

Practice Parameters for the Respiratory Indications for Polysomnography in Children

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Background: There has been marked expansion in the literature and practice of pediatric sleep medicine; however, no recent evidence-based practice parameters have been reported. These practice parameters are the first of 2 papers that assess indications for polysomnography in children. This paper addresses indications for polysomnography in children with suspected sleep related breathing disorders. These recommendations were reviewed and approved by the Board of Directors of the American Academy of Sleep Medicine.

Methods: A systematic review of the literature was performed, and the American Academy of Neurology grading system was used to assess the quality of evidence.

Recommendations for PSG Use:

1. Polysomnography in children should be performed and interpreted in accordance with the recommendations of the AASM Manual for the Scoring of Sleep and Associated Events. (Standard)
2. Polysomnography is indicated when the clinical assessment suggests the diagnosis of obstructive sleep apnea syndrome (OSAS) in children. (Standard)
3. Children with mild OSAS preoperatively should have clinical evaluation following adenotonsillectomy to assess for residual symptoms. If there are residual symptoms of OSAS, polysomnography should be performed. (Standard)
4. Polysomnography is indicated following adenotonsillectomy to assess for residual OSAS in children with preoperative evidence for moderate to severe OSAS, obesity, craniofacial anomalies that obstruct the upper airway, and neurologic disorders (e.g., Down syndrome, Prader-Willi syndrome, and myelomeningocele). (Standard)
5. Polysomnography is indicated for positive airway pressure (PAP) titration in children with obstructive sleep apnea syndrome. (Standard)
6. Polysomnography is indicated when the clinical assessment suggests the diagnosis of congenital central alveolar hypoventilation syndrome or sleep related hypoventilation due to neuromuscular disorders or chest wall deformities. It is indicated in selected cases of primary sleep apnea of infancy. (Guideline)
7. Polysomnography is indicated when there is clinical evidence of a sleep related breathing disorder in infants who have experienced an apparent life-threatening event (ALTE). (Guideline)
8. Polysomnography is indicated in children being considered for adenotonsillectomy to treat obstructive sleep apnea syndrome. (Guideline)

9. Follow-up PSG in children on chronic PAP support is indicated to determine whether pressure requirements have changed as a result of the child's growth and development, if symptoms recur while on PAP, or if additional or alternate treatment is instituted. (Guideline)
10. Polysomnography is indicated after treatment of children for OSAS with rapid maxillary expansion to assess for the level of residual disease and to determine whether additional treatment is necessary. (Option)
11. Children with OSAS treated with an oral appliance should have clinical follow-up and polysomnography to assess response to treatment. (Option)
12. Polysomnography is indicated for noninvasive positive pressure ventilation (NIPPV) titration in children with other sleep related breathing disorders. (Option)
13. Children treated with mechanical ventilation may benefit from periodic evaluation with polysomnography to adjust ventilator settings. (Option)
14. Children treated with tracheostomy for sleep related breathing disorders benefit from polysomnography as part of the evaluation prior to decannulation. These children should be followed clinically after decannulation to assess for recurrence of symptoms of sleep related breathing disorders. (Option)
15. Polysomnography is indicated in the following respiratory disorders only if there is a clinical suspicion for an accompanying sleep related breathing disorder: chronic asthma, cystic fibrosis, pulmonary hypertension, bronchopulmonary dysplasia, or chest wall abnormality such as kyphoscoliosis. (Option)

Recommendations against PSG Use:

16. Nap (abbreviated) polysomnography is not recommended for the evaluation of obstructive sleep apnea syndrome in children. (Option)
17. Children considered for treatment with supplemental oxygen do not routinely require polysomnography for management of oxygen therapy. (Option)

Conclusions: Current evidence in the field of pediatric sleep medicine indicates that PSG has clinical utility in the diagnosis and management of sleep related breathing disorders. The accurate diagnosis of SRBD in the pediatric population is best accomplished by integration of polysomnographic findings with clinical evaluation.

Keywords: Polysomnography, pediatric, indications, clinical utility, sleep related breathing disorders, obstructive sleep apnea syndrome

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1.0 INTRODUCTION

Assessment for sleep disorders in children has long relied on a comprehensive history and physical exam. In certain conditions, most commonly sleep related breathing disorders (SRBD), polysomnography (PSG) was performed as an adjunctive tool to aid in the diagnosis. PSG also has been used to evaluate abnormal sleep related movements and behaviors as well as part of the diagnostic assessment for narcolepsy. Because PSG is relatively expensive, time consuming, and not consistently applied by pediatric physicians, it is important to understand its strengths, limitations, and clinical utility in children.

