Respiratory Indications for Polysomnography in Children

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Disclosure

I have no conflict of interest to declare

Abbreviations

• PSG: Polysomnography
• SRBD: Sleep related breathing disorders
• OSA: Obstructive sleep apnea
• ALTE: Apparent life threatening event
• PAP: Positive airway pressure
• NIPPV: Non-invasive positive pressure ventilation
• NOD: Nocturnal oxygen desaturation

Polysomnography

• Electrographic recording of simultaneous physiologic variables during sleep and is currently considered the gold standard for objectively assessing sleep disorders

Pediatric Sleep Study Montage

− EEG - For sleep stages
− EMG – for chin tone and leg movements
− EOG – eye movements
− Nasal pressure
− Oro-nasal thermister
− Airflow
− Chest and abdominal belts/summary – respiratory effort
− Oximetry with waveform
− ETCO2 with waveform
− Snoring microphone
− EKG - heart rate and rhythm
− Body position
− Video

Grigg-Danberger et al, JCSM 2007; 3: 201

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**PSG**

**Indications**
- Respiratory
  - Sleep-related breathing disorders
  - OSA
  - Central sleep apnea
  - Sleep hypoventilation
  - Periodic breathing
  - Sleep hypoxemia
- Non-Respiratory
  - Periodic limb movement of sleep (PLMS)
  - Narcolepsy
  - Nocturnal events
  - Seizures vs. parasomnia
  - REM behavior disorders

**Not indicated**
- Typical Parasomnias
- Insomnia
- Circadian rhythm sleep disorders
- Restless legs syndrome

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- Differentiate benign snoring from snoring associated with OSA
- Assess severity of OSA
- Clarify diagnosis when sx and risk factors are discordant
- Screen children at high risk for OSA (e.g., Down syndrome, achondroplasia)
- Delineate severity of OSA in children at risk for peri- and post-op complications
- CPAP titration

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**AASM level of Recommendations**
- **S** = Standard
  - Generally accepted patient-care strategy reflecting high degree of clinical certainty; implies level 1 or overwhelming Level 2 evidence
- **G** = Guideline
  - Patient-care strategy reflecting moderate degree clinical certainty; implies Level 2 or consensus of Level 3 evidence
- **O** = Option
  - Patient-care strategy reflecting uncertain clinical use; implies inconclusive or conflicting expert opinion

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**AAN evidence grading system for diagnostic tests**
- **Level 1**: Prospective, broad spectrum patients, reference (gold) standard definition, blinded, low risk for bias
- **Level 2**: Prospective, narrow spectrum or retrospective broad spectrum, reference standard, compared to controls, blinded, moderate risk for bias
- **Level 3**: Retrospective, narrow spectrum, reference standard not applied by performer/interpreter of test, moderate high risk for bias
- **Level 4**: Reference standard not applied independently, expert opinion, descriptive case series, very high risk for bias
Utility of these parameters

- AASM expects:
  - Impact on professional behavior, patient outcome, cost
  - Should meet need of most patients in most situations
  - Are not inclusive of all proper method of care or exclusive of other methods of care
  - Interpreted by clinicians with necessary skills to use results meaningfully and recognize artifacts
  - Ultimate judgment must be made by physicians based on clinical situation, available diagnostic tools, treatment options and other resources

Background

- 3500 candidate papers reviewed: 243 included
  - 1967-2000: < 5 papers/yr
  - 2001-2006: 18/yr
  - 2007-2009: 37/yr

Methodology for PSG

- PSG in children should be performed and interpreted in accordance with the 2007 AASM Manual for Scoring of Sleep and Associated Events (S)
- Insufficient data to support unattended in-home testing for clinical (non-research) purposes

Methodology

- Pediatric PSG best tolerated when:
  - Performed with caregiver present
  - Caregiver and child are oriented to sleep lab in advance; may include application of limited number of sensors
  - PSG technologist is experienced and comfortable working with children
  - Sleep lab environment is child-friendly
  - Sleep specialist provides specific guidance and recommendations in advance

