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Workstation 3

Scoring and Interpreting polysomnography and polygraphy in adults

Renata Riha (Edinburgh, UK)
Raphael Heinzer (Lausanne, CH)
Conflict of interest disclosure

There is no real or perceived conflicts of interest that relate to this presentation.
Workstation 3

- Indications for sleep studies in adults
- Scoring sleep in adults
- Scoring respiratory events during sleep in adults
- Normal values for adult sleep studies and polygraphy
- Indications for treatment of sleep disordered breathing in adults
- Case-based discussion
Indications for sleep studies in adults

- Many sleep disorders can be diagnosed clinically
- BUT many require full evaluation in a sleep laboratory
- PSG (and PG) recommended in sleep-related breathing disorders
- PSG recommended for evaluating parasomnias
- PSG and daytime testing important in evaluating hypersomnia
- Insomnia, RLS and circadian rhythm disturbances - evaluated using other methods
What can PSG show us?

• Measures physiological data during sleep and wake overnight

• Gives information on
  – Duration/amount of sleep
  – Patterns of sleep
  – Quality of sleep
  – Behaviours during sleep
How do we deal with the data?

Scroll through study several times:

– Sleep staging – 30s epoch

– EEG arousals – 30s epoch

– Respiratory events – 2min / 5min epoch
  • 10min epoch to screen for Cheyne-Stokes

– Periodic leg movements – 5min epoch
Scoring sleep in adults

• Based on unit of epoch
  – 30s in most labs

• Each epoch reviewed in turn and assessed as a whole for its sleep stage

• In some situations, the page before or after can influence the decision

• To score a certain stage of sleep at least half the epoch (15 seconds) must be classified as that stage
Scoring Criteria

• Each stage of sleep defined by certain characteristics

• Rechtschaffen and Kales (1968)

• AASM Manual for the Scoring of Sleep and Associated Events (2007)
  – Version 2.0 (2012)
  – Version 2.3 (2016)
## Sleep stages

<table>
<thead>
<tr>
<th>R&amp;K (1968)</th>
<th>AASM (2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 / Wake</td>
<td>W</td>
</tr>
<tr>
<td>1</td>
<td>N1</td>
</tr>
<tr>
<td>2</td>
<td>N2</td>
</tr>
<tr>
<td>3</td>
<td>N3</td>
</tr>
<tr>
<td>4</td>
<td>REM</td>
</tr>
</tbody>
</table>

EA Hill, Edinburgh
Stage W

• Eyes open
  – fast beta activity (>13Hz) on EEG
  – high EMG tone
  – EOG blinks

• Eyes closed
  – alpha waves (8-13Hz) – in some, not all
  – clearest on occipital EEG
Stage W

Eye movements
Stage W
Stage N1

- Theta activity (4-7Hz) on EEG
  - Vertex sharp waves - clearest on central EEG

- Rolling eye movements on EOG
  - often accompanied by ↓ in EMG
Stage N1
Stage N2

- Presence anywhere on page of:
  - Sleep spindle
    - fast burst (0.5–2s) of 12 –15Hz activity
    - clearest on central EEG
  - OR
  - K complex
    - -ve EEG deflection followed by +ve
    - clearest on frontal EEG

- Background - low voltage, mixed frequency EEG
Stage N2

- Keep scoring stage N2 until:
  - change to any other stage (except N1)
  - arousal
  - major body movement
  - No “3-minute rule”
Stage N2

- K complex
- Sleep spindles

From AASM

Low voltage, mixed frequency background EEG
**Stage N3**

- Delta/slow waves in $\geq 20\%$ ($\geq 6s$) of epoch
  - 0-3 Hz, $\geq 75\mu V$ in amplitude

- Do not confuse K complexes with slow waves
  - K complexes separated in time
  - slow waves tend to occur in runs
Stage N3
Stage R

- Bursts of rapid eye movements on EOG
  - Not on every page
- Very low amplitude EMG (atonia)
- Low voltage, mixed frequency EEG
  - Similar to stage N1
- Sawtooth waves
  - Clearest on central EEG
  - Often precede bursts of REMs
- Phasic twitches on EMG
Stage R

- Onset of stage R:
  - first appearance of low voltage, mixed frequency EEG, REMs and low EMG

