REVIEW

Diagnosis of Obstructive Sleep Apnea Hypoventilation Syndrome – Techniques, Old and New

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ABSTRACT

Obstructive Sleep Apnea Hypoventilation Syndrome (OSAHS) is increasingly being recognised as an important cause of morbidity in children. Research and new technology has proposed new methods in the diagnosis of OSAHS. Traditional methods of diagnosis including clinical assessment, prediction models, polysomnography, oximetry as well as newer diagnostic techniques such as finger plethysmography, frequency domain analysis of heart rate variability and pulse transit time are discussed. Full night attended polysomnography, the gold standard in the diagnosis of OSAHS, remains the investigation of choice for diagnosis of paediatric OSAHS.

***Keywords** : OSAHS, pediatrics , diagnosis, polysomnography, and new techniques*

INTRODUCTION

OSAHS is a common sleep disorder in adults that is increasingly being recognised in children with an incidence of 1-3% in preschool and school aged children[1-3]. OSAHS has been described as a public health problem comparable to smoking in its effects upon society[4]. Untreated OSAHS can be associated with significant morbidity including neurocognitive deficits, growth failure, cardiovascular consequences or even death. Less tangible effects include loss in productivity, quality of life as well as psychological sequelae[3, 5 – 7].

Despite increasing global awareness of the disease amongst healthcare workers as well as the general public, it is still largely unrecognised and underdiagnosed[8]. Young et al estimated that 93% of women and 82% of men with moderate to severe OSAHS are not diagnosed [9]. In children with OSAHS, diagnosis is often made more difficult due to reduced and subtler symptoms and signs[5 -7]. In Singapore, the level of awareness amongst healthcare workers has increased with increased numbers of physicians trained in sleep medicine as well as increasing number of diagnostic centres both in the public and private healthcare sectors. However, a survey of the general public still revealed poor public awareness of the disease with at least two thirds having never heard of the term OSAHS and up to 55% of obese children attending regular follow ups for obesity having previously undiagnosed OSAHS (unpublished communications, Tang et al). Failure to recognise OSAHS is costly to both the individual and to society; underdiagnosis is thought to cost the USA $3.4 billion in additional medical costs per year [10].

Thus, OSAHS is common and has a significant impact on the patient, his family and society. As OSAHS is treatable but is frequently underdiagnosed, better and improved diagnostic techniques are of paramount importance in its management.

CLINICAL ASSESSMENT

Children with OSAHS may present with a variety of symptoms and signs. Habitual snoring, the commonest symptom of OSAHS is also common in the general population. It is estimated that 9 - 10% of children have habitual snoring with only 1-3% having OSAHS[1]. More discerning features of witnessed apneic episodes, breathing difficulty and cyanosis are less uncommon. Physical examination during wakefulness is often normal. Various studies, including one done locally on obese children, have demonstrated the inability of the clinical history and physical examination to distinguish primary snoring from OSAHS in children[11-14]. The presence of large tonsils and adenoids, large soft palate, retrognathia, micrognathia and certain facial configurations increases the risk of disease. These features have been detected by cephalometry, MRI or CT scans in patients with OSAHS[15 - 17]. However, these measurements are of little predictive value and the literature is scarce on their norms in the paediatric population. The American Thoracic Society has stated that clinical assessment alone, even by a trained physician, does not reliably distinguish OSAHS from primary snoring and does not have sufficient diagnostic sensitivity upon which to base a recommendation for surgery[14].

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CLINICAL PREDICTION MODELS

Prediction models for both primary and secondary care that calculate the probability of a patient having OSAHS using self reported symptoms combined with demographic and anthropometric data e.g., Gender, BMI, age have been developed to try to improve the predictive value of clinical variables with varying success. A recent study prospectively utilised those models to predict the presence of OSAHS in adults showed that all 4 models used were not sufficiently accurate to discriminate between patients with or without OSAHS but could be useful in prioritising patients for polysomnography [18]. These models have not been validated in the paediatric population. A study in children utilising an OSA score first conceived by Brouillette et al (including symptoms of difficulty in breathing, witnessed apnoea and snoring) in a prediction model showed a poor sensitivity of 42.3% for the detection of OSAHS in obese Singapore school children as opposed to the clinician's impression with a sensitivity of 81.7%[11].

