Assessment of Sleep and Breathing

Chapter 18
Sleep Medicine

• Significant advances during the past several years
  – Heightened appreciation of sleep disorders
  – Increased scientific research now available
• Polysomography
• Polysomnogram is recording of
  – EEG
  – EOG
  – EMG
  – Other physiological features monitored
Functions of Sleep

• Essential for survival
• Restoration/Recuperation
• Energy Conservation
• Circadian Rhythms
Normal Sleep Stages

• Heterogeneous physiologic state of activity
• Normal sleepers progress through a standard sleep sequence
• Two basic types of sleep
Sleep Cycles

• Usually about 10-30 minutes to fall asleep
  – <5 minutes indicates excessive sleepiness
  – >30 minutes due to lack of sleepiness, emotional stress, environmental disturbances, medication, illness, or pain

• Full sleep cycle:
  – Stage one
  – Stages 2-4
  – Return to stage 3 then stage 2
  – From stage 2 comes REM
  – End of REM in the conclusion of the first cycle

• Normal night’s sleep = 4-6 cycles of sleep
Normal Sleep Cycle

- Normal sleep cycle. The sleeper progresses through Stages 1, 2, 3, and 4; followed by a return to Stage 3 and 2. From Stage 2 the sleeper moves into REM sleep. The end of REM sleep ends the first sleep cycle. From REM sleep, the sleeper moves back to Stage 2 and a new sleep cycle begins.
Wake Cycle – Eyes Open

• The EEG shows Beta waves, and high frequency low amplitude activity. The EOG look very similar to REM sleep waves—low amplitude, mixed frequency, and sawtooth waves. EMG activity is relatively high.
Drowsy Cycle – Eyes closed, awake

• The EEG is characterized by prominent Alpha waves (>50%). The EOG shows slow-rolling eye movements, and the EMG activity is relatively high.
NREM Sleep

4 stages of NREM Sleep

• Stages 1 and 2
  – Light sleep stages

• Stages 3 and 4
  – Deep sleep or slow wave sleep stages
NREM Stage 1

- Large eye rolls and low amplitude EEG waves
- Between drowsiness and sleep
- Person feels sleepy and often experiences a drifting or floating sensation
- Sleeper may experience sudden muscle contractions called **hypnic myoclonia**
- Under normal conditions
  - Stage 1 lasts between 10 to 12 minutes and is very light sleep
- A person can be easily awakened during this period
NREM Stage 2

- Still a relatively light sleep
  - Although arousal is a bit more difficult
- Stage 2 occupies the greatest proportion of the total sleep time
  - Accounts for about 40 percent to 50 percent of sleep
- Duration of Stage 2 is between 10 and 15 minutes
- If awakened, person may say he or she was thinking or daydreaming
- sleep spindles, K complexes
NREM Stage 3

• Medium deep sleep
  – 20 percent to 50 percent of the EEG activity consists of high-amplitude (> 75 μV)

• Dreaming may occur
  – Less dramatic, more realistic, and may lack plot

• Sleeper becomes more difficult to arouse

• Stage 3 is usually reached about 20 to 25 minutes after the onset of Stage 1
NREM Stage 4

- Deep slow wave sleep
- Present when more than 50 percent of the EEG activity consists of delta waves
  - Amplitude $> 75 \mu V$, and frequency $2 \text{ Hz or less}$
- Sleeper is very relaxed and seldom moves
- The vital signs reach their lowest, normal level
- Oxygen consumption is low
- Patient very difficult to awaken
- Stage 4 important for mental and physical restoration
- Stage in which bed-wetting, night terrors, and sleepwalking are most likely to occur
REM Sleep

