INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) in children is a common disorder, with prevalence estimates of approximately 1-2%. Furthermore, premature infants and children with other conditions including craniofacial disorders, obesity, neuromuscular disorders, Down syndrome, chronic lung disease, sickle cell anemia, central hypoventilation syndromes, and a number of other genetic and metabolic diseases are at higher risk of sleep-disordered breathing. Obstructive sleep apnea syndrome can result in serious morbidity, including neurocognitive disorders such as poor learning, behavioral problems, and attention-deficit/hyperactivity disorder, failure to thrive, cor pulmonale, and even death if untreated in more severe cases (1, 2, 3). In addition, there are high economic costs of untreated OSAS in children (4).

The primary treatment for obstructive sleep apnea in children is adenotonsillectomy. Survey data of otolaryngologists have shown that most children in the United States who undergo adenotonsillectomy are evaluated primarily by office-based, sleep-related history in 93% of the cases, with objective testing in less than <10% of the cases (5). Yet, systematic reviews have indicated that clinical history and physical examination are not reliable for diagnosing obstructive sleep apnea in children (1, 2, 6).

The American Thoracic Society has published a consensus statement to define the indications for evaluating breathing during sleep in children and adolescents, standards for the indications, techniques and interpretation of polysomnography for evaluating breathing disorders in children and adolescents, and to identify areas where the knowledge base is lacking and will require research in order to establish recommendations (7). The American Academy of Pediatrics has developed an evidence- and consensus-based practice guideline for the diagnosis and management of childhood obstructive sleep apnea syndrome, including diagnostic studies (1, 2). Abbreviated and other screening studies have been evaluated for children with sleep disorders. The purpose of this Position Paper is to review the available diagnostic studies for evaluation of children with sleep disorders. The specifications, indications, and limitations will be discussed.

POLYSOMNOGRAPHY

Overnight polysomnography (PSG) is the best available diagnostic test for OSAS. However, it is not widely available and PSG diagnostic criteria for morbidity and correlation with adverse outcomes have not been definitively established. Nonetheless, it remains the “gold standard” for evaluation of OSAS, including evaluation of suspected upper airway obstruction in children with craniofacial anomalies, bronchopulmonary dysplasia, other chronic lung diseases, neuromuscular disease, obesity, Down syndrome, sickle cell anemia, and other genetic and metabolic disorders. In addition, polysomnography may be indicated for alveolar hypoventilation syndromes, infants with suspected abnormal respiratory control or recurrent
isolated bradycardia without central apnea, nocturnal asthma with suspicion of gastroesophageal reflux (PSG with pH monitoring), assessment of neuromuscular patients for possible initiation as well as adequacy of ongoing home respiratory support, including supplemental oxygen, CPAP, or assisted ventilation (1, 2, 7, 8).

Polysomnography simultaneously measures multiple physiological variables including sleep state, respiration, gas exchange, snoring, cardiac rhythm, and muscle activity. Behavioral aspects of sleep may also be ascertained. This study should be conducted in an environment that is least disruptive to the child’s normal sleep pattern. Consensus guidelines for the performance of pediatric polysomnography, including laboratory setting, supervision, personnel, scoring and reporting have been established (7). Several studies on normal pediatric polysomnographic data are available, for some age and ethnic groups (21-23).

Measurements of polysomnography include the following (7):

Respiratory parameters
1. Respiratory effort, to detect paradoxical inspiratory rib cage movement and to identify obstructive apnea or hypoventilation (chest wall, abdominal movements by strain gauges, respiratory inductance plethysmography [RIP] or magnetometers)
2. Airflow measurements (eg, oronasal thermistors, thermocouples, nasal air pressure and/or capnography, snoring recording)
3. Ventilation (end-tidal CO₂, transcutaneous CO₂ [PtcCO₂])
4. Oxygenation (pulse oximetry [SpO₂], transcutaneous oxygen [PtCO₂]

Nonrespiratory variables
1. Sleep staging (electroencephalogram [EEG], electrooculogram [EOG], chin electromyelogram (EMG), and body position monitor)
2. Electrocardiogram (ECG) to evaluate cardiac rate and rhythm disturbances
3. Electromyelogram (EMG) over the anterior tibialis and motion sensors to detect and quantitate movement arousals
4. (Optional) Audiovisual recording

Indications for polysomnography (1, 2, 3, 7, 8):
1. Assessment of obstructive sleep apnea syndrome in otherwise apparently healthy children
2. Repeat PSG in children with ongoing symptoms of obstructive breathing during sleep despite surgical intervention
3. Assessment and titration of patient with obstructive sleep apnea syndrome treated with non-invasive ventilation (Continuous positive airway pressure [CPAP] or Bi-level positive airway pressure [BiPAP])
4. Assessment of sleep-disordered breathing with suggestive symptoms and signs of airway obstruction in patients with other medical conditions, including craniofacial disorders, specifically midfacial hypoplasia and retro- or micrognathia, Down syndrome (Trisomy 21) and other genetic and metabolic disorders, laryngomalacia, neuromuscular conditions, obesity, and sickle cell anemia, bronchopulmonary dysplasia
5. PSG with esophageal pH monitoring to assess the relationship of gastroesophageal reflux with respiratory events such as nocturnal asthma, cough, apnea or hypoxemia
6. Neuromuscular, including cerebral palsy, patients with impaired respiratory function at risk for central and/or obstructive apnea or hypoventilation
7. Assessment of patients with progressive chronic respiratory failure, such as neuromuscular disease and cystic fibrosis, for planning, implementation, and monitoring of nocturnal assisted ventilation
8. Alveolar hypoventilation syndromes, for assessment of need for, as well as monitoring of, adequacy of artificial ventilation
9. Certain infants with a history of apnea in whom obstructed apnea or abnormal ventilatory control is highly suspected

