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บทความวิชาการ

มโนมติและการวัดการนอนหลับ
Conceptual and Measurement of Sleep

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For many years, scientists have been puzzled by two questions: What is sleep?, and; What is its function? Before the availability of electrophysiological monitoring, sleep was thought to be a simple, passive and uniform phenomenon and sleep was only defined by behavioral criteria. The characteristic hallmarks of sleep included lack of movement; reduced postural muscle tone; closed eyes; lack of response to limited stimuli ; and subtle changes, including more regular breathing, more relaxed expiration, and increased upper airway noise (Stradling, 1993). Shaver and Giblin (1989) defined sleep as a state of active, heterogeneous, neurophysiological functioning, synchronized with the light-dark cycle of the environment and characterized by cycling of the stages of sleep throughout the sleep period time. Sleep is a complex process characterized by physiological, biological, behavioral, and electroencephalographic events.

When studied using polysomnography, sleep is classified into various stages and cycles that are known as "sleep architecture". Polysomnography records sleep stages according to brain wave (electroencephalogram, EEG), eye movements (electro-oculogram, EOG) and muscle tension (electromyogram, EMG). Sometimes the assessment includes blood oxygen saturation and expired carbon dioxide. Human brain waves are one indicator, along with other sleep behaviors that distinguishes sleep from waking and the sleep stages (Shaver & Landis, 1994).

Sleep stages. Human beings alternate between three states: wakefulness, NREM sleep, and REM sleep (Chuman, 1983). Sleep can be divided into two main parts, rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep. Each sleep cycle lasts about 90 - 100 minutes and people go through 4-5 cycles during the night (McGonigal, 1986). Wakefulness is characterized by a spontaneous, low-voltage, random, fast electrical activity and the muscle activity is high. The pattern of EEG is desynchronized. Alpha waves are only present when the eyes are closed and the person is beginning to get drowsy (Stradling, 1993). NREM sleep is divided into four distinct stages: stage 1, stage 2, stage 3, and stage 4.

Stage 1, which may be called a transitional sleep, is a transitional phase between full wakefulness and sleep. It occurs when a person becomes drowsy. The alpha wave disappears, the overall frequency falls, and the theta waves may appear on the EEG. The eyes begin to roll

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slowly from side to side. In a normal person, this stage lasts only 1-7 minutes (Hauri, 1982). A person may experience myoclonic jerks of the face, hands, or feet (McGonigal, 1986 & Parker, 1995). Response to stimuli will decrease, but a person is still easily awakened and aware of his surroundings. Short dreams may develop.

Stage 2 or light sleep is defined by the appearance of "sleep spindles" that are short bursts of waves at 12-14 Hz and consist of 6-25 actual complete waves. Additionally, K. complexes appear. Muscle tone is reduced and eye movements are absent. A person is unaware of his surroundings but is easily aroused.

Stage 3 and 4 are characterized by the appearance of big, slow delta waves. These stages are known as deep slow-wave sleep (SWS) or delta sleep. During stage 4, a person is difficult to awaken. Sleep walking can occur in this stage. REM sleep is characterized by bursts of rapid eye movement. The EMG is flat because of hyperpolarized motor neurons in the brain stem and spinal cord (Parker, 1995). Individuals usually report dreams during this stage. REM sleep is believed to be important for mental restoration, learning, memory, and psychological and emotional well-being (Chuman, 1983 & Parker, 1995).

Sleep variables. Generally, information of sleep from polysomnography includes the time taken to fall asleep (sleep onset latency, SOL), the latency in various stages, the percent of time spent in each stage, and the distribution of sleep stages over the sleep period time (SPT) (Shaver & Giblin, 1989). Other information is used to evaluate sleep stability. Examples include the time spent sleeping/time spent in bed (sleep efficiency index), the number of sleep stage changes from deep sleep to awakening or stage 1 and lasting less than 10 seconds per hour, and the number of stage changes to a lighter stage of sleep or to waking per hour (Shaver & Giblin, 1989).

