

Polysomnography in Children: 2006 Update

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Abstract Polysomnography is the standard investigation for diagnosing obstructive sleep apnoea syndrome and a wide range of sleep problems in children. The initial standards were published more than 10 years ago. Over the past decade, technology evolved rapidly. New clinical data were published. This update outlines the current standard, important changes, unanswered questions, and the future direction of development of polysomnography in children.

Key words Children; Polysomnography; Sleep

Introduction

Polysomnography is considered the gold standard for diagnosing obstructive sleep apnoea syndrome (OSAS) and a variety of sleep problems in children.^{1,2} Since the publication of the standards by the American Thoracic Society 10 years ago, there has been considerable advancement in technology and new clinical data. To the family physicians and paediatricians, it is particularly challenging to understand what is inside the "black box" of this test. This update addresses a few major issues and current status of the practice of paediatric polysomnography in children.

Polysomnography as a "Gold Standard" Diagnostic Tool for OSAS in Children

Most clinicians will agree that all children should be specifically enquired for any loud habitual snoring during

health visits. We also know clearly that history and physical examination could not pinpoint the diagnosis of OSAS in a child with loud habitual snoring.^{1,3} Estimation of size of tonsils and adenoids by means of physical examination and imaging studies may tell us how likely the diagnosis of OSAS is.^{4,5} But on an individual child, it is not going to help on making a definitive diagnosis of OSAS, nor does it tell us how severe the OSAS is. For the same reason, endoscopic examination also has similar shortcomings. This concept has become clear now, as we know OSAS in children is not only associated with enlarged tonsils and adenoids, but also the presence of abnormal airway collapsibility during sleep.⁶ In other words, in two otherwise healthy children with the same degree of adenotonsillar enlargement, one may suffer from OSAS because of presence of abnormal airway collapsibility, while the other may be normal.

Attempt to estimate the likelihood of diagnosis of OSAS by using the adverse daytime effects of OSAS has not been successful. Among children with OSAS, only a minority suffers from sleepiness, heart failure, rhythm abnormality, hypertension, bruxism, nocturnal enuresis, or early morning headache. The assessment of daytime sleepiness is particularly not very helpful. In adults with OSAS, their apnoea hypopnoea index is much higher. They have daytime sleepiness because of increased arousals related to the obstructive events. In children with OSAS, however, their apnoea hypopnoea index is much lower, and only a minority of the obstructive events ends up in arousals. Their

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sleep architectures are often undisturbed.⁷ As a result, sleepiness is not a reliable measure in children with suspected OSAS, even with objective measurement using multiple sleep latency test.⁸

Thus, in all children known to have loud habitual snoring, polysomnography is still considered the "standard" investigation. The main problem with this approach is that the demand for doing proper polysomnography in children is high worldwide, yet the provision of this is limited, even in the developed countries.⁹ This makes the waiting time unacceptably long. In Hong Kong, we face similar situation, both in public and private sectors.¹⁰

The Laboratory Standards

This is a relatively less controversial area. The original published statement is still considered as the "gold standard" for clinical practice.¹¹ To the family physicians and paediatricians, it is important to recognise the importance of proper laboratory setting and interpretation of the study. In brief, polysomnography in children should be performed in the proper setting. In young children, this will mean that the study has to be attended during the whole night by a trained technician to ensure the quality of the study. It is equally important to note that none of the current polysomnographic systems can generate accurate automated report on paediatric polysomnographic studies. An automated report can both underestimate and overestimate the clinical condition.¹¹ For this reason, paediatric polysomnographic studies should all be reviewed manually using the raw data by trained physicians with knowledge on paediatric polysomnographic studies. The accuracy and agreement of manual scoring is dependent on the training background and the experience of the physicians. In the best hands, an interscorer agreement of at least 70-80% is expected.^{12,13}

In general, the result from a single night study is sufficient for diagnostic purpose for children with suspected OSAS.¹⁴⁻¹⁶ A slight night-to-night variation does exist, especially in cases with borderline severity.

A wide variety of devices with abbreviated leads have been marketed as "screening" device or "new tools". However, before more evidence is available, one should rely on the standard technique for making definitive diagnosis of OSAS in children.

New Technology and New Parameters to Be Included

Recording of state of being (the electroencephalogram, electrooculogram, chin electromyogram) has not changed. Pressure transducer airflow using nasal or oronasal cannula has now replaced thermistor as the device for measuring airflow.¹⁷⁻¹⁹ However, in unattended studies, it is often easier to lose a signal from the cannula than the thermistor. Various non-invasive ways of detecting effort such as pulse transit time have not been widely accepted because of the limitation in the technology itself.²⁰⁻²³ Oesophageal pressure measurement remains the gold standard for measuring effort.²⁴ However, this is still not popular in paediatric practice.

Acceptance for measuring gaseous exchange disturbance has been better in the past few years.¹¹ This is particular important in children. The main problem lies in the technical limitation when one has to measure flow and carbon dioxide level with two lumen cannula on each side of the nostril. A few companies manufacture nasal split nasal cannula with one nostril used for carbon dioxide measurement, one nostril for flow detection. The use of this kind of cannula has not been widely accepted because of problem with unilateral nasal block and normal cycling of breathing between the two nostrils.

The Polysomnographic Report

Four important questions are answered in a proper polysomnographic report for a child suspected to have OSAS.

- a) Is the sleep architecture disturbed?
- b) How frequent are the respiratory events?
- c) How disturbed is the sleep by the respiratory events?
- d) Is there any gaseous exchange abnormality?