Limitations of polysomnography (1, 2, 3, 6, 7, 16):
1. While consensus guidelines for performance, scoring, and reporting of polysomnography in children have been established. Normative data have recently been published
2. There remain issues of limited standardization of equipment
3. Shortage of facilities able to perform pediatric polysomnography
4. Limited correlation of polysomnographic parameters with adverse outcomes or ability to predict morbidity

ABBREVIATED POLYSOMNOGRAPHY

Daytime nap polysomnography
Nap polysomnography is polysomnography performed during a shorter period of a daytime nap. In general, more severe abnormalities are seen with in overnight than nap studies performed on the same patients.

Indication:
1. Screening test for OSAS

Limitations:
1. It may underestimate severity, but is useful if positive.
2. Compared to polysomnography, it has a positive predictive value of 77-100% and a negative predictive value of 17-49% (1).

Overnight oximetry
Overnight pulse oximetry during sleep with trend graph recordings has been utilized for evaluation of OSAS in otherwise healthy children. However, comparison with PSG has yielded conflicting results. Pulse oximetry manually scored for desaturation showed excellent positive predictive (97%) but poor negative predictive (47%) probability. However, oximetry utilizing an automatic scoring algorithm for desaturation index showed poor correlation (9, 10). Motion sensing sensitive oximetry may improve the reliability of this technique as well as the quality of PSG studies (11). Thus, while oximetry is more readily available and easier to use, it is limited by its low negative predictive value, and by the limitations of oximetry performance (19). Beyond OSAS evaluation, oxygen saturation studies are utilized for evaluation of oxygenation in various chronic lung disorders.

Indications:
1. Patients with chronic lung disorders, such as bronchopulmonary dysplasia and cystic fibrosis, to assess adequacy of oxygenation and titration of oxygen therapy
2. Screening test for OSAS
Limitations:
1. Technical limitations, especially due to motion artifact
2. May have high positive predictive value, but low negative predictive value
3. Limited correlation studies

**Other unattended monitoring**

Beyond oximetry, more parameters in unattended sleep monitoring in home have been evaluated in children, though only in small studies. These have included non-commercial PSG and one recent study in children with the POLY-MESAM. Compumedics PS-2. And Embleetta PDS systems (2, 12, 17, 18).

**Indication:**
1. Screening for OSAS

**Limitations:**
1. Sensitivity and specificity compared to PSG need to be established based on the specific equipment being used. A wide range has been reported in the limited pediatric studies.

**OTHER TECHNIQUES FOR ASSESSMENT OF SLEEP-DISORDERED BREATHING**

**Audio taping and videotaping**

Variable methods of audiotaping and videotaping have suggested that these modalities may be helpful, but have not been adequately investigated with discrepancies in results from different centers. The AAP Committee for the Practice Guideline was unable to reach consensus on acceptable rates for false-negative and false-positive results for these alternatives to PSG (2).

**Questionnaires, Clinical Assessment**

Several studies have attempted to utilize questionnaires or other clinical criteria to substitute for PSG. However, many of them have not correlated their results with PSG. Several studies have attempted correlation with PSG, but low sensitivity and specificity have been noted (1, 2, 6). One study has shown some specificity—though low sensitivity—of a screening questionnaire compared with an unattended home polysomnogram (17). A retrospective study has suggested that a standardized questionnaire may be more predictive of OSA-related neurobehavioral morbidity and response to adenotonsillectomy compared with PSG (20). On the other hand, there is a lack of a universally accepted validated PSG threshold for clinically significant disease. A recent study evaluated children with a clinical assessment score suggestive of OSAS but with a negative PSG. Those who underwent tonsillectomy and adenoidectomy had improved scores compared to children who did not undergo surgery. The authors concluded that clinical assessment could be useful in diagnosing upper airway obstruction (13).

**Radiological evaluation**

Recent experiences with cine magnetic resonance imaging (MRI) and respiratory-gated MRI have shown promising results (14, 15). MRI may be especially helpful for children with persistent obstructive sleep apnea despite tonsillectomy and adenoidectomy and other surgeries to help define the level(s) of airway obstruction (14).
CONCLUSIONS

Sleep-disordered breathing is a common problem in children. However, there are controversies in the diagnosis and treatment of this condition. In general, history and physical examination have been shown to be inadequate in discriminating between snoring and obstructive sleep apnea syndrome. Low cost screening methods with both high sensitivity and high specificity are not available. Screening methods such as nap polysomnography and overnight oximetry, in general, may be useful if positive in discriminating primary snoring from obstructive sleep apnea syndrome.

The most comprehensive laboratory assessment tool currently available for sleep ventilatory abnormalities is polysomnography. Many recommendations and guidelines on use of polysomnography are based on limited evidence and consensus (23). In addition, there are issues regarding normative data, diagnostic criteria, and thresholds for morbidity for polysomnography. Nonetheless, it is the most objective method available and currently is considered the “gold standard” for the evaluation of children with sleep-disordered breathing (1, 2, 3, 6, 7, 8, 16).

REFERENCES

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Visit the ALA of California website for state activities & advocacy issues at www.CaliforniaLung.org

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