Recommendations Against PSG

- Nap (abbreviated) PSG is not recommended for the evaluation of OSAS in children (O)
  - Underestimates prevalence and severity SRBD (3 level 4 and collective expert opinion)
    - Sensitivities 69-75%
    - Specificities 60-100%
- Home oximetry may be specific for OSAS when positive, but low sensitivity (3 papers)
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### Diagnostic Indications for PSG in Sleep Related Breathing Disorders (SRBD)

- Clinical assessment suggests the diagnosis of OSAS in children (S)
- OSAS in children should be diagnosed based on clinical and PSG data
- Clinical evaluation (Hx, PE, audio/visual recordings, questionnaires) alone does not have sufficient sensitivity/specificity to establish the diagnosis

### Correlation with Clinical History

- Snoring/other nocturnal symptoms have inconsistent correlation with PSG findings (11 studies; 6 Level 2; 3 Level 3; 1 Level 4)
  - Sensitivity/selectivity poor in unselected populations of snoring children
    - Brouilette OSA score (1984) misclassified 25%
  - Clinical history not sufficiently accurate, reliable, or stable compared with physiologic (PSG) measurements

### Correlation with Clinical Findings

- Physical features have variable strengths of association with PSG findings (11 studies; 2 Level 2; 3 Level 3; 6 level 4)
  - PE focused on anatomic structures during wakefulness
  - Obesity - strongest association
  - PSG parameters correlated best with combination multiple signs/symptoms (eg: mouth breathing, tonsillar hypertrophy) > individual features
- Clinically significant increase in systolic and diastolic BP associated with AHI > 5; independent of obesity (12 papers)

### Correlation with Other Measures of SRBD

- Audio/video recordings correlated but insufficient for dx (2 level 2 and 2 Level 3)
  - Sensitivity ranges: 71 – 94%
  - Specificity ranges: 52-80%
- Sleep questionnaires (9 studies; 2 Level 2):
  - Low sensitivity/better specificity
  - Poor correlation with PSG findings
  - Insufficient to differentiate primary snoring from OSAS or assess severity
- Subjective sleepiness measures (1 Level 1, 3 Level 2, 4 Level 3, 3 Level 4)
  - Most papers support association sleepiness ratings with abnormal PSG, BUT sleepiness alone does not predict PSG-defined OSAS

### Correlation with Clinical Findings

- Radiographic evaluation (1 Level 2; 2 Level 3; 1 Level 4)
  - Lateral neck x-rays: upper airway narrowing and adenoidal size correlated with PSG OSAS
- Naso-oro-pharyngeal endoscopy (3 Level 3-4) variably correlated with PSG
  - Inclusion bias: studies limited to patients suspected of OSAS

### Diagnostic Indications for PSG in Sleep Related Breathing Disorders

- High risk conditions for OSAS
  1. Obesity associated with SRBD (13-78%), >8yo (9 papers)
    - Significantly higher AHI in obese children (7 studies)
    - Have higher levels of sleepiness (MSLT) (4 studies)
    - Residual OSA more likely to persist post T&A (7 studies)
    - Increased risk for hypertension, metabolic syndrome
  2. Down syndrome (57-100%) (5 level 4)
    - Factors: midfacial hypoplasia, glossoptosis, hypotonia, hypothyroidism
    - Significant SRBD by age 4 yr
  3. Prader-Willi syndrome (93%) (1 Level 3, 6 level 4)
    - GH administration (3 papers); insufficient evidence for routine PSG

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Diagnostic Indications for PSG in Sleep Related Breathing Disorders

4. Neuromuscular disorders
   - Muscular dystrophies (31-53%):
     - NOD and hypercapnia common, esp. in REM
     - Central apneas associated with O2
     - NOD in NREM associated with high risk of death in 2 years
     - Annual PSG with pCO2 monitoring when wheelchair bound (ATS 2004)