SLEEP STUDIES

Full attended nocturnal polysomnography (PSG) or a Level I study is traditionally regarded as the gold standard for the diagnosis of OSAHS. Typically it requires admission to hospital with a trained technician present through the night.

Various techniques for monitoring respiration are available[19]. Thermistors, which detect changes in temperature with respiration, is the most common type of airflow sensor used in sleep laboratories. It provides a qualitative measurement of oronasal airflow and its accuracy varies depending on the position of the patient, position of sensors and presence of nasal obstruction. Nasal pressure sensors connected to the nose via nasal prongs are more accurate though it can be affected by nasal obstruction and mouth breathing[20-21]. Endtidal carbon dioxide measurement is a standard measurement in all paediatric sleep monitoring and serves as an additional qualitative airflow channel as well as for detection of prolonged partial hypoventilation, a feature in paediatric OSAHS. Endtidal CO_2 may be underestimated in children with chronic lung disease and increased physiological dead space as well as neonates with small tidal volume or rapid respiratory rates. Transcutaneous CO_2 measurement is also used in place of or in conjunction with Endtidal CO_2 measurements in some laboratories but has been shown to correlate less well with $PaCO_2$, with a longer response time[22-23].

Respiratory effort can be assessed in different ways. Measurement of changes in oesophageal pressure is done in some adult sleep centers to reflect the increased work of breathing in the diagnosis of upper airway resistance syndrome. Chest and abdominal wall motion can be measured by strain gauges, pressure transducers, or impedance wires placed around the chest and abdomen allowing the distinction of central versus obstructive events. Respiratory inductance plethysmography (RIP) detects the changes in volume of the chest and abdomen during inspiration and expiration and when properly calibrated, can provide an estimation of tidal volume. The American Sleep Disorders Association (ASDA) Task force recommends the use of RIP or measurement of nasal pressure to detect airflow and ventilation[24].

Electrophysiological monitoring of sleep includes use of electroencephalography (EEG), electro-oculography (EOG), and chin electromyography (EMG)[25]. This allows confirmation of sleep, amount of sleep stages, quality of sleep as well as quantifies the number of arousals, an indicator of sleep disturbance. One other approach to the recording of sleep is actigraphy which uses various types of activity monitors to detect both integrated generalised movements and small movements that occur at the distal extremities. Actigraphy appears to provide reliable estimates of total sleep time in normal subjects and patients with insomnia, but its reliability has not been systemically investigated in sleep apnea populations[26]. This method is not recommended routinely in the diagnosis of OSAHS but may be a useful adjunct to a detailed history in the assessment of sleep disorders in adults.

Portable home studies or Level II studies offer the theoretical advantage of home sleep environment and representative data in a cost-effective way. However, one has to balance this against failure due to technical problems and data loss, with increased costs from repeat testing. Monitoring of the study through modems that would alert a hospital based technician to a problem so that a phone call can be made to correct the problem can be done in some centres to reduce data loss. The majority of the studies reporting a high quality rating on portable monitors (for which sensitivity and specificity were reported) have been performed in the attended setting. Data proving cost effectiveness of unattended portable monitoring are lacking [27].

Level III studies are partial home studies. These studies use limited channels, which include some type of cardiorespiratory monitoring without the measurement of sleep reducing sensitivity and specificity of the devices, and gives no information on architecture and quality of sleep. Also, this is not recommended when more complex respiratory disorders e.g., neuromuscular disease, central hypoventilation, chronic lung disease or non pulmonary sleep disorders co exist with OSAHS or is a differential diagnosis[28].

Level IV studies are very limited home studies or screening tools and measure only 1 or 2 parameters such as pulse rate and oximetry. This is further discussed below.