Over the past 30 years, pediatric sleep medicine has exponentially advanced in terms of improved awareness of pediatric sleep disorders and the development of many important technical tools. The early data supporting the clinical utility of PSG were limited because of inconsistency in polysomnographic criteria for SRBDs. Clinical guidelines regarding indications for pediatric PSG based on these early data were published by professional organizations,^{1,2} but these older publications were largely consensus-based due to a paucity of evidence-based data.

In 2007 the AASM commissioned a task force to review the literature published on the indications for PSG in children. Because the task force identified such a large number of publications, it divided the project into 3 separate review papers: (1) the respiratory indications for PSG; (2) the non-respiratory indications for PSG; and (3) the indications for PSG in children with attention deficit hyperactivity disorder (ADHD) or autistic spectrum disorder (ASD). It should be noted that in 2009 the SPC changed its grading system to the GRADE methodology, redefining criteria for Standards, Guidelines, and Options to be consistent with GRADE specifications.³ Because this project began in 2007, the older grading process in use at that time was used to grade the evidence.

This parameter paper focuses on the respiratory indications for PSG. It is based on a comprehensive review of the literature to evaluate the validity and reliability of PSG and to determine its clinical utility for assessment and management of various respiratory disorders. It highlights pediatric respiratory disorders with a high prevalence of polysomnographic abnormalities and addresses various treatment modalities such as surgery and positive airway pressure.

2.0 METHODS

The Standards of Practice Committee of the AASM, in conjunction with specialists and other interested parties, developed these practice parameters based on the accompanying review paper.⁴ A task force of content experts was appointed by the AASM in 2007 to review and grade evidence in the scientific literature regarding the validity, reliability, and clinical utility of PSG in pediatric sleep disorders. In most cases recommendations are based on evidence from studies published in the peer reviewed literature or on generally accepted patient care strategies. When scientific data were absent, insufficient or inconclusive, the Rand/UCLA Appropriateness Method was used to develop consensus recommendations by identifying the collective opinion of the SPC and task force. The Rand/UCLA Appropriateness Method combines the best available scientific evidence with the collective judgment of experts to yield statements regarding the appropriateness of performing procedures.

In particular, it involves development of a list of specific indications derived from the scientific evidence. Completion of rating sheets that evaluated the appropriateness of these indications was conducted in 2 rounds by members from both the SPC and task force. Based on these ratings, indications were classified as appropriate, uncertain, or inappropriate. Indications that were classified as appropriate were used to develop these recommendations; indications that were uncertain or inappropriate were rejected.

The Board of Directors of the AASM approved these recommendations. All members of the AASM Standards of Practice Committee and Board of Directors completed detailed conflict-of-interest statements and were found to have no conflicts of interest with regard to this subject.

These practice parameters define principles of practice that should meet the needs of most patients in most situations. These guidelines should not, however, be considered inclusive of all proper methods of care or exclusive of other methods of care reasonably directed to obtaining the same results. The ultimate judgment regarding propriety of any specific care must be made by the physician, in light of the individual circumstances presented by the patient, available diagnostic tools, accessible treatment options, and resources.

The AASM expects these guidelines to have an impact on professional behavior, patient outcomes, and, possibly, health care costs. These practice parameters reflect the state of knowledge at the time of publication and will be reviewed, updated, and revised as new information becomes available. This parameter paper is referenced, where appropriate, using square-bracketed numbers to the relevant sections and tables in the accompanying review paper, or with additional references at the end of this paper. For this paper, the Standards of Practice Committee decided to use an evidence grading system developed by the American Academy of Neurology (AAN) for assessment of diagnostic tests. The system involves 4 tiers of evidence, with Level 1 studies judged to have a low risk of bias and Level 4 studies judged to have a very high risk of bias. Table 1 describes the essential features of the evidence grading system used by the task force. Definitions of levels of recommendations used by the AASM appear in Table 2.

3.0 RECOMMENDATIONS

3.1 Methodology

3.1.1 Polysomnography in children should be performed and interpreted in accordance with the recommendations of the AASM Manual for the Scoring of Sleep and Associated Events. (Standard)

A detailed evidence-based and consensus-based review of PSG was conducted during development of the AASM Manual for the Scoring of Sleep and Associated Events under the aegis of the AASM Scoring Manual Steering Committee.⁷ This document specifies the optimal equipment for PSG and standardizes the scoring of events. The SPC considers this the standard of practice, and therefore did not conduct a separate, independent review for this practice parameter.