- Stop scoring REM when there is:
  - change to stage W or stage N3
  - ↑ EMG tone
  - arousal followed by low amplitude, mixed frequency EEG with slow rolling eye movements (N1)
  - major body movement followed by SEMs without a sleep spindle or K complex
  - sleep spindle or K complex present in first 15s of an epoch in absence of eye movements
Stage REM

Burst of rapid eye movements

Loss of muscle tone (atonia)
Scoring respiratory events during sleep in adults

- Apnea (Central, obstructive, mixed)
- Hypopnea (Central, obstructive)
- Respiratory effort related arousals (RERA)

Determination of the duration of the events
AASM recommandations

Sleep–Related Breathing Disorders in Adults: Recommendations for Syndrome Definition and Measurement Techniques in Clinical Research
The Report of an American Academy of Sleep Medicine Task Force

Rules for Scoring Respiratory Events in Sleep: Update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events
Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine

Berry et al. Journal of Clinical Sleep Medicine 2012;8:597-619
How many respiratory events do you see?
According to **Chicago** (AASM 1999) criteria: **6 hypopneas**
According to AASM 2007 (recommended) criteria: 0 events
According to AASM 2013 criteria: 5 hypopneas
Apnea Rules for Adults

AASM 2013 update:

1. drop in peak signal excursion by \( \geq 90\% \) of pre-event baseline using

   **AND**

2. duration of the \( \geq 90\% \) drop in sensor signal is \( \geq 10 \text{ seconds} \)

If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for an apnea, the entire event should be scored as an apnea.

The definition does **NOT** require an associated arterial oxygen desaturation
Central apnea

- No airflow
- No chest or abdominal movements

Obstructive apnea

- No airflow
- Presence of chest and abdominal efforts
Central vs Mixed apnea

- oronasal thermal sensor
- Chest
- Abdomen

1 obstructed breath at the end of apnea

Is this a mixed apnea?

Is this a central apnea?
Hypopnea Rules for Adults

**AASM 2013 update:**

1. Peak signal excursion drop by \( \geq 30\% \) of pre-event baseline using nasal pressure / PAP device flow

2. Duration of this drop \( \geq 10 \) seconds

3. There is a \( \geq 3\% \) oxygen desaturation from pre-event baseline OR the event is associated with an **arousal**
Differences between obstructive and central hypopnoeas

For an obstructive hypopnoea at least one of the following criteria must be met:

- Snoring during the event
- Increased inspiratory flattening of the nasal pressure device compared to baseline
- Thoracoabdominal paradox occurs during the event but not during pre-event breathing

For a central hypopnoea, none of these criteria must be present
Obstructive hypopnea

Central hypopnea
Respiratory event duration

This event should be scored as an apnea and its duration would be 38 seconds.
Respiratory effort related arousals

RERA can be scored if

- There is a sequence of breaths lasting at least 10 seconds characterized by increasing respiratory effort (oesophageal pressure) or by flattening of the inspiratory portion of the nasal pressure leading to arousal

- The sequence of breaths does not meet criteria for an apnea or hypopnea.

- RERA index can be added to AHI to provide RDI (respiratory disturbance index)
Respiratory effort related arousals

EEG

Nasal pressure

Oesophageal pressure

SaO₂

Thorax

Abdomen
Respiratory effort related arousals

EEG

Nasal pressure

SaO₂

Thorax Abdomen
Cheyne-Stokes Respiration in Civil Engineering
Cheyne-Stokes Breathing Rule for Adults (AASM 2013)

1. There are episodes of at least 3 consecutive central apneas and/or central hypopneas separated by a crescendo and decrescendo change in breathing amplitude with a cycle length of at least 40 seconds (typically 45 to 90 seconds).

2. There are 5 or more central apneas and/or central hypopneas per hour associated with the crescendo/decrescendobreathing pattern recorded over a minimum of 2 hours of monitoring.

Note: The duration of CSB (absolute or as a percentage of total sleep time) or the number of CSB events should be presented in the study report.
Cheyne stokes breathing

Typically seen in patients with heart failure and low left ventricular ejection fraction.
Idiopathic or altitude-induced central apneas

Recording of a young mountaineer in Ladakh (3200 m). The main difference with Cheyne-Stokes is the shorter cycle length and the absence of crescendo-decrescendo.
Respiratory polygraphy

Since there are no official scoring rules for polygraphy, the PSG AASM criteria are commonly used for PG

Problems:

- No EEG to determine arousals as scoring criterion for hypopnea

- Total sleep time (to calculate AHI) has to be estimated based on patients’ report or surrogate variables (movements etc…)
PG vs PSG