Although all of these parameters are important, most general practitioners rely heavily on the frequency of the obstructive events. The most commonly reported index on the frequency of obstructive events is the apnoea hypopnoea index (AHI). This represents the number of obstructive apnoea and obstructive hypopnoea per hour of total sleep time. This is different from respiratory disturbance index

(RDI), in that it doesn't include respiratory event related arousals (RERA).²⁵ To include RERA accurately, an oesophageal pressure monitoring has to be included in the study. Although this has been reported to be well tolerated in children, it is still not a popular technique.²⁴

In the older literature, obstructive apnoea index (OAI) or apnoea index (AI) has been reported. The original accepted normal limit for AI is less than one per hour.¹¹ The same data have later been reviewed to include the obstructive hypopnoea, making the normal AHI of <1.5 per hour.²⁶ It has been heavily criticised that this normal value only represents the statistical norm, but not clinical norm. However, most researchers who have seen enough normative data will tend to agree that in normal children, their AHI should be <1.5 per hour. In fact, this has been so widely accepted that it is now published as a standard in the second edition of the International Classification of Sleep Disorder.²⁷

Central apnoeas lasting less than 20 seconds are commonly seen during sleep onset and following arousals. These are generally considered physiological phenomena and are not scored. Central apnoeas in children are scored when they last for 20 seconds or more, or when they are associated with desaturation below 90%, irrespective of the length of the apnoea.²⁸ Short central apnoeas associated with desaturations below 90% are often seen in children with significant lung pathology associated with impaired ventilation. Long central apnoeas are seen in specific conditions, such as Hirschsprung's disease and central hypoventilation syndromes.

What is an Abnormal AHI?

If one looks at the literature published in the past decade, this is probably one of the most confusing parameters. While some state that AHI greater than 1.5 per hour but less than 5 per hour is mild OSAS, others state that AHI of less than 5 per hour is primary snoring (meaning that it is short of the diagnosis of OSAS).^{29,30} Children with AHI of less than 5 per hour were also shown to have adverse daytime neurobehavioural outcome.³⁰ A new consensus seems to evolve out of these findings. Most researchers now label children with AHI between 1.5 per hour and 5 per hour as having mild OSAS, while children with AHI greater than 5 per hour will be labelled as having definite OSAS. These will appear in the publications in the years to come.

The problem of abnormal AHI in adolescent group has not been resolved yet. In adults, OSAS is defined as AHI

greater than 15 per minute in the absence of daytime sleepiness and witnessed apnoea.²⁷ Thus, it is particularly difficult to determine whether an adolescent at the age of 16 years old with loud habitual snoring, having an AHI of 10 is within normal limit. There are hardly any solid data in this grey area to support any standard. This reflects the difficulty in performing this kind of studies. At the moment, most researcher will look at whether disturbance in sleep (e.g. arousal index, sleep architecture) and whether gaseous exchange abnormality is present or not. The outcome data, however, are still lacking.

How Disturbed is the Sleep?

This depends on assessment of sleep architecture against an age-dependent norm. A commonly used index for signifying degree of sleep fragmentation is the arousal index.³¹ This is a measurement of frequency of brief EEG changes per hours of total sleep time. For a few years, arousals scoring in young children has been modified in various ways.^{29,32,33} In adults, the American Academy of Sleep Medicine (AASM) defined arousal as a sudden shift in EEG frequency lasted for 3 to 15 seconds with a set of preset rules.³¹ In children, various modifications exist over the past few years. However, it is now clear that, scoring of arousals have to follow the adult AASM criteria because of the technical limitation.³⁴ We also know that in children, only a minority of obstructive apnoeas were followed by arousals.^{7,20,32,34} Thus, the search into autonomic changes as markers for sleep fragmentation has been active. Also, the cyclic alternating pattern is being extensively studied.³⁵ But because of the difficulty in scoring these, their clinical use is still limited, at least at the present moment.

The Issue of Susceptibility

This is the hot emerging issue. The study in airway collapsibility in children has shown that children with OSAS have increased airway collapsibility. In the current working model, we believe children with airway narrowing during sleep have differential susceptibility to developing obstructive apnoea. There may be gene environmental interaction as well in determining this susceptibility, not only in the risk for developing OSAS, but also the severity of the OSAS, and the susceptibility in developing adverse pathophysiology as a result of the OSAS. Data are limited. But the preliminary work on screening of affected individual

by detection of RNA activation and target protein in serum and urine has been encouraging.³⁶⁻³⁸

Polysomnography for Noninvasive Ventilation Titration and Other Sleep Disorders

Apart from its role in diagnosis of OSAS in children, polysomnography remains as an integral part of the multiple sleep latency test in the objective measurement of sleepiness and diagnosis of narcolepsy.³⁹ Attended manual titration test is also the only objective and reliable test for determining the optimum level of non-invasive ventilatory setting for children requiring nocturnal non-invasive ventilatory support.^{40,41} Besides, polysomnography remains as a definitive tool for diagnosis of a whole range of specific sleep related disorders.

The Future of Paediatric Polysomnographic Studies

A new set of standardised scoring rules is being developed and reviewed by the AASM. Before the publication of this new standard, we still rely on the Rechtschaffen and Kales manual published in 1970, and the various supplementary publications published in various journals.⁴² The new rules are not meant to be a radical change to what is being practised. Rather, it is a more precise summary with some further modification based on the current standard.

Paediatric polysomnography has evolved from an extension from adult studies, and has become a specialised study. Over the past decade, a solid standard has been established. On the basis of this, outcome data based on standard polysomnographic measurement data will continue to emerge in the next decade.

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