In the opinion of the task force, PSG is best tolerated by the child and parent under the following conditions: (a) when PSG is performed with the caretaker present; (b) when the

parent and child have been oriented to the sleep laboratory in advance, including, in some cases, application of a limited number of sensors to illustrate the procedure to the child; (c) when the PSG technologist is experienced and comfortable in dealing with children in the sleep laboratory environment that is child-friendly; and (d) when the sleep specialist provides specific guidance and recommendations in advance of the PSG with regard to the child's care during the night.

Unattended testing outside the sleep laboratory in children has been used predominantly in research settings. There is a paucity of research comparing it to traditional in-laboratory attended sleep studies or other objective clinical outcomes, and there are insufficient data upon which to base reliable clinical recommendations for children at this time.

3.2 Diagnostic Indications for Polysomnography in Sleep Related Breathing Disorders

3.2.1 Polysomnography is indicated when the clinical assessment suggests the diagnosis of obstructive sleep apnea syndrome in children. [Review Section 4.2.1] (Standard)

3.2.2 Polysomnography is indicated when the clinical assessment suggests the diagnosis of congenital central alveolar hypoventilation syndrome or sleep related hypoventilation due to neuromuscular disorders or chest wall deformities. It is indicated in selected cases of primary sleep apnea of infancy. (Guideline)

Obstructive sleep apnea syndrome should be diagnosed based upon clinical and polysomnographic criteria. This parameter is based on an extensive literature review conducted by the Indications for PSG in Children task force.

The task force found that clinical evaluation alone does not have sufficient sensitivity or specificity to establish a diagnosis of OSAS. Clinical parameters such as history [4.2.1.1.1, 4.2.1.1.3, 4.2.1.1.4.1], physical examination [4.2.1.1.5], audio or visual recordings [4.2.1.1.2], and standardized questionnaires [4.2.1.1.3] did not consistently identify the presence or absence of OSAS when compared with PSG. Snoring and other nocturnal symptoms in 2 Level 1,^{8,9} 4 Level 2,¹⁰⁻¹³ 11 Level 3,¹⁴⁻²⁴ and 18 Level 4²⁵⁻⁴² studies showed inconsistent correlations with respiratory parameters of PSG. Physical features of children evaluated in 11 papers (2 Level 2^{11,13}; 3 Level 3^{23,24,43}; 6 Level 4)^{25,40,41,44-46} showed variable strengths of association with respiratory PSG parameters with obesity demonstrating the strongest association (see below). Polysomnographic parameters correlated best with a combination of multiple signs and

Table 1—Levels of evidence⁵

Level	Description
1	Evidence provided by a prospective study in a broad spectrum of persons with the suspected condition, using a reference (gold) standard for case definition, where test is applied in a blinded fashion , and enabling the assessment of appropriate test of diagnostic accuracy. All persons undergoing the diagnostic test have the presence or absence of the disease determined. Level 1 studies are judged to have a low risk of bias.
2	Evidence provided by a prospective study of a narrow spectrum of persons with the suspected condition, or a well designed retrospective study of a broad spectrum of persons with an established condition (by " gold standard ") compared to a broad spectrum of controls , where test is applied in a blinded evaluation, and enabling the assessment of appropriate tests of diagnostic accuracy. Level 2 studies are judged to have a moderate risk of bias.
3	Evidence provided by a retrospective study where either person with the established condition or controls are of a narrow spectrum , and where the reference standard, if not objective, is applied by someone other than the person that performed (interpreted) the test . Level 3 studies are judged to have a moderate to high risk of bias.
4	Any study design where test is not applied in an independent evaluation or evidence is provided by expert opinion alone or in descriptive case series without controls . There is no blinding or there may be inadequate blinding . The spectrum of persons tested may be broad or narrow . Level 4 studies are judged to have a very high risk of bias.

Table 2—AASM levels of recommendations

Term	Definition
Standard	This is a generally accepted patient-care strategy that reflects a high degree of clinical certainty and generally implies the use of Level 1 evidence or overwhelming Level 2 evidence.
Guideline	This is a patient-care strategy that reflects a moderate degree of clinical certainty and implies the use of Level 2 evidence or a consensus of Level 3 evidence.
Option	This is a patient-care strategy that reflects uncertain clinical use and implies inconclusive or conflicting evidence or conflicting expert opinion.