- Resembles eyes open wake epoch
- EEG records low voltage, mixed EEG activity
  - Frequent sawtooth waves
- Alpha waves may be present
- EOG records rapid eye movements (REM)
- EMG records low electrical activity
  - EMG documents a temporary paralysis of most of the skeletal muscles
    - Arms, legs
- Breathing rate increases and decreases irregularly
  - Heart rate becomes inconsistent with episodes of increased and decreased rates
- Snoring may or may not present
- REM is not as restful as NREM sleep
- REM is also known as paradoxical sleep
- Most dreams occur during REM sleep
<table>
<thead>
<tr>
<th>STAGE</th>
<th>EEG</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eyes Open Wake</strong></td>
<td><img src="image1" alt="EEG waveform" /></td>
<td>The EEG shows Beta waves, and high frequency low amplitude activity. The EOG look very similar to REM sleep waves-low amplitude, mixed frequency, and sawtooth waves. EMG activity is relatively high.</td>
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<tr>
<td><strong>Eyes Closed Wake</strong></td>
<td><img src="image2" alt="EEG waveform" /></td>
<td>The EEG is characterized by prominent Alpha waves (&gt;50%). The EOG shows slow-rolling eye movements, and the EMG activity is relatively high.</td>
</tr>
<tr>
<td><strong>NON-RAPID EYE MOVEMENT (NON-REM SLEEP)</strong></td>
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<tr>
<td>Stage 1 (light sleep)</td>
<td><img src="image3" alt="EEG waveform" /></td>
<td>The EEG shows low voltage mixed frequency activity, Alpha waves (8-12 Hz, &lt;50%), and Theta waves. Some Beta waves (&gt;13 Hz) may also appear. Vertex waves commonly appear toward the end of Stage 1. The EEG shows slow, rolling eye movements. The EMG reveals decreased activity and muscle relaxation. Respirations become regular and the heart rate and blood pressure decrease slightly. Snoring may occur. If awaken, the person may state that they were not asleep.</td>
</tr>
<tr>
<td>Stage 2 (light sleep)</td>
<td><img src="image4" alt="EEG waveform" /></td>
<td>The EEG becomes more irregular and is comprised predominantly with Theta waves (4-7 Hz), intermixed with sudden bursts of Sleep spindles (12-18 Hz), and one or more K complexes. Vertex waves may also be seen during this stage. The EEG shows either slow eye movements or absence of slow eye movements. The EMG has low electrical activity. The heart rate, blood pressure, respiratory rate, and temperature decrease slightly. Snoring may occur. If awaken, the person may say they were thinking or daydreaming.</td>
</tr>
<tr>
<td>Stage 3 (medium deep sleep)</td>
<td><img src="image5" alt="EEG waveform" /></td>
<td>EEG shows 20%-50% Delta waves. Both Sleep spindles and K complexes may be present. EEG shows little or no eye movement and the EMG activity is low. Continued decrease in the heart rate, blood pressure, respiratory rate, body temperature, and oxygen consumption. Snoring may occur and there is no eye movement. Dreaming may occur and the sleeper becomes more difficult to arouse.</td>
</tr>
<tr>
<td>Stage 4 (deep sleep)</td>
<td><img src="image6" alt="EEG waveform" /></td>
<td>EEG shows more than 50% Delta waves. The EEG shows no eye movements, and the EMG has little or no electrical activity. The sleeper is very relaxed and seldom moves. The vital signs reach their lowest, normal level. Oxygen consumption is low. The patient is very difficult to awaken. Bed-wetting, night terrors, and sleepwalking may occur.</td>
</tr>
<tr>
<td><strong>RAPID EYE MOVEMENT (REM)</strong></td>
<td><img src="image7" alt="EEG waveform" /></td>
<td>About 90 minutes into the sleep cycle, there is an abrupt EEG pattern change. The EEG pattern resembles the wakeful state with low voltage, mixed EEG activity. Sawtooth waves are frequently seen. Alpha waves may be seen. The respiratory rate increases and is irregular and shallow. The heart rate and blood pressure increase. Rapid eye movement occurs and there is paralysis of most skeletal muscles. Most dreams occur during REM.</td>
</tr>
</tbody>
</table>
Common EEG Waveforms

An electroencephalogram (EEG) measures the electrophysiologic changes in the brain. The EEG electrical activity is characterized by frequency in cycles per second or hertz (Hz), amplitude (voltage), and the direction of major depolarization (polarity). The following are the most common frequency ranges:

**Beta Waves** (>13 Hz)
- One of the four brain waves, characterized by relatively low voltage or amplitude and a frequency greater than 13 Hz. Beta waves are known as the “busy waves” of the brain. They are recorded when the patient is awake and alert with eyes open. They are also seen during Stage 1 sleep.