The American Sleep Disorders Association in its practice parameters for the use of portable recording in the assessment of OSAHS has set forth its recommendations for portable or unattended recordings[26]. In summary, their recommendations are that standard PSG is the accepted test for the diagnosis and determination of the severity and treatment of OSAHS. Unattended recordings are an acceptable alternative only when : (1) The clinical symptoms are severe and indicative of sleep apnea, and the initiation of treatment is urgent and standard PSG is not readily available; (2) If the patient cannot be studied in the sleep laboratory; and (3) for follow up studies when the diagnosis has been previously established and therapy initiated in order to evaluate response to therapy.

In Singapore, affordability of the level I PSG, and accessibility of the hospitals and sleep laboratories facilitate the use of 'gold standard' full night attended polysomnography for diagnosis. Moreover, the laboratory induced 'first night' effect and night to night variability was found to be not clinically significant in children and most adults[29-30].

SCREENING STUDIES

Screening studies including home audiocassette taping, home video cassette taping, sleep sonography, nap studies and nocturnal pulse oximetry have been used but most have insufficient sensitivity and specificity for the definitive diagnosis of OSAHS[31-33]. Also, these tests are limited because they fail to detect obstructive hypoventilation and hypercapnia, cannot distinguish between central and obstructive apnea and gives no information about sleep disruption.

PULSE OXIMETRY[34- 40]

Nocturnal pulse oximetry is increasingly being used for initial screening as it is readily available, relatively inexpensive and can be performed at home, hence, enabling the patient to have a typical night's sleep. However, its role in the diagnosis of OSAHS is contentious, as it is less sensitive and specific than polysomnography[34-36]. This is especially true in a population with mild OSAHS and very obese patients. Pulse oximetry may not be a cost-effective screening tool[37-40]. Oxygen desaturations are common in obstructive apnea but can be absent with hypopnea, in events with increased upper airway resistance or prolonged partial hypoventilation resulting in false negative results. Oxygen desaturations also occur frequently in other cardiovascular and respiratory conditions unrelated to airway obstruction, resulting in false positive results. Movement artifacts, poor peripheral arterial blood flow, changes in haemoglobin structure and quantity, as well as issues related to tissue optics in very obese patients may limit the accuracy of the results. Devices with low sampling rates can also significantly underestimate oxygen dips. The sensitivity of nocturnal pulse oximetry in the diagnosis of OSAHS ranges from 31% to 98% and specificity from 41% to 100% depending on definition, population studied and device used[34]. It should also be noted that non-pulmonary sleep disorders e.g., periodic limb movements disorder or narcolepsy, often a differential diagnosis in patients with sleep disorders will not be detected by oximetry.

The parameters reported in pulse oximetry vary widely but include total number of desaturations, oxygen desaturation index (ODI), and desaturations per hour, highest SaO_2, lowest SaO_2, mean SaO_2 and cumulative time spent below a specified SaO_2. A 4% desaturation is most commonly considered to be significant, but 3% and 5% desaturations are also used. With regard to ODI, there is no consensus as to which figures represent a normal or abnormal result.

Thus, pulse oximetry may be useful in screening and prioritising patients (without significant cardiac or respiratory disease) who would require a PSG to elucidate type and severity of OSAHS. Important patient outcomes, such as compliance with therapy after diagnosis, risk of surgical complications, cure after surgical intervention have not been studied. A negative pulse oximetry cannot be used to rule out OSAHS.

NAP STUDIES[41- 42]

Daytime or evening nap studies have been done in several adult and paediatric centres as an alternative screening tests for OSAHS. These studies have shown to be a specific with an almost 100% positive predictive value in some centers. However the negative predictive value is poor (only 17% in one study hence rendering it a poor screening test). Even in those with a positive nap study, respiratory abnormalities i.e., apnea hypopnea index, SAO_2 nadir, peak Endtidal CO_2 were consistently underestimated. Some reasons for this include the shorter duration of test and frequent absence of REM sleep. Nap studies frequently need to be confirmed by nocturnal polysomnography and therefore any potential cost advantage of nap studies may evaporate.

NEWER TECHNIQUES

The effect of the large intrapleural pressure swings during obstructive respiratory events on the autonomic nervous system, pulse and blood pressure have given rise to the development of newer non-invasive techniques to measure apnoea or hypopnoea. Indirect measurement of peripheral vasoconstriction and transient tachycardia through a finger plethysmograph, analysis of very low frequency components of the heart rate variability and the measurement of the change of pulse transit time during episodes of apnea have revealed promising results.

