Sleep Study Interpretation

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Outline

- Indications for PSG
- Hook-up, preparation for PSG
- Types of sleep studies
  - Diagnostic, titration, split night
- Indices derived from PSG
- Approach to reading sleep study reports
Polysomnography

- Single most important laboratory technique used in the diagnosis & treatment of sleep disorders

- The technique of recording, analyzing, & interpreting multiple simultaneous physiologic characteristics during sleep
Indications

- Excessive daytime sleepiness
- Obstructive sleep apnea
- Breathing difficulties during sleep
- Behavior disturbances during sleep
- Poor sleep quality or Insomnia to exclude other sleep disorders
Parameters monitored in PSG

- Sleep Parameters
  - EEG
  - EOG
  - EMG

- Cardiopulmonary Parameters
  - ECG
  - Air Flow
  - Effort
  - SaO2
Amplitude

Time

1 sec

Moving Paper

Input 1 (Exploring electrode)

Input 2 (Reference electrode)

Differential Amplifier

+  
-  

Amplitude

uV

1 sec

Time

Cycles per second or Hz
EEG Frequency Bands

- Alpha: 8 to 13 Hz
- Beta: >13 Hz
- Delta: <4 Hz (0.5-2Hz)
- Theta: 4 to 7 Hz
Alpha waves - 8-13 cps
Beta waves -> 13 cps
Theta waves -4-7cps
Sleep spindle
• 12-14 cps;
• at least 0.5 sec duration; ie. 6-7 distinct waves w/in the half second

K complexes
- negative sharp wave immed ffd by a positive component
> 0.5 sec, maximal over vertex regions
Delta waves
• 0.5 to 2 cps
• 75 uV
## Sleep Stages

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<th>Stage W</th>
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<tr>
<td>Non-REM</td>
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<td>Stage N1</td>
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<td>Stage N2</td>
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<tr>
<td>Stage N3</td>
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<tr>
<td>Stage R</td>
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</table>
Awake - low voltage - random, fast

Drowsy - 8 to 12 cpsi - alpha waves

Stage 1 - 3 to 7 cpsi - theta waves

Stage 2 - 12 to 14 cpsi - sleep spindles and K complexes

Delta Sleep - 1½ to 2 cpsi - delta waves > 75 mV

REM Sleep - low voltage - random, fast with sawtooth waves
STAGE WAKE

- Eyes closed - alpha waves (>50%)
- Eyes open - low voltage mixed frequency
- Relatively high tonic EMG
STAGE N1

- Low voltage, mixed freq activity, 2-7cps range
- ↓amount(<50%), amplitude, freq of alpha
- Decreased tonic EMG
- With SEM; Without REM
STAGE N2

- Background of low voltage, mixed freq activity
- Presence of spindle and/or K-complex
- Delta waves <20% of epoch
STAGE N3
• Moderate amounts of high amp, slow wave activity, delta waves occupying >20% epoch
STAGE REM

- Low voltage, mixed freq activity
- EOG- paroxysmal, relatively sharply contoured, high-amplitude activity
- EMG- lowest tone in the record
- Absence of spindles, K complexes, & delta
AROUSALS

- Abrupt shift in EEG freq (theta, alpha &/or freq>16hz but not spindles)
- EEG freq shift duration of >/=3 secs
- Previously asleep for >/= 10secs
Tonsillar size scoring

Mallampati grading
<table>
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<tr>
<th>Situation</th>
<th>Chance of Dosing (0-3)</th>
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<tr>
<td>Sitting and reading</td>
<td>0 1 2 3</td>
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<tr>
<td>Watching television</td>
<td>0 1 2 3</td>
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<tr>
<td>Sitting inactive in a public place – ex theater or meeting</td>
<td>0 1 2 3</td>
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<tr>
<td>As a passenger in a car for an hour without a break</td>
<td>0 1 2 3</td>
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<tr>
<td>Lying down to rest in the afternoon</td>
<td>0 1 2 3</td>
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<tr>
<td>Sitting and talking to someone</td>
<td>0 1 2 3</td>
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<tr>
<td>Sitting quietly after lunch (when you’ve had no alcohol)</td>
<td>0 1 2 3</td>
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<tr>
<td>In a car, while stopped in traffic</td>
<td>0 1 2 3</td>
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</table>