**Alpha Waves** (8-13 Hz)
- One of the four brain waves, characterized by a relatively high voltage or amplitude and a frequency of 8-13 Hz. Alpha waves are known as the “relaxed waves” of the brain. They are commonly recorded when the individual is awake but in a drowsy state and when the eyes are closed. Alpha waves are commonly seen during Stage 1 sleep. Bursts of Alpha waves are also seen during brief awakenings from sleep-deleted arousals. Alpha waves may also be seen during REM sleep.

**Theta Waves** (4-7 Hz)
- One of the four types of brain waves, characterized by a relatively low frequency of 4-7 Hz and low amplitude of 0.5-20 microvolts (μV). Theta waves are known as the “drivative waves” of the brain. They are seen when the individual is awake, but relaxed and sleepy. They are also recorded in Stage 1 sleep. REM sleep, and as background waves during Stage 2 sleep.

**Delta Waves** (<4 Hz)
- The slowest of the four types of brain waves. Delta waves are characterized by a frequency of less than 4 Hz and high amplitude (>75 μV) broad waves. Although delta EEG activity is usually defined as < 4 Hz, in human sleep scoring, the slow-wave activity used for scoring is defined as EEG activity < 2 Hz (0.5 second duration) and a peak-to-peak amplitude of > 75 μV. Delta waves are called the “deep sleep waves.” They are associated with a dreamless state from which an individual is not easily aroused. Delta waves are seen primarily during Stage 3 and 4 sleep.

**K Complexes**
- K complexes are intermittent high-amplitude, high-frequency waves of at least 0.5 second duration that signals the onset of Stage 2 sleep (green bars). A K complex consists of a sharp negative wave (upward deflection), followed immediately by a slower positive wave (downward deflection), that is 0.5 seconds. K complexes are usually seen during Stage 2 sleep. They are sometimes seen in Stage 3. Sleep spindles are often superimposed on K complexes.

**Sleep Spindles**
- Sleep spindles are sudden bursts of EEG activity in the 12-14 Hz frequency (0 or more distinct waves) and duration of 0.5 to 1.5 seconds (pink bars). Sleep spindles mark the onset of Stage 2. They may be seen in Stage 3 and 4, but usually do not occur in REM sleep.

**Sawtooth Waves**
- Sawtooth waves are notched-jagged waves of frequency in the Theta range (3-7 Hz) (brown bars). They are commonly seen during REM sleep. Although sawtooth waves are not part of the criteria for REM sleep, their presence is a clue that REM sleep is present.

**Vertex Waves**
- Vertex waves are sharp negative (upward deflection) EEG waves, often in conjunction with high amplitude and slow (0-7 Hz) activity (yellow bars). The amplitude of many of the vertex sharp waves are greater than 20 μV and, occasionally, they may be as high as 200 μV. Vertex waves are usually seen at the end of Stage 1.
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- One of the four brain waves, characterized by relatively low voltage or amplitude and a frequency greater than 13 Hz. Beta waves are known as the “busy waves” of the brain. They are recorded when the patient is awake and alert with eyes open. They are also seen during Stage 1 sleep.
Alpha Waves (8-13 Hz)

• One of the four brain waves, characterized by a relatively high voltage or amplitude and a frequency of 8-13 Hz. Alpha waves are known as the “relaxed waves” of the brain. They are commonly recorded when the individual is awake, but in a drowsy state and when the eyes are closed. Alpha waves are commonly seen during Stage 1 sleep. Bursts of Alpha waves also are seen during brief awakenings from sleep—called arousals. Alpha waves may also be seen during REM sleep.
Theta Waves (4-7 Hz)

- One of the four types of brain waves, characterized by a relatively low frequency of 4-7 Hz and low amplitude of 10 microvolts (μV). Theta waves are known as the “drowsy waves” of the brain. They are seen when the individual is awake, but relaxed and sleepy. They are also recorded in Stage 1 sleep, REM sleep, and as background waves during Stage 2 sleep.
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K-Complexes

• K complexes are intermittent high-amplitude, biphasic waves of at least 0.5 second duration that signal the start of Stage 2 sleep. A K complex consists of a sharp negative wave (upward deflection), followed immediately by a slower positive wave (downward deflection), that is > 0.5 seconds. K complexes are usually seen during Stage 2 sleep. They are sometimes seen in Stage 3. Sleep spindles are often superimposed on K complexes.
Sleep Spindles

