RESEARCH BRIEF

# Pediatric Polysomnographic Studies at a Tertiary-care Hospital in Singapore

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*Received: November 04, 2013;*
*Initial review: January 06, 2014;*
*Accepted: March 28, 2014.*

**Objectives**: To investigate the indications for conducting polysomnography studies and their outcomes. **Methods**: Retrospective analysis of pediatric polysomnography studies performed over a four-year period (2009-2012). **Results**: 425 diagnostic studies and 100 non-invasive positive-pressure ventilation titration studies were conducted. Of these, 389 were performed in male children. Obstructive sleep apnea was the most common diagnosis; 49.6% (211 studies). Other diagnoses included central apnea, narcolepsy, and periodic limb movement disorder. Night time symptoms (snoring, frequent night awakenings, restless sleep) were present in 294 children, and 161 children had daytime symptoms (excessive daytime sleepiness, early morning fatigue, poor concentration at school). 13 studies (2.5%) were inadequate for analysis, reflecting the challenges of conducting studies in children. **Conclusion**: Dedicated pediatric sleep laboratories with properly trained staff are important to minimize failure rates and diagnose these conditions accurately.

**Keywords:** *Child, Diagnosis, Parasomnias, Sleep problems.*

Sleep is an essential physiological process which plays a major role in the cognitive and neurobehavioral development of children. The behavioral adverse effects of inadequate sleep include impairment of memory consolidation, emotional dysregulation, slow-down in decision-making, and failure to keep sustained attention [1-3]. The prevalence of sleep disorders is estimated at 25-40% in children below 18 years [4,5].

Polysomnography is an important investigative tool for evaluating pediatric sleep disordered breathing. Both the American Thoracic Society (ATS) and the American Academy of Pediatrics (AAP) recommend polysomnography as the diagnostic tool of choice in the evaluation of SDB in children [6,7]. There are various respiratory indications for polysomnography, whether it is to assess for obstructive sleep apnea syndrome (OSAS), non-invasive positive-pressure titration, assessment for hypoventilation, or response to an intervention to treat OSAS (*e.g.* adenotonsillectomy) [8]. Non-respiratory indications include daytime sleepiness, parasomnias, and sleep-related movement disorders [9]. We conducted a retrospective study to review the profile of pediatric polysomnography studies conducted at a tertiary-care university hospital in Singapore.

## Methods

We reviewed all pediatric polysomnography studies over a four-year period (2009 - 2012) in children up to 18 years of age at the National University Hospital in Singapore. Each study was a full polysomnography incorporating electrocardiography (ECG), electromyography (EMG), chin electro-oculography (EOG), electro-encephalography (EEG), respiratory movements (thoracic and abdominal bands, Compumedics model V3 THOR TP and V2 ABDO TP), airflow, oxygen saturation, carbon dioxide monitoring, microphone, position and leg EMG, and video. Compumedics ProFusion PSG 2 software (Compumedics Limited) was used for analysis. Studies were conducted overnight in a dedicated pediatric sleep laboratory by a qualified on-site sleep technician with experience in pediatric polysomnography, and subsequently reported by consultant pediatric pulmono-logists. The American Academy of Sleep Medicine (AASM) scoring manual 2007 (pediatric criteria) was used as a reference for scoring and diagnosing sleep disorders for all children up to 18 years of age [10].

## Results

Five hundred and twenty-five pediatric polysomnographic studies were carried out during the study

period. Of these, 389 were performed in male children. Age range was from 2 months to 18 years (median 10 years). Four hundred and twenty-five were diagnostic studies (***Table* I**) and the remaining 100 were CPAP or BiPAP titration studies.

Of the 425 diagnostic studies, night-time symptoms were present in 294 children (259 had snoring, 52 had frequent night awakenings, 42 had restless sleep, and 59 had gasping or witnessed pauses in breathing in sleep). Daytime symptoms were present in 161 children (113 had excessive daytime sleepiness, 39 had early morning fatigue, and 38 reported poor concentration at school). Three children had exclusively daytime symptoms (in particular, excessive daytime sleepiness) with no night-time symptoms, and underwent multiple sleep latency testing (MSLT), all of which were normal. One child who presented with sleep attacks and cataplexy was evaluated and diagnosed as narcolepsy using an overnight sleep study followed by MSLT.

Among children who snored ($n$=259), 121 had normal studies that were negative for OSAS, 78 had mild OSAS, 21 had moderate OSAS, and 39 had severe OSAS.

Two children had abnormal movements in sleep; one was diagnosed with periodic limb movement disorder (PLMD) and was treated with gabapentin, while the other had multiple periodic limb movements but fell short of the criteria for PLMD.

Of the 13 children with significant central apnea, 7 had central apnea indices of 6.0 or more; one each had Angelman syndrome (20.5 events/hour), Lennox-Gastaut syndrome (6.0 events/hour), complex congenital heart disease with complete heart block (19.1 events/hour), Olivopontocerebellar atrophy (7.3 events/hour), Jeune thoracic dystrophy (43.4 events/hour), and Spinal muscular atrophy type 3 (6.0 events/hour).