- **PG can underestimate the AHI**
  
  - Total recording time (PG) is always greater than total sleep time (denominator of the AHI)
  
  - Arousals cannot be detected on PG (less hypopnea can be scored)

- **PG can overestimate the AHI**
  
  - Respiratory events can be scored during wake time PG recordings (no EEG)
Normal values for adult sleep studies and polygraphy

Official apnea-hypopnea index (AHI) severity classification

- Normal: <5/h
- Mild: 5-15/h
- Moderate: 15-30/h
- Severe: >30/h
Prevalence of SDB according to different AHI thresholds in the general population

N= 2162 PSG

AHI >5/h
AHI > 15/h
AHI > 30/h

AASM 1999  AASM 2007  AASM 2012

HypnoLaus sleep cohort 2015
Problems and open questions

1. Should these « official » thresholds be used with all scoring criteria and new recording techniques?

2. Should the same AHI thresholds be used for a 20 years old woman and an 80 years old man?

3. Can the same AHI reference values be used for polygraphy and polysomnography?

Cave: The AHI should not be taken as a positive/negative value but should be seen as a continuum and integrated in the clinical picture of the patient.
Indications for treatment for sleep disordered breathing in adults

1. Daytime sleepiness associated with sleep disordered breathing (SDB)
   a. Other causes of sleepiness should be excluded (sleep curtailment etc …)
   b. There is no direct correlation between AHI and sleepiness severity
   c. If there is no improvement in daytime sleepiness with SDB treatment,
      other causes should be investigated (narcolepsy, idiopathic hypersomnia,
      depression …)

2. Severe SDB in presence of cardiovascular disease or important CV risk factors
   a. The observed blood pressure reduction with CPAP is modest (2-3 mmHg)
   b. The protective effect of SDB treatment as secondary prevention for stroke
      or heart infarct is still debated
Case-based discussion
Case 1

- Man 82 years old
- Heavy snorer
- Witnessed apneas during sleep by bed partner
- Epworth 5/24, no daytime complaints
- Blood pressure 158/90

- Polysomnography: AHI 35/h, obstructive

Shall we recommend treatment?
Case 2

- Man 35 years old
- Heavy snorer
- Epworth 13/24, no obvious cause for sleepiness
- No cardiovascular risk factors or comorbidities

Polygraphy: AHI 9/h, obstructive hypopnea + flow limitations

What would be the next step?
Case 3

- Woman 35 years old
- Occasional snorer
- Epworth 9/24
- Recently diagnosed with depression
- Polygraphy: AHI 22/h, obstructive hypopneas

Shall we recommend a treatment?
Respiratory polygraphy pitfalls
Automatic Analysis

Hypopnea (27.89s)
Apnea Obstructive (40.32s)
Hypopnea (24.75s)
Automatic scoring is not reliable!

Automatic Analysis

Apnea Obstructive (28.42s)  Apnea Obstructive (19.49s)  Apnea Obstructive (17.66s)
How would you score these events on polygraphy?
Periodic legs movement-induced breathing instability
Hypopneas or not?
Periodic limb movements during sleep
Automatic PG report: AHI 50/h
Apnea or hypopnea?

Nasal pressure

SaO2
Apnea or hypopnea?

According to AASM 2013 rule, the whole event should be scored as 28 sec apnea.
1 or 2 hypopnea(s)?
1 or 2 apnea(s)?
Baseline for SpO2? Baseline for nasal pressure?
Baseline for SaO2?  Baseline for nasal pressure?
Is this a hypopnea?

116 seconds

67 seconds

Should there be a maximal duration for hypopnea?
Is this a hypopnea?

> 3 min

Should there be a maximal duration for hypopnea?
How would you score these events on polygraphy?
What is this?

Courtesy Dr N. Petitpierre
Central Sleep Apnoea

- Apnoea associated with a lack of respiratory effort (>10 seconds)

- Diagnosed on PSG
  - primary diagnosis if >=50% of apnoeas are scored as central

- CSA and OSA may co exist
Central apnoea?
Messages

✓ Never trust automatic scoring

✓ Always perform visual analysis and beware of atypical cases

✓ PLMS can induce breathing instability, CPAP does not detect PLMS which may lead to false pressure increases

✓ Cough, talking, sneezing, catathrenia can look like apnea or hypopnea