- Sleep spindles are sudden bursts of EEG activity in the 12-14 Hz frequency (6 or more distinct waves) and duration of 0.5 to 1.5 seconds. Sleep spindles mark the onset of Stage 2. They may be seen in Stage 3 and 4, but usually do not occur in REM sleep.
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- Sawtooth waves are notched-jagged waves of frequency in the Theta range (3-7 Hz). They are commonly seen during REM sleep. Although sawtooth waves are not part of the criteria for REM sleep, their presence is a clue that REM sleep is present.
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- Vertex waves are sharp negative (upward deflection) EEG waves, often in conjunction with high amplitude and short (2-7 Hz) activity. The amplitude of many of the vertex sharp waves are greater than 20 μV and, occasionally, they may be as high as 200 μV. Vertex waves are usually seen at the end of Stage 1.
Sleep Continuity Theory

As sleep interruption increases, daytime alertness decreases.

Sleep-Disordered Breathing:

- Diverse spectrum
- Birth to old age
- Sleep Apnea
- Upper airway resistance syndrome
- Snoring
Factors that affect sleep

- Age
- Illness
- Environment
- Fatigue
- Lifestyle
- Emotional stress
- Alcohol and stimulants
- Diet
- Smoking
- Motivation
- Medications
Common Sleep Disorders

**Insomnia**
- Most common sleep disorder
- Classified as
  - Transient
  - Short-term
  - Chronic

**Hypersomnia**
- Periods of long deep sleep
- Psychological factors
- Extreme drowsiness associated with lethargy
Common Sleep Disorders

Narcolepsy
- Sudden sleep attacks
- Occur several times/day
- Symptoms persist throughout life

Restless Leg Syndrome
- Intense unpleasant sensations
- Motor restlessness
- Causes insomnia

Periodic Limb Movement Disorder
- Repetitive, rhythmic movements of the legs
- Occurs during non-REM sleep
- Patient usually not aware of the problem
Upper Airway Resistance Syndrome

• Frequent sleep interruptions
• Do not become hypoxic during sleep
• Excessive daytime sleepiness due to poor sleep continuity
• Thought to be underrecognized and undertreated
Sleep Apnea

**Obstructive**
- Cessation of airflow through the nose and mouth with the persistence of diaphragmatic and intercostal muscle activity
- Loud snoring followed by silence
- Excessive daytime sleepiness
- Hypoxia

**Central**
- Cessation of airflow with no respiratory efforts
- Not as common as OSA
- Periodic breathing
Obstructive Apnea
Central Apnea
Management of Sleep Apnea

- Behavioral
- Medical
- Surgical
- Goals are to:
  - Normalize oxygen saturation and ventilation
  - Eliminate apnea, hypopnea, and snoring
  - Improve sleep architecture and continuity
Uvulo-Palato-Plasty (UPP)
Surgeon's View
Sleep Disorders in the Hospitalized Patient

- Obstructive sleep apnea
- Central alveolar hypoventilation syndrome (obesity)
- Insomnia
- Sleep disorders associated with medical or neurologic disorders
  - COPD
  - ALS or other neurological disorders
  - Asthma
  - Alcoholism
  - Depression and anxiety
Sleep in the ICU

• Characteristics
  – Decreased REM and SWS sleep
  – Decreased total sleep time
  – Increased sleep fragmentation
  – Circadian rhythm disturbances with the uncoupling of day and night

• Disrupted both objectively and subjectively
• Patient-staff interactions have a more significant impact than ambient noise levels
• Measures to improve sleep in the ICU
CRT-SDS/RRT-SDS

• The National Board for Respiratory Care (NBRC) announced the launch of a new specialty examination for respiratory therapists performing sleep disorders testing and therapeutic intervention. The CRT-SDS and RRT-SDS certification examination will be offered for the first time during the AARC International Congress in December 2008.

• To qualify you need to:
  – Be a CRT or RRT having completed a CAAHEP accredited respiratory therapist program including a sleep add-on track. OR
  – Be a CRT with six months of full time clinical experience in a sleep diagnostics and treatment setting under medical supervision (MD, DO, or PhD). OR
  – Be an RRT with three months of full time clinical experience in a sleep diagnostics and treatment setting under medical supervision (MD, DO, or PhD).