5. Cerebral palsy
   - Increased obstructive, central apneas
   - Improvement with T&A

6. Chiari malformation / meningoencephalocele / spina bifida (40 – 60%)
   - 35% obstructive / 25% central
   - OSAS persists post T&A; PAP
   - Central apnea/hypoventilation: supplemental O2, methylxanthines, NPPV

Diagnostic Indications for PSG in Sleep Related Breathing Disorders

• Intermediate risk conditions for OSAS:
  - Prematurity (2 Levels 3 and 4)
  - African American race (3 Level 2; 1 Level 3; 2 Level 4)
  - Increased risk SRBD and residual SRBD post T&A
  - Family history of SDB significant modifier risk (1 Levels 3 and 4)
  - Allergic rhinitis (limited evidence)
  - Systemic hypertension

Children in these intermediate risk groups ought to be queried for signs/symptoms of SRBDs and should undergo PSG if present.

Diagnostic Indications for PSG in Sleep Related Breathing Disorders

• Sickle cell disease (Level 2, 5 Level 4)
  - Low baseline oximetry values, NOD “not unexpected”
  - Inconsistent increased prevalence of OSAS:
    - 36% episodic hypoxemia, improvement post-op
    - 63% AHI > 1
    - No difference SRBD in mild vs. severe SCD
    - Increased risk of AHI (55 vs. 12%)
    - Children with SCD and OSAS have more severe NOD
    - Oximetry alone probably not useful screening method for OSAS

Diagnostic Indications for PSG in Sleep Related Breathing Disorders

1. Primary sleep apnea of infancy (G)
   - No studies of utility of PSG in establishing primary sleep apnea of infancy diagnosis
   - Most diagnosed without PSG (clinical hx/observation)
   - PSG may not be available in NICU settings

2. ALTE: PSG is indicated when there is clinical evidence of a sleep-related breathing disorder in infants who have experienced an ALTE (G) (1 Level 1; 5 Level 2, 4 Level 3, 3 Level 4)
   - Subtle, non-specific PSG abnormalities in some infants significant % normal PSG (Level 2, B Level 3, 3 Level 4)
   - PSG does not assess for altered cardiovascular control
   - Infants with ALTEs may be at increased risk of later SRBD BUT had other risk factors (FH, facial dysmorphism)
   - PSG findings not predictive of ALTE recurrence
3. SIDS: Risk assessment for SIDS (7 level 1)
   - PSG abnormalities in SIDS infants neither sufficiently distinctive nor predictive to support routine use (4 level 1)
   - No papers provide specific guidance regarding PSG in discontinuation apnea monitors
   - ”PSG does not provide sufficiently distinctive or predicative findings to support a routine clinical indication for PSG”

4. Laryngotraheomalacia (1 Level 4)
   - PSG may have clinical utility in evaluation of SDB before and after surgical intervention

5. GERD and SDB: PSG and esophageal pH monitor in suspected GER and SRBD (1 Level 2, 2 Level 3, 4 Level 4)

### Indications for Pre-operative PSG

- **Tonsillectomy**
  - 2nd most common ambulatory surgery
  - 530,000 T&As performed annually in children < 15 yr in US
  - SDB new primary indication for surgery
  - < 10% of children undergo pre-op PSG, fewer post-op

- **Why pre-op PSG?**
  - T&A has small risk of complications (hemorrhage - 0.2-2%)
  - Clinical parameters unreliable for predicting OSAS
  - Certain conditions increase surgical risk
    - Obesita
    - Down syndrome
    - Statin use disease
    - HIE
    - Heart disease
    - Prader-Willi
  - Severe OSAS have increased risk of post-op complications
  - PSG data may be helpful in parental decision-making

### Indications for Post-op PSG

- **Assess residual OSAS in children (S)**
  - Up to 75% obese, 10 to 75% non-obese children
  - 70-90% reduction in severity (OAHI < 5)
  - OSAS can recur 1 year post-op

