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Sleep frequently asked questions 3: What are the indications for and challenges in performing polysomnography in infants?

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Infants are particularly susceptible to a variety of breathing disorders during sleep, including obstructive sleep apnea. Polysomnography, a diagnostic modality that is the gold standard for the assessment of sleep-disordered breathing in children, is well-suited to evaluate these young patients.

Breathing is irregular in neonates, whose respiratory rate is faster and more variable than older children¹. Distinguishing between normal and abnormal breathing during sleep or wake can be difficult, especially in infants born prematurely or with congenital conditions. The traditional definition of “prolonged” apnea in infants includes cessation of breathing for 20 seconds or longer, or briefer if associated with bradycardia or cyanosis². Neonatologists generally have not distinguished between central or obstructive pauses in breathing. However, polysomnography is increasingly being used in infants to evaluate for obstructive sleep apnea, particularly in high-risk infants and has several advantages over other modes of assessment. However, there are limited data available for infant polysomnography, which presents challenges for those performing, interpreting, and treating based on the results of these studies.

While most research on the evaluation of pediatric obstructive sleep apnea (OSA) using polysomnography has focused on older children, infants are uniquely suited to develop OSA. Up to 50% of total upper airway resistance occurs in the nasopharynx, and narrowing of the nasopharynx or other parts of the craniofacial anatomy due to congenital abnormalities like mandibular hypoplasia, laryngomalacia, or mid-face hypoplasia can further contribute to upper airway obstruction during the neonatal period. The highly compliant airway of the infant and relative ventilatory instability can further contribute to a propensity for upper airway obstruction during sleep in infants. Infants with OSA carry a significant healthcare burden. A high percentage of infants diagnosed with OSA have a history of prematurity or underlying congenital condition and require the coordination of care by multiple subspecialties³.

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INDICATIONS FOR POLYSOMNOGRAPHY IN INFANTS/INFANTS AT HIGH-RISK FOR OBSTRUCTIVE SLEEP APNEA

As with older children, the primary indication for polysomnography in infants is for the evaluation of sleep related breathing disorders. Especially in infants, the clinical history and physical examination alone are poor predictors of objectively measured upper airway obstruction. Many otherwise healthy infants without obstructive sleep apnea frequently snore⁴, but snoring has not been found to be predictive of OSA presence or severity in infants with cleft palate and micrognathia^{5,6}. Polysomnography is indicated when clinical evaluation is suggestive of sleep related breathing disorders and remains the gold standard diagnostic modality for the evaluation of OSA in all children, including infants⁷. There are a number of factors that may predispose infants to obstructive sleep apnea, including craniofacial conditions like mandibular or mid-face hypoplasia^{8,9}, laryngomalacia¹⁰, nasal obstruction¹¹, or conditions that cause hypotonia¹², among other factors.

History and physical exam can be unreliable for the assessment of OSA so polysomnogram should be repeated following treatment of infants with OSA¹³. While there have been limited studies of the long-term efficacy of positive airway pressure (PAP) for OSA in infants, continuous positive airway pressure (CPAP) has been shown to be effective in eliminating obstructive events even in very young infants^{14,15}. As with older children, infants requiring treatment of OSA with CPAP should have a titration polysomnogram to ensure adequate pressure.

In addition to OSA, polysomnography can be useful in the evaluation of hypoventilation in infants; continuous monitoring of end-tidal and/or transcutaneous CO₂ is recommended for children undergoing testing. For infants with central disorders of hypoventilation, polysomnography can be used both for the initial diagnostic testing and then to assess treatment with positive pressure ventilation. For children with congenital central hypoventilation syndrome, the recommendation is for evaluation of ventilation during sleep and then routine reassessment of ventilatory needs¹⁶.

Current evidence suggests that polysomnography has a limited role in the evaluation of acute, resolved respiratory events in infants. Polysomnography has been recommended as part of the evaluation for apparent life-threatening event (ALTE) when the history and physical examination are consistent with obstructive sleep apnea¹³. However, polysomnography is not part of the standard evaluation for infants with low risk brief resolved unexplained events (BRUE) that are considered for OSA by history and physical examination¹⁷.

While more limited pneumograms, or limited channel studies, have traditionally been used in the assessment of apnea of prematurity, polysomnography has the advantage of having a standardized scoring system for both central and obstructive pauses. Few studies have thus far attempted to use polysomnography to evaluate central apnea in infants. Brockman and colleagues found a tremendous amount of variability in central apneas using home polygraphs, especially at one month of age¹⁸. Full-night attended polysomnography is the gold standard for the evaluation of OSA in children, and abbreviated testing is not

considered sensitive or specific enough to be relied on for the clinical diagnosis of OSA¹⁹. The utility of briefer “nap studies” in the evaluation of obstructive sleep apnea have not been compared to full-night polysomnography in infants. As neonates do not have robust circadian rhythms, some centers use daytime testing in young infants, who will sleep and wake to feed both during the daytime and night.

CHALLENGES IN CONDUCTING POLYSOMNOGRAPHY IN INFANTS

Polysomnography in infants comes with unique challenges and requires personnel that are comfortable both with administering and interpreting the test (Table 1). Because infant sleep is less consolidated than older children, sleep efficiency may be reduced. Infants wake periodically to feed, and may require equipment to be adjusted frequently, making the study more labor-intensive for technologists.