**TOTAL SCORE**

0 = would never dose  
1 = slight chance of dozing  
2 = moderate chance of dozing  
3 = high chance of dozing

ESS > 10
Apnea

- temporary absence or cessation of breathing (airflow) during sleep; 10secs
  - CENTRAL APNEA – no effort to breathe is made
  - OBSTRUCTIVE APNEA – there is ventilatory effort but no airflow because the upper airway is closed
  - MIXED APNEA - initially no ventilatory effort but an obstructive apnea pattern is present when effort resumes
OBSTRUCTIVE APNEA
MIXED APNEA
HYPOPNEA

1. Decrease in nasal pressure amplitude $\geq 30\%$ from baseline
2. with oxygen desaturation of $\geq 3\%$ or an arousal
3. event $\geq 10$s
1. Increasing respiratory effort or flattening of nasal pressure waveform
2. event \( \geq 10 \)s
3. Followed by an arousal
Apnea/Hypopnea Index

- Apnea/Hypopnea index – apneas + hypopneas / total sleep time
- # Apneas + # Hypopneas x 60

TST in minutes

- 0-5/hr = Normal
- 5-15/hr = Mild
- 15-30/hr = Moderate
- >30/hr = Severe
Types of Sleep Studies

- **Diagnostic** – investigative study to determine if there are identifiable problems with the patient’s sleep.
- **CPAP Titration** – once the patient is identified as having sleep apnea, another study is performed in which the technician adjusts the CPAP level during the test.
- **Split Night** - combines a diagnostic study & a CPAP titration study into one night.
Positive Airway Pressure
Positive Airway Pressure
Indices derived from PSG

Sleep Related Indices

- Time in Bed (TIB)
- Total recording time (TRB)
- Total sleep time (TST)
- Sleep Efficiency >90%
- Sleep Latency <20 mins
- REM latency 90-120 mins
- Wake after Sleep Onset (WASO) <20 mins
- Sleep Period Time (SPT)
## Indices derived from PSG

### Distribution of Sleep:

<table>
<thead>
<tr>
<th>Stages of Sleep</th>
<th>Percentage of TST</th>
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<tr>
<td>N1</td>
<td>5% (3-8%)</td>
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<td>N2</td>
<td>50% (45-55%)</td>
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<td>N3</td>
<td>20% (15-20%)</td>
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<td>REM (R)</td>
<td>25% (20-25%)</td>
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</table>
Indices derived from PSG

Arousals

- Total arousal index
- Respiratory arousal index
- Periodic limb movement (PLM) Arousal Index <15/hr
- Respiratory Effort Related Arousals (RERA)
Indices derived from PSG

Abnormal activity during the study

- Periodic Limb movements index (PLMI)
- Bruxism
- ECG
Indices derived from PSG

Respiratory Indices

- Apnea Hypopnea index (AHI)
- RERA index
- Respiratory Disturbance Index (RDI)
- Oxygen saturation indices
Apnea/Hypopnea Index

- Apnea/Hypopnea index – apneas + hypopneas / total sleep time

- \# Apneas + \# Hypopneanas \times 60

  TST in minutes

- 0-5/hr = Normal
- 5-15/hr = Mild
- 15-30/hr = Moderate
- >30/hr = Severe
Factors affecting interpretation

- **Sleep Quantity & Quality** – decreased sleep quantity & poor sleep efficiency will overestimate AHI

- **Absent REM sleep** – underestimate AHI since apneas & hypopneas tend to be worse in REM sleep when respiratory muscles are more hypotonic
Factors affecting interpretation

- **Position** – apneas & hypopneas tend to be worse in supine position due to the base of tongue & soft palate falling back more easily when supine
Case 1