Adapted from Eddy⁶

symptoms rather than for any individual parameter.^{13,24} Audio or video recordings correlated with PSG respiratory parameters, but 2 Level 2^{11,47} and 2 Level 3^{48,49} studies showed they were not sufficient to establish a diagnosis of OSAS. Pediatric sleep questionnaires were evaluated in 9 articles in children referred for snoring, including 2 with Level 2 evidence,^{10,50} 3 with Level 3 evidence,^{14,51} and 4 with Level 4 evidence.^{27,34,37,41} The 2 Level 2 studies showed low sensitivities for questionnaires to predict polysomnographic evidence of OSAS with better specificities but were still insufficient to differentiate primary snoring from OSAS. Two of the 3 level 3 studies and all of the level 4 studies showed insufficient correlation between sleep questionnaires and PSGs.

The task force found that PSG in children is a reliable and valid measure of the presence of OSAS. Test-retest reliability, or consistency of results across multiple nights of polysomnographic testing, was demonstrated in 1 Level 2,⁵² 2 Level 3,^{18,53} and 1 Level 4⁵⁴ studies. There were no studies designed to test interrater reliability for scoring PSGs in children. Test-retest validity for PSG, or movement of various PSG parameters in the

expected direction after a therapeutic intervention for OSAS, was robust as demonstrated in all 45 studies [4.2.1.1.10].

Convergent validity, or whether PSG and an independent measure both change consistently in the presence of OSAS, was extensively evaluated, including objective [4.2.1.1.4.2] and subjective sleepiness [4.2.1.1.4.1], radiographic evaluation [4.2.1.1.6], neurocognitive and psychological evaluation [4.2.1.1.7], blood pressure [4.2.1.1.8], and quality of life measures [4.2.1.1.9]. Some, but not all, of these measures demonstrated convergent validity with PSG.

Additionally, there was clinical consensus by experts that the PSG is necessary to diagnose congenital central alveolar hypoventilation syndrome, sleep related hypoventilation due to chest wall disorders, and sleep related hypoventilations due to neuromuscular disorder, for which there was also low level evidence.⁵⁵⁻⁶³ There was also clinical consensus by experts that PSG is necessary in selected cases to diagnose primary sleep apnea of infancy when other medical disorders have been ruled out. Patients with CCHS and primary sleep apnea of infancy often present as neonates in the Neonatal Intensive Care Unit, where PSG may not be available. These recommendations are consistent with the recommendations outlined in the ICSD-2 Manual.⁶⁴

Lastly, the task force identified certain conditions associated with an elevated prevalence of SRBD including OSAS. The clinician should consider PSG in children with the following conditions if there is even the slightest suspicion of SRBD. A high prevalence of SRBD has been reported in children with obesity^{13,65-71} (13%⁶⁷ to 78%⁶⁵) [4.2.2.1], Down syndrome^{37,72-74} (57%³⁷ to 100%⁷⁴) [4.2.2.8.1.1], Prader-Willi syndrome⁷⁵⁻⁸⁰ (93%⁷⁵) [4.2.2.8.1.2], neuromuscular disorders⁵⁵⁻⁶³ (53% in one study of children with Duchenne Muscular Dystrophy⁵⁶) [4.2.2.8.4], Chiari malformations and myelomeningocele⁸¹⁻⁸⁴ (60% in one series of children with CM⁸⁴) [4.2.2.8.4], and craniofacial anomalies that obstruct the upper airway^{32,38,85-87} (48% in children with achondroplasia,⁸⁵ 76% in a group of infants with Pierre Robin sequence,⁸⁶ and 50% to 91% in 2 small series of craniofacial dysostoses^{32,87}) [4.2.2.8.2]. Obesity was identified as an independent risk factor for having SRBD. Furthermore, SRBD was identified as an independent risk factor for hypertension,^{20,88-96} suggesting that the clinician should evaluate children who present with hypertension for the possibility of underlying SRBD.

Children in the following categories have an intermediate level of risk for OSAS: those with history of prematurity^{25,97-99} (prevalence of OSAS of 7.3%)⁹⁷ [4.2.2.2], African American race^{34,100-102} (conflicting data) [4.2.2.3], family history of SRBD^{102,103} (sparse data) [4.2.2.4], and allergic rhinitis^{101,102,104} (not well defined) [4.2.2.5]. Children in these intermediate risk groups ought to be queried for signs or symptoms of SRBDs, and should undergo PSG if present.