Subjective components of sleep. Sleep involves not only the objective components but also the subjective components (Shaver, Giblin & Paulsen, 1991). Subjective sleep can include both quantitative and qualitative aspects. Examples of quantitative sleep aspects include the usual time of sleeping, estimates of sleep duration, sleep latency, or number of arousals, number of awakenings, number of nightmares, and amount of dreams. More subjective qualitative sleep aspects are the depth of sleep, restfulness of sleep, the ease of getting to sleep, and the ease of awakening

Many studies have been conducted to investigate the dimensions of sleep quality, especially its meaning from patients' perceptions. Johns (1971) documented that subjective sleep quality was related to the delay to sleep, total time awake, duration of night sleep and nightmares. Others described sleep quality relating to specific factors such as a "morning factor" (ease awakening, enough sleep, etc.), a "sleep factor" (awakenings, sleep depth, etc.), "sleep latency," "amount of dreaming", etc. (Webb, Bonnet & Blume, 1976). Some have

reported that dimensions of sleep quality may consist of three parts: the disturbance, effectiveness and nap supplementation of sleep (Snyder - Halpern & Verran, 1987 & Knapp - Spooner & Yarcheski, 1992).

In summary, sleep is a complex phenomenon that can be described in different ways. Scientists can approach sleep from biological, physiological, behavioral or subjective perspectives. It should be emphasized that normal sleep is difficult to define subjectively because individuals vary enormously (Closs, 1988). Assessment of sleep quality by subjective measurements may not be comparable to objective measurements.

Measurements of Sleep

In terms of sleep research, there are several approaches to the measurement of sleep and its correlates. In the following paragraphs, the current objective and subjective sleep measurement techniques are discussed. Advantages and disadvantages of each technique and the issue about reliability and validity of these measurements are emphasized.

Objective Sleep Measurements

These objective measurements include polysomnography, measuring body movement, and bedside monitor systems.

Polysomnography. Polysomnography includes recordings of EEGs (electro-encephalogram), EOG (electrooculogram), and EMG (chin electromyogram). The EOG and EMG are useful in distinguishing between REM and NREM sleep (Schwab, 1994). This method provides the most reliable way of measuring all sleep parameters such as the onset, progress and depth of sleep. It remains the best validated method to assess sleep (Buckle, Pouliot & Millar, 1992). Its reliability and validity are documented in many studies.

Unfortunately, some disadvantages preclude the use of polysomnography as a routine method to measure sleep in critical care units. Polysomnography is expensive, time-consuming, and requires technical training to operate the equipment and to score sleep stages (Snyder-Halpern & Verran, 1987 & Schwab, 1994). A polygraph machine, EEG machine, paper or computer discs, electrodes, paste, and collodion for electrode application are costly. Scoring and interpreting the recordings can be time-consuming. Some illness factors such as drugs or anesthesia may have an effect on EEG changes. Consequently, signs of EEG sleep may be difficulty to interpret during acute illness episodes. For example, certain drugs such as atropine sulfate and hyoscyamine sulfate produce an EEG characteristic of sleep even during wakefulness (Bradley & Elkes, 1957 as cited in Johns, 1971 & cited in Closs, 1988). Metabolic disturbances such as hyponatremia after cardiac surgery may cause dissociation in EEG signs of sleep and wakefulness (Harden, Glaser & Pampiglione, 1968). Due to its large size, this equipment requires more space in the critical care unit. Also, the odor of the collodion

Body movements. Information about sleep quality may be drawn from measurement of body movements, especially when combined with other measurements (Johns, 1971). During sleep, body movements will decrease, particularly in REM sleep (Closs, 1988). Many different technologies are used to measure body movements such as night cap, wrist actigraph, and static charge-sensitive bed.

Night cap. A small portable sleep monitor called "night cap" has been developed to measure body movements. The night cap can not distinguish among sleep stages 1 to 4. Data about sleep are derived from using eyelid and head movement sensors to discriminate among wake, NREM and REM sleep (Ajilore, Stickgold, Rittenhouse & Hobson, 1995). The agreement between the nightcap and polysomnography was 87 % based on 1-min. epochs, 93 % for NREM, 80 % for REM and 72 % for wake. When the values for sleep latency, REM latency, wake time, NREM time and REM time calculated from night cap were compared with the values calculated from polysomnography, no significant differences were found (Ajilore et al., 1995). When compared with subjective reports of sleep quality made by the subjects after each night's sleep, the data from night cap correlated well (Ajilore et al, 1995). The night cap is more appropriate in critical care units than polysomnography, as it is less intrusive and the night cap circuitry is contained in a small and easily portable case. However, the night cap cannot differentiate between the four stages of NREM sleep because it does not measure brain waves. Second, this method is not appropriate for people who have brain surgery. Studies evaluating sleep patterns of critically ill patients with the night cap may be an area of research in the future.

