Interpreting the Pediatric PSG

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Objective

- To understand how polysomnography is used in the diagnosis and management of pediatric sleep disorders

Pediatric PSGs

- PSGs can be performed on children of all ages
- A parent accompanies the child
- Techs are typically 1:1 or 1:2 with patients
- Family may be in the lab from 6 p.m. to 6 a.m.
- A technician will score the study, and a sleep center physician reviews the data and generates a report
Overnight Polysomnography

- EEG (electroencephalogram) to measure and record brain wave activity
- EMG (electromyogram) to record muscle activity such as face twitches, teeth grinding, and leg movements; it also helps in determining the presence of REM stage sleep.
- EOG (electro-oculogram) to record eye movements; these movements are important in determining the different sleep stages, particularly REM stage sleep.
- EKG (electrocardiogram) to record heart rate and rhythm
- Nasal pressure transducer and thermister to record airflow
- End-tidal CO₂ monitor / transcutaneous CO₂ monitor to assess CO₂ levels
- Pulse oximeter to assess oxyhemoglobin saturation
- Snore microphone to record snoring activity
- Respiratory effort belts to evaluate breathing (chest and abdomen)
- Digital audio and video record to assess movements and behaviors
- Expanded EEG montage to capture nocturnal seizures

Not for Everyone

- Not all children are suitable candidates for PSG (e.g. severe autism)
- We estimate level of complexity, with “1” being straightforward versus “3” or “4” for a complex child or difficult titration
- May try ‘desensitization’ for children who are tactile averse, or have high degree of anxiety; tour of the sleep lab may be helpful

5 week old with OSA, periodic breathing; scored by Anders criteria; transcutaneous CO₂ applied
5 week old with trace alternant EEG pattern in quiet sleep; note regular breathing. Paradoxical movement is normal for age.

Scoring Sleep in Infants

- Sleep spindles are usually present in NREM sleep of infants 2-3 months post-term or older
- K complexes are usually present in NREM sleep of infants 4-6 months post-term or older
- Slow wave activity is usually present 4-5 months post-term
- N1, N2, N3 can be scored in most infants 5-6 months post-term
- Therefore, no fixed upper age when Anders’ criteria are no longer used

Scoring an Obstructive Apnea

- Event lasts at least 2 baseline breaths
- \( \geq 90\% \) fall in signal amplitude (thermistor)
- Continued respiratory effort throughout the entire period of absent airflow

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Obstructive Sleep Apnea

- Obstructive apnea index >1 is statistically abnormal (ICSD-2)
- An obstructive AHI >1.5 is considered abnormal:
  - AHI 1.5-5 mild OSA
  - 5-10 mod OSA
  - >10 severe OSA

The degree of desaturation, hypoventilation may modify severity
- OSA is typically REM related or exclusively in REM

Obstructive Sleep Apnea

- May need to intervene urgently for desaturations <70%, hypoventilation with ETCO2 > 70 torr, or AHI >20 (i.e. possible referral to ENT or CPAP titration)
- Sleep architecture typically preserved, as children don’t have many cortical arousals (but may have movement or autonomic arousals)
- Even short apneas may be associated with severe hypoxemia because of the faster RR and lower FRC cf. adults

13 year old girl with severe OSA
Example of severe OSA, with severe desaturations and pervasive paradoxical breathing; saturations drop further with start of REM sleep (120 sec view)

Four month old infant with severe OSA; O2 added at ½ L after 2nd REM period, later increased to 1 liter

Mixed apnea with bradycardia in an infant
Mixed apnea in an older child

Mixed and obstructive apnea in a 7 y.o. boy (120 sec screen)

28 mo old boy
Baseline PSG:
AHI 37.1,
O2 sat nadir 71%

Post-T&A PSG,
2 months later:
AHI 0.4,
O2 sat nadir 95%
Adenotonsillectomy

- Treatment of choice for OSA in pediatrics, particularly young and non-obese
- Can be highly effective
- Children with more severe OSA may be re-studied 6 weeks after surgery
- Patients with residual OSA or who are not surgical candidates go on to CPAP/BiPAP titration

CPAP titration for severe OSA
Periodic Breathing Rule
Score periodic breathing if there are ≥ 3 episodes of central apnea lasting >3 sec separated by ≤ 20 sec of normal breathing

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Periodic breathing in a 2 year old
Periodic Breathing

Periodic breathing comprised 10% of total sleep time

Tachypnea Followed by Apnea in Wakefulness

11 year old girl with Rett Syndrome; PB while asleep was normal

Scoring a Central Apnea

Absent inspiratory effort throughout the event and
- The event lasts 20 sec or more
- The event has a typical 2 breath duration and is associated with an arousal or a ≥3% desaturation

OR,
- The event is associated with a decrease in HR to < 50 bpm for ≥ 5 sec or < 60 bpm for 15 sec (infants under 1 yo only)

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Central apnea following an arousal

Scoring an Hypopnea

If all criteria are met:
• Peak signal excursions drop by ≥ 30% of pre-event baseline using nasal pressure
• The duration of the drop lasts for ≥ 2 breaths
• There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal

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Obstructive hypopnea with desaturation
Obstructive hypopnea followed by arousal (no desaturation)

**Hypoventilation Rule**

Score sleep-related hypoventilation when >25% of TST is spent with CO₂ >50 torr, either arterial PCO₂ or surrogate (transcutaneous PCO₂ or ETCO₂)

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Elevated CO2 from re-breathing (face in pillow)

4 month old with OSA. RR is 26 in SWS. ETCO2 waveform is limited by RR (no plateau). (60 sec view)

15 yo boy with encephalopathy, intractable epilepsy (Depakote, Lamictal, Ativan, PB, and vagal nerve stimulator), referred for evaluation of OSA
120 sec view:
Note synchronous
chin activity and
hypopnea

360 sec view:
Note regular
spacing of events

Hypnagogic Hypersynchrony

30 sec view:
arousal to wake

10 sec view,
Sz montage: repetitive spikes
Right frontal-
central-
temporal regions
Sleep Related Movements

- RLS/PLMS
- Bruxism
- Sleep-related Rhythmic Movement Disorder

6 year old boy. What’s going on? (30 sec screen)
Headbanging—note the frequency is very regular (approx. 1 Hz)

Bruxism—note the increased chin EMG
Behavioral Insomnia: Sleep Onset Association Type

- Child requires parent (or object, situation) to fall asleep; affects initial sleep onset and each awakening; can severely disrupt family
- Treatment:
  - Extinction (‘Ferberizing’)
  - Graduated extinction (weaning parents’ presence)
- Approach is in small steps → aim for success
- Target initial sleep onset first, then night wakings, then naps

Behavioral Insomnia: Limit Setting Type

- Lack of bedtime routine
- No consistent bedtime
- “Curtain Calls”
- Child may fall asleep anywhere in the house

Treatment:
- Apply consistent rules
- Bedtime chart (e.g. 2 books)
- Remove t.v., other technology from bedroom
- Simple rewards for desired behavior
Polysomnography

- The gold standard for diagnosis of obstructive sleep apnea, central sleep apnea, periodic breathing, and nocturnal hypoventilation
- The gold standard for diagnosis of periodic limb movements in sleep
- Valuable in assessing treatment response with these disorders
- Not useful for insomnia issues, unless secondary to an intrinsic sleep disorder

CHOP Sleep Center

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