Overall, the above data on SRBD prevalence and disease associations included 1 Level 1,⁶⁵ 6 Level 2,^{13,86,88-90,100} 17 Level 3,^{20,57,60,61,66,67,70,76,84,85,91-93,95,97,98,102} and 32 Level 4 studies.^{25,32,34,37,38,55,56,58,59,62,63,68,69,71-75,77-83,87,94,96,99,101,103,104}

In summary, high quality data demonstrate that PSG is indicated for the diagnosis of OSAS in children both because clinical parameters alone lack reliability to correctly classify disease and because PSG is a valid and reliable clinical tool. PSG is

also indicated for the diagnosis of sleep related hypoventilation due to neuromuscular or chest wall deformities and congenital central alveolar hypoventilation syndrome and in selected cases of primary sleep apnea of infancy, with the realization that some of these patients will be in a NICU and not have access to polysomnography; these conclusions are based less on evidence than on a consensus of expert opinion. Children should be diagnosed with SRBDs by an integration of clinical evaluation and PSG. In addition, certain clinical conditions, as delineated above, are associated with a high prevalence of SRBD. These patients should be screened for symptoms and signs of SRBD and undergo PSG if present.

3.2.3 Nap (abbreviated) polysomnography is not recommended for the evaluation of obstructive sleep apnea syndrome in children. [Review Section 4.2.1.3] (Option)

Three Level 4 studies^{74,105,106} in children demonstrated that nap PSG is not as reliable as overnight PSG for identifying SRBD [4.2.1.3] and underestimated the prevalence and severity of SRBD, with sensitivities ranging from 69% to 75% and specificities from 60% to 100%. This recommendation is based on these limited studies and collective expert opinion using the Rand/UCLA Appropriateness Method.

3.2.4 Polysomnography is indicated when there is clinical evidence of a sleep related breathing disorder in infants who have experienced an apparent life-threatening event (ALTE). [Review Sections 4.2.4.4, 4.2.4.6] (Guideline)

Four Level 2,^{52,107-109} 8 Level 3,^{22,110-116} and 3 Level 4 studies^{35,117,118} [4.2.4.4, 4.2.4.6] showed subtle, nonspecific PSG abnormalities in some infants who had experienced an ALTE. The PSG findings were not predictive of recurrence of ALTE. Studies of infants who eventually succumbed to sudden infant death syndrome (SIDS) (4 Level 3)^{22,111,113,114} demonstrated PSG abnormalities that were neither sufficiently distinctive nor predictive to support routine use of PSG for children at risk for SIDS. Finally, 2 low level studies^{109,116} showed that infants who had experienced an ALTE may be at increased risk to develop SRBD. These infants, however, had other risk factors for SRBD, such as a family history of SRBD or facial dysmorphism. Clinical suspicion of SRBD in a patient with ALTE should prompt consideration of PSG.

3.3 Indications for Preoperative Polysomnography

3.3.1 Polysomnography is indicated in children being considered for adenotonsillectomy to treat obstructive sleep apnea syndrome. [Review Section 4.2.3] (Guideline)

Adenotonsillectomy (AT) is commonly performed as a first-line treatment of OSAS in children, yet the diagnosis of OSAS is often based on clinical parameters alone.¹¹⁹ The task force reviewed the literature to determine the clinical utility of PSG to confirm the diagnosis of OSAS prior to AT. Whether or not a PSG prior to AT has clinical utility is important for some of the following issues (see review paper for a more complete discussion):

(1) AT is a surgical procedure with a small risk of hemorrhage, infection, upper airway compromise, and pain, and should only be performed if necessary.

(2) Clinical parameters may be unreliable for predicting OSAS.

(3) Children with certain medical disorders are at higher surgical risk (e.g., sickle cell anemia, HIV, coagulopathies, congenital heart disease).

(4) Children with severe OSAS have a higher risk for certain postoperative complications including respiratory compromise.

The task force identified 30 papers pertaining to the clinical utility of PSG prior to AT. Twenty-three of these papers were referenced previously as they demonstrated test-retest validity of PSG in the setting of AT.

First the task force reviewed the literature to determine whether PSG prior to AT correlated with symptoms or physical features of SRBD. As detailed above, history and physical examination were not always reliable predictors of SRBD in children [4.2.1.1.1, 4.2.1.1.3, 4.2.1.1.4.1, 4.2.1.1.3, 4.2.1.1.5]. Three Level 3 papers^{18,23,43} showed the limitations of history and physical examination for diagnosing OSAS in children specifically scheduled for AT. In 1 Level 2¹¹ and 2 Level 4^{26,41} studies, the authors concluded that a negative PSG did not rule out clinically significant SRBD that may respond to AT; however, all 3 demonstrate that as one changes the cut-off of a polysomnographic definition of OSAS to be more in-line with the recommendation in the ICSD-2, the percentage of PSG-positive subjects increases, improving the clinical utility of PSG.