Wrist actigraph. An actigraph is a small piezoelectric transducer worn on the wrist like a watch. It is relatively unobtrusive and contains a motion detector and a memory bank. By measuring body movements over 24-hour periods, actigraph can quantify sleep and wakefulness (Schwab, 1994). It correlates well with polysomnography during stages of sleep and during full wakefulness; the correlations are not good in transitions between sleep and wakefulness (Sadeh, Hauri, Kripke & Lavie, 1995 & Cole, Kripke, & Gruen, 1992). The data gained from actigraph correlates with that of sleep logs (Hauri & Wisbey, 1992). However, reliability and validity have not been tested in the critical care settings. Studies evaluating sleep patterns of critically ill patients with an actigraph have never been published; this may be an area of research in the future. There are some advantages of this equipment. Compared with polysomnography, actigraph requires less space and is less expensive. Actigraph can be used in individuals varied in age from infancy to adulthood. When used in critically ill patients, actigraph is relatively less obtrusive. Its disadvantages are similar to those of polysomnography in that it requires extensive technical training for data reduction and analysis.

Bedside monitor systems. In order to indirectly assess sleep in the critical care unit, the information gleaned from bedside monitor systems should be considered. Many physiological parameters have been shown to vary during sleep (Johns, 1971). Heart rate, blood pressure, and respiratory rate decrease during NREM sleep and increase and show greater variability during REM sleep (Snyder, 1967). Though the information about sleep form this technique is not as complete as that of polysomnography, it can provide additional information to assess sleep and wake states. This is more likely to occur if bedside monitoring variables, including heart rate, blood pressure and respiration are used with other signs of sleep such as closed eyes, lack of movements and decreased awareness of surroundings. However, some pharmacological therapies may affect heart rate to confound interpretations about sleep.

Subjective Sleep Measurements.

A subjective measure of sleep assesses qualitative and quantitative aspects of sleep information from patients' perceptions of their experiences (Closs, 1988). Objective measurements can not measure some subjective aspects of sleep such as restfulness, freshness and depth of sleep. Johns (1971) reported that subjective measurements might provide more reliable information about some aspects of sleep than do objective measurements such as polysomnography. Only patients can tell us about their feelings. These subjective measurements include visual analogue scales, sleep rating scales, questionnaires, interviews, sleep diaries and personal observation.

Visual analogue scales. The method is the simplest and most effective. The patients are asked to place a mark on the 100 mm horizontal line to tell their perceptions about their previous night's sleep. There are opposing statements at each end of the line, for example, best sleep and worst night. The measured distance of patients' marks provides a numerical value (Bond & Lader, 1974). However, some patients may not understand how to mark this scale because of their difficulty in performing cognitive functions. One of these types of scales is the Verran/Synder-Halpern Sleep Scale that measures patients' perceived sleep. It measures four dimensions of sleep problems: the attempted length, the disturbance, effectiveness, and nap supplementation of sleep. Of the three dimensions, sleep disturbance has six items measuring the extent and quality of sleep latency, mid-sleep awakening, movement during sleep, soundness of sleep, wake after sleep onset, and the quality of sleep disturbance. Sleep effectiveness has hour items measuring rest upon awakening, subjective quality of sleep, total sleep period, and sleep efficiency evaluation. Sleep supplementation has four items measuring daytime, morning, and evening sleep, and wake after final arousal. The attempted length of sleep is obtained from the "total sleep period" item in which patients indicate the total (from 0-10) hours of time they spend from the time they fall asleep to the time they awaken in the morning (Simpson, Lee & Cameron 1996). Another example is the Richards Campbell Sleep Questionnaire (Richards, 1987). This is a five-item instrument that uses a visual analog

scaling technique. Items measure sleep depth, falling asleep, awakening, returning to sleep and quality of sleep. Construct validity is supported for three of five items while content validity is supported for all five items by the correlation with polysomnography (Richards, 1987).