- **Indications for post-op**
  - Mild OSA but has symptoms of OSA after surgery
  - Moderate to severe OSAS (2 Level 2, 1 Level 3)
  - Certain conditions:
    - Obesita (2 Level 2, 1 Level 3, 3 Level 4)
    - Congenital abnormalities (1 Level 4, 4)
    - Down syndrome
    - Prader-Willi syndrome
    - Myelomeningocele
    - Neuromuscular disorders

### Indications for PSG to Assess response to treatment

- Positive airway pressure titration (S)
- Non-invasive positive pressure ventilation (NIPPV) titration in children neuromuscular disorders (O)

- Treatment of SDB with
  - Rapid maxillary expansion (O)
  - Oral appliances (O)
  - Ventilators (O)

- Children considered for treatment with supplemental oxygen do **not** routinely require PSG: Expert consensus
  - Nocturnal oximetry study generally sufficient
  - PSG may be useful in patients at risk for developing hypoventilation with supplemental O2 (O)

### Indications for PSG in Respiratory Diseases

- Tracheostomy for SDB: May benefit from PSG prior to decannulation (O)
- Respiratory disorders only if there is a clinical suspicion for an accompanying SDB (O)
  - Chronic asthma (1 Levels 3 and 4)
    - Regular clinical screening for signs/symptoms OSAS
  - Cystic fibrosis (2 Level 4)
    - Can be used to initiate and titrate NIPPV
  - Pulmonary hypertension (no studies)
  - BPD (no studies)
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ORL Guidelines

Clinical Practice Guideline: Polysomnography for Sleep-Disordered Breathing Prior to Tonsillectomy in Children

Peter J. Redline, MD, Michael H. Rosenberg, MD, MPH, Lin J. Brooks, MD, Melissa B. Froehley, MD, GAABY, Stephen Kohen, MD, PhD, GaABY, Paul B. Hinchliff, MD, Michael D. Nadelman, MD, Stephen H. Stroemer, DDS, Stephanie Jones, and Peter Robertson, MDPhD

ENT Recommendations - 2011

• Before determining the need for tonsillectomy, the clinician should refer children with SDB for PSG if they exhibit certain complex medical conditions such as:
  — Obesity, Down syndrome, Craniofacial abnormalities, NMD, sickle cell disease, or MPS
• Advocate for PSG prior to tonsillectomy for SDB in children without any of the co-morbidities listed above for whom the need for surgery is uncertain or when there is discordance between tonsillar size on physical examination and the reported severity of SDB

To review guidelines for indications for PSG, when children 2 to 18 years of age are considered for tonsillectomy

What we know!

• “Gold standard”
• Definitive utility in diagnosing SRBD
• Poor correlation between severity of symptoms and PSG indices (e.g. AHI)
• PSG is labor intense study
• Expensive
• Lack of adequately trained pediatric sleep MD

What We Don’t Know!

• Standardization of performance, scoring, interpretation
• Utility of PSG in broad range of pediatric populations
• Utility of PSG in selected pediatric populations
  — Infants < 12 months
  — Patients with chronic lung disease
• Differences in clinical outcomes following T&A with routine PSG
• Clinical utility for therapeutic purposes
  — Optimal timing?
  — Routine use?
• Diagnostic yield differences based on referring clinician type
• Clinical utility of ambulatory PSG

Thank you
References

- Respiratory Indications for Polysomnography in Children: An Evidence-Based Review; Sleep 34;3, 2011; 398A-398AW
- Executive Summary of Respiratory Indications for Polysomnography in Children: An Evidence-Based Review; Sleep 34;3, 2011; 389-98
- Practice Parameters for the Respiratory Indications for Polysomnography in Children; Sleep 34;3, 2011; 379-88
- Clinical Practice Guidelines: Tonsillectomy in Children; Otolaryngology-Head and Neck Surgery; 144; 2011; S1-30