To further establish clinical utility of PSG prior to AT, the task force reviewed the literature to determine whether PSG identified those children likely to develop perioperative complications. Ten papers addressed the clinical utility of PSG for assessment of perioperative risk of respiratory complications related to AT in children. One Level 2,¹²⁰ 1 Level 3,¹²¹ and 4 Level 4 studies¹²²⁻¹²⁵ showed a positive correlation between PSG measures of OSAS severity and postoperative respiratory complications. In 1 study, respiratory complications occurred as late as the first postoperative night¹²⁴ and in another, as long as 14 hours¹²⁵ after surgery. In 2 Level 4 studies,^{126,127} children without significant comorbid diseases who had no or mild abnormalities on preoperative PSG were likely to have an uncomplicated postoperative course. Although in 2 Level 4 studies^{30,128} preoperative PSG did not identify those who later developed perioperative complications, the majority of the evidence supports the clinical utility of preoperative PSG for predicting which children are at risk for postoperative respiratory compromise or prolonged stay and will need postoperative monitoring.

Lastly, to establish clinical utility of PSG prior to AT the task force examined whether the PSG could predict which children were more likely to have residual OSAS following surgery. Two Level 2 studies^{129,130} demonstrated that children with higher preoperative AHIs had a greater likelihood of residual OSAS following AT.

In summary, as delineated in practice parameter 3.2.1, PSG is indicated for the diagnosis of SRBD in children. Logically it follows that PSG is indicated to diagnose OSAS prior to AT when OSAS is the primary indication for AT. There are data indicating that history and physical examination alone have limitations for predicting OSAS and that the preoperative AHI can guide the physician in perioperative and postoperative management. At this time, the task force was unable to identify prospective studies addressing whether clinical outcomes fol-

lowing AT are better when PSG is routinely performed prior to AT. The evidence taken as an aggregate indicates that preoperative PSG has strong clinical utility prior to AT for treatment of OSAS.

3.4 Indications for Polysomnography to Assess Response to Treatment

3.4.1 Children with mild obstructive sleep apnea syndrome preoperatively should have clinical evaluation following adenotonsillectomy to assess for residual symptoms. If there are residual symptoms of obstructive sleep apnea syndrome, polysomnography should be performed. [Review Section 4.2.3] (Standard)

This recommendation is a logical extension of parameter 3.2.1. There are Level 2 and 3 studies documenting a high prevalence of residual OSAS after AT. In 1 Level 2 study, residual OSAS was detected in as many as 75% of non-obese children,¹³¹ and in 1 Level 3 study,¹³² 75% of a combined obese and non-obese pediatric population had residual OSAS following AT for OSAS. Although many patients had some degree of residual obstruction, most had a considerable reduction in the severity of the OSAS (postoperative results in the 2 studies above showed 90%¹³¹ and 71%¹³² of the children had a postoperative OAH1 < 5). In 1 Level 2 study,¹³⁰ which excluded obese children, the rate of residual polysomnographic evidence of OSAS was 10% to 28% (depending on the criteria used). Another Level 2 study found that OSAS can recur 1 year postoperatively, so patients should be reevaluated periodically.¹²⁹ Given the high prevalence of residual obstruction, clinicians should evaluate children postoperatively for symptoms of OSAS and if present, a PSG should be performed.

3.4.2 Polysomnography is indicated following adenotonsillectomy to assess for residual sleep related breathing disorder in children with preoperative evidence for moderate to severe OSAS, obesity, craniofacial anomalies that obstruct the upper airway, and neurologic disorders (e.g., Down syndrome, Prader-Willi syndrome, and myelomeningocele). [Review Section 4.2.3] (Standard)

Incomplete resolution of OSAS was more common in children with high preoperative AHI (exact cut-off not established as norms and statistical methods varied from study to study) (2 Level 2,^{129,130} 1 Level 3¹³²), obesity (2 Level 2,^{129,130} 1 Level 3,¹³² 3 Level 4^{101,133,134}), craniofacial anomalies that obstruct the upper airway (1 Level 3¹³⁵ and 1 Level 4⁸⁸), and neurologic disorders such as myelomeningocele (1 level 4⁸¹) and Down syndrome (1 Level 4⁴²), while absence of obesity and craniofacial abnormalities (2 Level 3,^{132,136} 1 Level 4¹³⁷) and lower AHI (2 Level 2,^{129,130} 1 Level 3¹³²) favored a good outcome. Children with neuromuscular disorders can have a mix of both obstructive and central sleep apnea and require PSG following AT to determine the need for CPAP or NIPPV as demonstrated in 2 level 4^{81,83} studies. This recommendation is a logical extension of 3.2.1. These populations are at increased risk for having residual SRBD and are often difficult to reliably evaluate clinically.