- 50/M with HPN, DM
- Excessive daytime sleepiness with snoring & witnessed apneas during sleep
- BMI 35.5  ESS 18
- Nose: no septal deviation; normal turbinates
- Soft palate low, tonsils: Grade 3;
- Mallampati score: 4
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<thead>
<tr>
<th></th>
<th>Value</th>
<th>%Stage N3</th>
<th>13.5%</th>
<th>%REM</th>
<th>22.2%</th>
<th>Arousal Index</th>
<th>45.4/hTST</th>
<th>PLMI</th>
<th>2.8/h</th>
<th>REM AHI</th>
<th>81.6/hr</th>
<th>AHI</th>
<th>72.9/hr</th>
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<tr>
<td>Total sleep time</td>
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<td>Time in bed</td>
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<td>Sleep Efficiency</td>
<td>91.2%</td>
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<td>NREM AHI</td>
<td>70.4/hr</td>
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<tr>
<td>AHI</td>
<td>72.9/hr</td>
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</table>
Question 1

What is the severity of OSA?

A. Mild
B. Moderate
C. Severe
D. Very severe
Apnea/Hypopnea Index

- Apnea/Hypopnea index – apneas + hypopneas / total sleep time
- \# Apneas + \# Hypopneas \times 60

TST in minutes

- 0-5/hr = Normal
- 5-15/hr = Mild
- 15-30/hr = Moderate
- >30/hr = Severe

72.9/hr
Case 2

- 32/M with no previous medical problems
- Excessive daytime sleepiness with snoring & witnessed apneas during sleep
- BMI 27.5  ESS 14
- Nose: hypertrophic inferior turbinates;
- Soft palate low, tonsils: Grade 1;
- Mallampati score: 3
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<tr>
<th></th>
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<th>%Stage N3</th>
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<tr>
<td><strong>Total sleep time</strong></td>
<td>429 min</td>
<td>5.0%</td>
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<tr>
<td><strong>Time in bed</strong></td>
<td>475 min</td>
<td>%REM</td>
<td>17.0%</td>
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<tr>
<td><strong>Sleep Efficiency</strong></td>
<td>90.3%</td>
<td>Arousal Index</td>
<td>11.3/hr</td>
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<tr>
<td><strong>Lowest satn</strong></td>
<td>88%</td>
<td>PLMI</td>
<td>3.1/h</td>
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<tr>
<td><strong>NREM AHI</strong></td>
<td>4.1/hr</td>
<td>REM AHI</td>
<td>46.8/hr</td>
</tr>
<tr>
<td><strong>AHI</strong></td>
<td>13.8/hr</td>
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</tbody>
</table>
Question 2

What is your impression?

A. Position dependent OSA
B. REM dependent OSA
C. Severe OSA
D. Primary snoring
Case 3

- 55/F with HPN, CAD, dyslipidemic, s/p Coronary bypass surgery.
- Loud snoring, choking episodes during sleep, falls asleep while driving
- BMI 38.5, neck circumference = 42.5 cm, ESS of 16/24.
- Nose: normal turbinates
- Soft palate low, tonsils: Grade 2;
- Mallampati score: 4
Question 3

What type of sleep study will you request?

A. Unattended portable sleep monitoring
B. CPAP titration study
C. Split night study
D. Multiple Sleep Latency test
Portable sleep monitoring

Type III

Type IV
Limitations of Portable Monitoring

- Inability to assess sleep architecture
- REM sleep and/or supine related OSA undetected
- Arousals, RERA’s not detected
- Potential misdiagnosis if comorbid conditions present (ie. COPD, CHF, hypoventilation)

**AHI underestimated**

- In-lab PSG: \( \text{AHI} = \text{apneas} + \text{hypopneas} / \text{hours of sleep} \)
- PM: \( \text{AHI} = \text{apneas} + \text{hypopneas} / \text{hours recording time} \)
The “Split Night” Challenge

- You need to monitor the severity of apnea in the first half of the night to determine if criteria are met.
- You will have a limited amount of time to titrate the patient.
AASM Split Night Rules

- An **AHI of at least 40** is documented during a minimum of 2 hours of diagnostic PSG.

- considered at an AHI of 20 to 40, based on clinical judgment (e.g., if there are also repetitive long obstructions & major desaturations).