Breathing is less regular in infants during sleep, particularly during REM sleep. Airway closure has been shown to occur even in central apneas in neonates²⁰, and distinguishing between obstructive and central apneas is more difficult in infants than older children (Figure 1). Tidal volumes are smaller, so relatively small changes can result in greater aberrations to both thermistor and nasal pressure waveforms. The proper positioning of respiratory flow sensors is critical in acquiring quality data from the study. Paradoxical breathing is common even in healthy infants, so this is often not a useful parameter to use in the assessment of obstructive events. Because of their rapid respiratory rate, the end-tidal CO₂ waveform may not have a reliable plateau in infants, making the value less reliable. Transcutaneous CO₂ monitoring may be used as a secondary measure²¹.

There is significant age-related variability in normal EEG and respiratory patterns in infants, making scoring sleep challenging, particularly in preterm infants. There are now standardized guidelines for assessing sleep in infant polysomnography^{21,22}, but even among experts in the field there can be variability in scoring²³. Technologists and physicians scoring and interpreting studies on infants 37-48 weeks post-conceptual age should be familiar with and comfortable using infant sleep staging²¹.

Limited nasal masks are available for non-invasive positive pressure in infants, so polysomnograms to titrate PAP can be more challenging in infants than older children. Care should be taken to ensure a proper mask seal before attempting these studies. Accurately interpreting studies with infants being treated with high-flow cannula systems can be problematic as this airflow may distort thermistor and nasal pressure signals, making them uninterpretable.

CONCLUSIONS

With increased awareness of sleep-disordered breathing in infants, there is a need for standardized diagnostic tools for these patients. Polysomnography has several benefits for the evaluation of OSA in infants, including standardized setup and scoring of events. In addition, polysomnography can be used to assess for appropriate CPAP pressure in infants with obstructive sleep apnea and may be beneficial in the evaluation of ALTE with symptoms of sleep-disordered breathing. However, polysomnography has several important

limitations. Data regarding normative values for polysomnography in infants is limited to studies using older or non-standardized methodology or small studies. There have not been studies comparing polysomnography to more limited polygraphy, daytime testing, or briefer nap studies in infants at different ages.

There is a need for more robust normative sleep respiratory data in infants at different ages to be able to distinguish between normal and pathologic pauses in breathing. An assessment of the appropriateness of applying scoring rules for apnea and hypopneas to infants with a rapid respiratory rate and irregular breathing during REM sleep would also be beneficial. As the evaluation and management of infants with sleep-disordered breathing involves a multidisciplinary team, collaboration between neonatologists, primary care pediatricians, and other specialists is critical to ensure that the appropriate workup and treatment plan is initiated.

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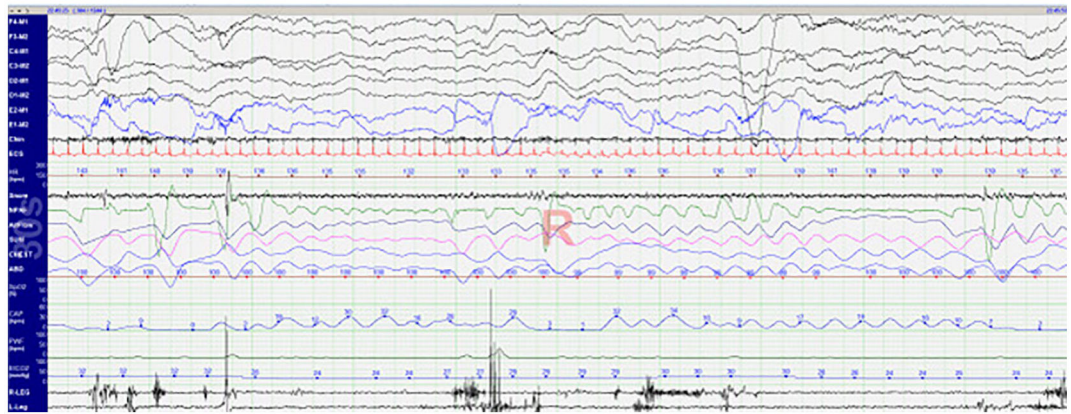


Figure 1. 30-second epoch of REM sleep in a healthy 2-week old infant.

Of note are intermittent variability in airflow seen in the thermistor (AirFlow) and nasal pressure (NPAF) signals as well as thoraco-abdominal asynchrony (CHEST and ABD) and lack of end-tidal plateau (CAP).

Table 1.

Challenges in infant polysomnography

Challenge	Potential solution
Sleep less consolidated than in older children	Adjust study time if needed to ensure adequate sleep time
Significant age-related EEG variability	Staff scoring and interpreting studies should be familiar with current AASM guidelines
Respiratory signal quality less reliable, irregular breathing	Ensure adequate staff to replace or relocate equipment as needed
Lack of end-tidal CO ₂ waveform plateau	Use calibrated transcutaneous CO ₂ monitoring as a secondary measure to evaluate hypoventilation
Limited nasal masks available for PAP titrations	Have appropriate masks available in sleep lab prior to titration studies

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