3.4.3 Polysomnography is indicated after treatment of children for obstructive sleep apnea syndrome with rapid maxillary expansion

to assess for the level of residual disease and to determine whether additional treatment is necessary. [Review Section 4.4.3] (Option)

This is a rarely performed treatment for OSAS in children with only limited data regarding efficacy. Two low level studies evaluated children following rapid maxillary expansion (RME). Significant residual disease remained after RME in 1 Level 3¹³⁸ and 1 Level 4 study¹³⁹ [4.4.3]. PSG was useful to establish residual disease and the efficacy of staged treatment. Given the paucity of evidence demonstrating the efficacy for this new procedure, it is recommended that children treated with rapid maxillary expansion have follow-up PSG. This recommendation is based on consensus expert opinion using the Rand/UCLA Appropriateness Method.

3.4.4 Children with OSAS treated with an oral appliance should have clinical follow-up and polysomnography to assess response to treatment. [Review Section 4.4.3] (Option)

This is a relatively new treatment for OSAS in children with limited studies available. One Level 2⁸⁶ and 1 Level 4 study⁴⁰ used PSG to demonstrate clinical efficacy of dental devices in children [4.4.3]. Given the paucity of evidence demonstrating the efficacy for this new procedure, it is recommended that children treated with a dental device have follow-up PSG. This recommendation is based on consensus expert opinion using the Rand/UCLA Appropriateness Method.

3.4.5 Polysomnography is indicated for positive airway pressure (PAP) titration in children with obstructive sleep apnea syndrome (Standard)

3.4.6 Polysomnography is indicated for noninvasive positive pressure ventilation (NIPPV) titration in children with other sleep related breathing disorders. [Review Section 4.4.1] (Option)

PSG was shown to be a valid measure to assess response to therapy for SRBD. There were insufficient data on autotitration PAP (APAP) in children to assess this mode of therapy. Four papers (1 Level 2,¹⁴⁰ 3 Level 4¹⁴¹⁻¹⁴³) demonstrated that PSG was useful to determine optimal PAP settings in children and infants. It was particularly important for children at risk for multiple types of SRBD, such as those with neurologic disorders. Five studies (1 Level 3⁵⁷ and 4 Level 4^{56,144-146}) evaluated or described the use of PSG for titration of nocturnal intermittent positive pressure ventilation (NIPPV) in children with SRBD and neuromuscular disorders. These studies demonstrated either clinical or physiologic improvement with NIPPV that was titrated using PSG.

3.4.7 Follow-up PSG in children on chronic PAP support is indicated to determine whether pressure requirements have changed as a result of the child's growth and development, if symptoms recur while on PAP, or if additional or alternate treatment is instituted. [Review Section 4.4.2] (Guideline)

Growth and development should be considered in children on chronic PAP treatment as symptoms may resolve or worsen with significant changes in the child's morphology. One Level 4 study¹⁴⁶ [4.4.2] demonstrated that many children required pressure changes (66%) in PAP level, even in the absence of interventions, suggesting that PAP requirements might change with growth and development. Clinical judgment should be used to

determine the timing and frequency of follow-up PSG. This recommendation is a generally accepted patient care strategy.

3.4.8 Children treated with mechanical ventilation may benefit from periodic evaluation with polysomnography to adjust ventilator settings. [Review Section 4.4.5] (Option)

PSG is useful for assessing optimal ventilator settings since respiration worsens during sleep and wake ventilator settings may not be adequate for sleep. There were no studies addressing the use of PSG in the management of ventilator settings that met inclusion criteria. This recommendation is based on consensus expert opinion using the Rand/UCLA Appropriateness Method.