- at AHI values below 40, determination of CPAP pressure requirements, based on split-night studies, may be less accurate than in full-night calibrations.
Case 3 cont…

- A split night study was done

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<thead>
<tr>
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<th>Diagnostic</th>
<th>Titration</th>
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<tr>
<td>TST</td>
<td>144.0</td>
<td>450.0</td>
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<tr>
<td>REM mins</td>
<td>15.0</td>
<td>140.0</td>
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<tr>
<td>SWS duration</td>
<td>53.5</td>
<td>21.5</td>
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<tr>
<td>Sleep Efficiency</td>
<td>62.3</td>
<td>90.3</td>
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<tr>
<td><strong>RDI (avg # / hr TST)</strong></td>
<td><strong>81.6</strong></td>
<td><strong>3.4</strong></td>
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<tr>
<td>Minimum SpO2 during sleep (%)</td>
<td>50%</td>
<td>70%</td>
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</table>
Therapy distribution

<table>
<thead>
<tr>
<th>IPAP Level (cmH2O)</th>
<th>EPAP Level (cmH2O)</th>
<th>Total Duration (min)</th>
<th>Sleep Duration (min)</th>
<th>Sleep (%)</th>
<th>REM (%)</th>
<th>Min. SpO2 (%)</th>
<th>Pos 1 S (%) Dur</th>
<th>Snore (% SPT)</th>
<th>Resp Total (A + H + RERA)</th>
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<tbody>
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<td>4</td>
<td>4</td>
<td>23.8</td>
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<td>0.6</td>
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<tr>
<td>Time</td>
<td>HR, BPM</td>
<td>SpO2, %</td>
<td>Stage</td>
<td>CA, sec</td>
<td>OA, sec</td>
<td>MA, sec</td>
<td>HYPO, sec</td>
<td>RERA, sec</td>
<td>IPAP, cmH2O</td>
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<td>9:54:07 PM</td>
<td>11 PM</td>
<td>12 AM</td>
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<td>4 AM</td>
<td>5 AM</td>
<td>6 AM</td>
<td>7 AM</td>
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</table>

Night Hypnogram
Question 4

What is your pressure recommendation?

A. CPAP at 7 cm of water
B. CPAP at 8 cm of water
C. CPAP at 9 cm of water
D. CPAP at 10 cm of water
Titration guidelines

The pressure of CPAP or BPAP selected for patient use following the titration study should reflect control of the patient's obstructive respiration by:

- a low (preferably < 5 per hour) respiratory disturbance index (RDI) at the selected pressure,
- a minimum sea level SpO2 above 90% at the pressure
- and with a leak within acceptable parameters at the pressure
Titration guidelines

- **Optimal titration**
  - reduces RDI < 5 for at least a 15-min duration and
  - should include supine REM sleep at the selected pressure
  - not continually interrupted by spontaneous arousals or awakenings
  - titration duration should be > 3 hr
Question 5

When will the patient need a follow-up PSG?

A. change in weight by 10%
B. recurrence of symptoms
C. intolerance of CPAP therapy
D. All of the above
Follow-up PSG is indicated for

- **After substantial weight loss** (e.g., 10% of body weight) to ascertain whether CPAP is still needed at the previously titrated pressure.

- **After substantial weight gain** (e.g., 10% of body weight) has occurred in patients previously treated with CPAP successfully, who are again symptomatic despite the continued use of CPAP, to ascertain whether pressure adjustments are needed.
Follow-up PSG is indicated for

- **When clinical response is insufficient** or when symptoms return despite a good initial response to treatment with CPAP.

- **Follow-up polysomnography is NOT routinely** indicated in patients treated with CPAP whose symptoms continue to be resolved with CPAP treatment.
Key Points

- PSG is the gold standard in the diagnosis of obstructive sleep apnea & other sleep disorders
- Report must be interpreted in the proper context of patient’s clinical scenario
- When looking at a report examine the quantity and quality of sleep, REM sleep, and position that may affect interpretation
- Optimal titration is reached when RDI<5, oxygen saturation >90% & include supine REM.
NEED COFFEE!!
THANK YOU!!!
Introduction to the Sleep Lab