Subjective rating scales. This is a simple method to assess perceived moods and feelings about sleep. One of these types of scales is the Stanford Sleepiness Scales (SSS) that is used to quantify subjective sleepiness level. This measurement uses a 7 point scale of equal interval. It is very sensitive to measure sleep deprivation. It correlates with polysomnography (Hoddes, Zarcone, Smythe, Phillips & Dement, 1973). The advantages of this measure is that it is inexpensive and simple.

Questionnaires. Most sleep questionnaires include self-administered questions relating to duration and quality of sleep. Some questionnaires provide more detail about the number of awakenings and sleep habits. One of the sleep questionnaires is the St. Mary's Hospital Sleep Questionnaire. This questionnaire consists of 14 questions for patients to complete. It has been already tested in surgical, medical, psychiatric patients and normal volunteers. Kennel's tau was used to provide test-retest validity data. Correlation coefficients ranged from 0.7 to 0.96 (Ellis, Johns, Lancaster, Raptopolulas, Angelopoulos & Priest, 1981).

Advantages of the questionnaire is that it requires little time, and it is convenient for a researcher for data collection. However, some disadvantages of this method should be considered. For example, it can not be used for some people who are not able to read and write. In critical care settings, some patients may not be able to complete the questionnaire because of their serious physical condition, impairment in cognitive functioning, and changes in mental status.

Interviews. This method consists of a thorough review of the patients' past and present sleep/wake patterns, snoring history, sleep-related breathing disturbances, chronic nocturnal pain, parasomnias (sleep walking, sleep talking, and night terrors) and difficulties in initiating and/or maintaining sleep (Norman, Chediak, Kiel & Cohn, 1990). This method enables the researchers to clarify questions in order to get data that are missing. It is appropriate for patients who can not read and write the answers to the sleep questionnaires. A disadvantage of this method is that is time-consuming for researchers to collect data. As for critically ill patients, this method may not be appropriate for patients who are intubated or have impaired communication due to drugs or altered consciousness.

Sleep diaries. Sleep diaries or sleep logs are detailed day-by day reports of sleeping and waking activities (Rogers, Caruso & Aldrich, 1993). Patients record the number of hours slept; length of sleep onset; frequency of awakenings; early morning awakenings; the occurrence of sleep walking; nocturnal arousal or sleep attacks; quality of sleep; lack of restfulness; ingestion of medications; caffeine or alcohol; and day-time activity

(Haythornthwaite, Hegal & Kerns, 1991). This method is simple, convenient, inexpensive, and can be used outside laboratory settings. Sleep diaries provide more information than that of a one-time sleep questionnaire (Douglas, Carskadon & Houser, 1990). Sleep diaries also minimize the biases of recall memory that frequently occur when using self-reported measurement. Most self-reported measurements require patients to remember their sleep pattern that occurred many days ago.

However, its reliability and validity still need to be tested. There are only a few studies about the validity and reliability of sleep diaries. Most of studies are conducted in patients with chronic pain (Haythornthwaite et al., 1991) or narcolepsy (Rogers et al., 1993). Sleep diaries have not been used in critical care settings. Moreover, sleep diaries are limited to patients who can read and write. Sleep diaries may also not be appropriate for critically ill patients because these patients sometimes are unconscious or have impaired thought process.

Personal observation. This method is widely used in observing sleep behavior of children, the elderly and psychiatric patients. It provides information about the quality and duration of sleep. Usually, this method can identify only two stages; wakefulness and sleep. Sleep in most observational tools is defined as the presence of eye closure and absence of gross motor activity. Some measurements include breathing patterns such as apnea. This method is non-intrusive. However, some disadvantages should be considered. Its reliability is questionable because patients may wake up for only a few minutes without being observed. It is also difficult to distinguish periods of quiet wakefulness from sleep. At least one 15 - 30 minute interval of observation is needed to detect whether patients fall asleep (Johns, 1971 & Closs, 1988).

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