3.4.9 Children considered for treatment with supplemental oxygen do not routinely require polysomnography for management of oxygen therapy. [Review Section 4.4.6] (Option)

Nocturnal oximetry is generally sufficient to assess adequate oxygenation. However, PSG can be useful for titrating supplemental oxygen in patients who may hypoventilate and may be at risk for developing central apneas or hypercarbia with supplemental oxygen. There were no studies addressing this topic that met inclusion criteria. This recommendation is based on consensus expert opinion using the Rand/UCLA Appropriateness Method.

3.4.10 Children treated with tracheostomy for sleep related breathing disorders benefit from polysomnography as part of the evaluation prior to decannulation. These children should be followed clinically after decannulation to assess for recurrence of symptoms of sleep related breathing disorders. [Review Section 4.4.4] (Option)

One Level 3 study¹⁴⁷ demonstrated clinical usefulness of PSG as part of the evaluation to assess readiness for decannulation in children with long-term tracheostomy [4.4.4]. This recommendation is based on this study and on consensus expert opinion using the Rand/UCLA Appropriateness Method.

3.5 Indications for Polysomnography in Respiratory Diseases

3.5.1 Polysomnography is indicated in the following respiratory disorders only if there is a clinical suspicion for an accompanying sleep related breathing disorder: chronic asthma, cystic fibrosis, pulmonary hypertension, bronchopulmonary dysplasia, or chest wall abnormality such as kyphoscoliosis. [Review Sections 4.3.1.1 and 4.3.1.2] (Option)

In children with asthma, prevalence studies showed conflicting low level evidence for increased risk of SRBD ([4.3.1.1]^{102,148}). The data were too sparse to assess the clinical utility of PSG in children with cystic fibrosis, although 1 Level 4 study¹⁴⁹ demonstrated clinical utility of PSG to initiate and titrate noninvasive ventilation [4.3.1.2]. There were no studies addressing the clinical utility of PSG in children with unexplained pulmonary hypertension [4.2.2.7] or bronchopulmonary dysplasia [4.3.1.3]. Finally, a low level study¹⁵⁰ of children with kyphoscoliosis who could not undergo PFTs did not find statistically significant evidence that preoperative polysomnography could predict those at risk for prolonged postoperative ventilation after scoliosis repair [4.3.2.1]. As with all children, those with asthma, cystic fibrosis, unexplained pulmonary hy-

pertension, bronchopulmonary dysplasia, kyphoscoliosis, or chest wall deformity for whom there is a clinical suspicion of a SRBD should undergo PSG.

4.0 FUTURE RESEARCH

Improvement in diagnostic accuracy and clinical utility of PSG for evaluation of SRBD in children will require investigations that address a wide range of pediatric populations using adequate sample sizes and standardized methodology. Study designs should account for changes in respiratory physiology by age and maturation and should avoid bias through inclusion of a broad spectrum of subjects with a range of severity from normal to severe disease. Development of definitive and well-validated normative and pathological respiratory PSG values will help refine diagnosis and possibly treatment options in children with SRBD. Improved research design and methodology will also improve understanding of the earliest forms of SRBD and the natural history of SRBD in children.

There is an urgent need for research clarifying the clinical utility of polysomnography. For example, comparison of validated and relevant outcomes in patients managed with and without PSG would provide the most compelling evidence to evaluate the value of PSG in managing children with suspected SRBDs.

Findings indicate that PSG may be particularly useful in the evaluation of children with chronic health conditions such as obesity, metabolic syndrome, overt or evolving hypertension, and other conditions associated with cardiovascular risk. There is a need for further investigation of SRBD in children with neurodevelopmental and neuromuscular disorders, sickle cell anemia, craniofacial disorders, and certain infants who experience ALTEs.

The clinical utility and cost effectiveness of testing outside the sleep laboratory for certain groups of children with suspected SRBD needs further investigation. Preliminary evidence suggests that efforts to make the sleep laboratory experience more child-friendly will improve the quality of data collected as well as patient and family satisfaction.

Pediatric sleep medicine is a complex, dynamic, and multidisciplinary field, and the sleep specialist involved with evaluation and management of children faces an evolving landscape. The medical literature regarding pediatric PSG is expanding exponentially, and recording techniques and methods for digital analysis are changing at a rapid pace. Superimposed on these dynamic changes is the challenge of characterizing respiratory sleep disorders and the impact of SRBD on behavior and cognition in the developing child. Performance of PSG using standardized and developmentally appropriate methods has strong clinical utility in the diagnosis and management of SRBD in children. Accurate diagnosis and management of SRBD in children is best accomplished through careful integration of polysomnographic findings with the clinical evaluation.

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