleep history and all information related to possible causative disorders is essential in clinical assessment of patients with insomnia. The main objective of the treatment plan for is to eliminate the underlying conditions. Pharmacological and non-pharmacological interventions are both beneficial. Various non-pharmacological techniques have been introduced as successful treatments in patients with insomnia which are, namely:

1. stimulus control therapy;
2. relaxation therapy;
3. cognitive therapy;
4. paradoxical therapy;
5. sleep restriction, and;
6. sleep hygiene education.

Sleep hygiene was first described by Nathaniel Kleitman in 1939. Those practices that interfere with normal sleep and contribute to sleep complaints have been increasingly emphasized nowadays. These recommendations are general principles and are not applicable to all patients. When presenting this to the patient, it is usually better to focus on one or two of these principles at a time and to work slowly through the entire list. Data from normal sleepers demonstrate that sleep quality and quantity are adversely affected when certain sleep behaviors are followed. These data support the assumption that poor sleep hygiene can worsen sleep. There were various investigators introducing different sets of rules which could help patients with insomnia sleep better. The collective instructions of sleep hygiene and some supportive data are as follows:

1. Homeostatic drive for sleep

a. Avoid naps, except for a brief 10- to 15-minute nap 8 hour after arising. Daytime naps have been shown to decrease the depth of the subsequent major sleep episode and increase latency to sleep onset, likely due to lowered homeostatic pressure leading up to nocturnal sleep onset. However naps can be beneficial in some sleep disorders or in some patients who cannot obtain sufficient quantity of sleep.

b. Restrict the sleep period to the average number of hours that the patient has actually slept per night in the preceding week. Too much time in bed can decrease quality on the subsequent night.

c. Get regular exercise each day and finish at least 6 hours before bedtime.

d. Take a hot bath to raise body temperature within 2 hours before bedtime. A hot drink may help as well. Data show that increased body temperature prior to sleep, or passive body heating, can in crease depth of subse quent sleep in both normal sleepers and older insomniacs.

2. Circadian factors

a. Keep a regular time go to and out of bed everyday. Both processes combine to allow for a relatively constant level of alertness during the day and similarly stable sleep at night.

b. Do not expose to bright light if wake up at night. Light exposure during the habitual night