**TABLE I** PROFILE OF DIAGNOSTIC PEDIATRIC POLYSOMNOGRAPHIC STUDIES ($N$=425)

| *Outcome* | *Number (%)* |
|---|---|
| Normal | 178 (41.9) |
| *OSAS* | 211 (49.6) |
| Mild (AHI between 1 and 5) | 99 (23.3) |
| Moderate (AHI between 5 and 10) | 34 (8.0) |
| Severe (AHI greater than 10) | 78 (18.4) |
| Paradoxical breathing with normal AHI | 5 (1.2) |
| Central apnea | 13 (3.1) |
| UARS | 2 (0.5) |
| Abnormal movements | 2 (0.5) |
| Narcolepsy (positive MSLT) | 1 (0.2) |
| Inadequate study | 13 (3.1) |

*OSAS – Obstructive sleep apnea syndrome, AHI – Apnea-hypopnea index, UARS – Upper airway resistance syndrome, MSLT – Multiple sleep latency test.*

There were 13 studies that were performed post-adenotonsillectomy. However, only four had information of the apnea-hypopnea index (AHI) pre-surgery. Of the four studies, surgery reduced the obstructive AHI (oAHI) from 45.7 to 1.9 in a 13 year-old boy with Noonans syndrome, 22.9 to 7.7 in a 2 year-old girl with hemophagocytic lymphohistiocytosis, 27.3 to 6 in a 12 year-old obese boy, and 29.2 to 0.7 in an otherwise normal 9 year-old boy.

Pediatric polysomnography (100 studies) was used to titrate CPAP and BiPAP pressures for home ventilation in children. Seventy-two studies (72%) were on children with neuromuscular disorders; all were on BiPAP therapy. The remaining 28 children had severe OSAS and were on either CPAP or BiPAP therapy.

There were 13 inadequate studies (2.5%), which did not provide sufficient data to interpret adequately. They occurred in the first three years of the study period but not in the final year (2012). Five children could not settle to sleep, four slept under two hours, one child could not tolerate the CPAP mask during a titration study, one girl (a 12 year-old girl with end-stage renal disease and dilated cardiomyopathy) developed shortness of breath from acute pulmonary edema after recently starting intravenous fluids for a rising creatinine count, and two had no reasons documented.

## DISCUSSION

Symptoms suggestive of obstructive sleep apnea were the most common reason for referral in this study; half the diagnostic studies were positive for OSAS, other abnormalities were also detected, including central apneas and periodic limb movement disorders. About half of our children who snored did not have OSAS of any severity, but a quarter had moderate to severe OSAS. There was a small failure rate (about 3%) in completing adequate studies.

From our data, it is clear that snoring alone cannot predict which children have OSAS. This is in line with existing literature which show that this symptom is poorly predictive of underlying sleep-disordered breathing [11]. Our data support the available evidence that adenotonsillectomy can reduce the AHI significantly in children with OSAS, although not necessary down to normal values [12]. This has been associated in significant improvement in quality of life. As this was a retrospective review of our sleep laboratory database, while every effort was taken to collate all the data, it is inevitable that the data

**WHAT THIS STUDY ADDS?**

- Snoring during night time sleep and excessive day time sleepiness are the commonest indications of pediatric polysomnography studies.

are subject to information bias with a few missing variables due to non-entry by the attending physician and technician.

Polysomnography remains the key instrument in diagnosing sleep-disordered breathing as symptoms alone do not necessarily predict patients with this problem. Polysomnography is an unfamiliar and potentially frightening experience for children, particularly when done for the first time. Developmental, physiological and behavioral factors in children require different parameters of assessment and age-adjusted sleep scoring systems compared to adults [13]. A small proportion of our studies were not adequately completed, mostly due to the child's inability to sleep sufficiently. Caregivers reported that these children usually slept well at home. This illustrates the point that despite experienced pediatric staff, polysomnography can still be challenging to conduct on a child. It is also important to be aware of underlying medical problems that could potentially lead to clinical deterioration during the study, as occurred in one of our cases, hence the need for proper medical review before each study.

Children with symptoms suspicious of sleep disorders should undergo polysomnography as it remains the most accurate tool for diagnosing sleep-related problems. Our review highlights the variety of pediatric sleep disorders diagnosed using polysomnographic studies from our center. Dedicated pediatric sleep laboratories with properly trained staff are important to minimize failure rates and diagnose these conditions accurately.

*Contributors*: MTL, DYG and MBR: conceived and designed the study, and revised the manuscript for important intellectual content; MTL: will act as guarantor of the study; BKR and TJL: collected data, interpreted the data, and drafted the paper. The final manuscript was approved by all the authors.
*Funding*: None; *Competing interests*: None stated.

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