Finger plethysmography is a novel approach to the determination of sleep apnoea based on measuring the peripheral circulatory responses to an apnoeic event and its related arousal i.e., elevated peripheral resistance and transient heart rate elevation[43-44]. The apparatus is a finger plethysmograph coupled to a constant volume, variable pressure pneumatic system measuring pulsatile finger blood flow and pulse rate. Schnall et al used the finger plethysmograph in a study of 42 adult patients with OSAHS and demonstrated profound, transient vasoconstriction and tachycardia of a periodic nature, clearly seen with each apnoeic event, likely related to a transient arousal[43]. Good agreement was found between standard total apnoea-hypopnoea scoring and transient vasoconstriction and tachycardia events. They conclude that the finger tip exemplifies the scope of peripheral vascular responsiveness due to its high density of alpha sympathetic innervation. The lability of blood flow in one fingertip and the pulsatile finger blood flow patterns can be clearly diagnostic of OSAHS and other sleep-disordered breathing conditions.

Frequency domain analysis of heart rate variability during nocturnal sleep has been proposed to be a noninvasive low cost approach to diagnose and monitor subjects undergoing treatment at home [(45)]. Frequency domain analysis demonstrates two discrete frequency bands with physiological origins in the activity of the sympathetic and parasympathetic nervous systems. The low frequency (0.04-0.15Hz) indicates predominantly sympathetic activity and the high frequency (0.15-0.4Hz) the vagal activity. During repeated episodes of sleep apnoea, an increase of the very low frequency component and the appearance of a very low frequency peak which is abolished with treatment is noted. Another advantage of frequency domain analysis of heart rate variability is the determination of the type of apnea involved. The presence of high frequency signals after the onset of very low frequency signals indicates the occurrence of inspiratory efforts during occlusive apneas. Alternatively, the absence of this high frequency signal indicates the occurrence of central apneas.

Pulse transit time (PTT) refers to the time it takes a pulse wave to travel between 2 arterial sites, the speed of which is directly proportional to blood pressure i.e., PTT is inversely proportional to blood pressure. Since the 1970s PTT has often been used as a non-invasive surrogate marker of changes in blood pressure. Recently it has been proposed as a means of quantifying respiratory effort by detecting changes in the blood pressure oscillations associated with pleural swings (pulsus paradoxus) as well as blood pressure surges associated with micro arousals, thus, offering the possibility of estimating sleep fragmentation without the need for EEG recordings[46]. In a study of patients with OSAHS, a good correlation between the amplitude of PTT oscillations (ΔPTT) and the magnitude of negative pleural pressure swings as measured by oesophageal manometry was demonstrated[47 - 48]. PTT also has good sensitivity (91%) and specificity (95%) and negative predictive value (95%) at differentiating obstructive from central apnoeas when compared with oesophageal manometry[49]. PTT defined arousals also correlated well with oximetric desaturation and EEG micro arousals. Also, they were at least as good as ASDA defined EEG arousals at predicting quality of life and objective daytime sleepiness responses to nasal CPAP therapy[50]. Limitations of PTT measurement include that of a semi quantitative nature of measurement; frequent artefacts due to interference with the photoplethysmographic signal at the finger and disturbance of ECG leads; difficulty in scoring the signal in REM sleep because of large variations in respiratory drive and patient variability; coexisting cardiac disease and arrthymias. The equipment to measure this physiological signal is commercially available, relatively cheap and portable and is already used in some centers. Although showing great promise, the clinical role of PTT in OSAHS remains to be fully validated.

CONCLUSION

Since its inception, full attended nocturnal polysomnography has been regarded as the gold standard for the diagnosis of OSAHS with which new techniques are compared. Over the last decades, many new techniques for diagnosis have been proposed in an attempt to simplify technique, reduce costs and improve accuracy. Many of these tests show promise and have potential advantages but also suffer from limitations. To date, the full attended nocturnal polysomnography remains the gold standard for diagnosis of paediatric OSAHS.

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