

Diagnosis of the Obstructive Sleep Apnoea Syndrome

a report by

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In the last two decades, the awareness of obstructive sleep apnoea (OSA) and its deleterious consequences on patients' health, quality of life, cognitive performance (such as driving capacity and attention capacity) have been steadily increasing. Repeated episodes of upper-airway obstruction – associated with increased respiratory effort – cause repetitive complete or incomplete cessation of air flow, so-called apnoeas and hypopnoeas and may trigger cortical arousals in order to restore normal breathing. Apnoeas and hypopnoeas per hour of sleep are calculated as apnoea/hypopnoea index (AHI) or respiratory-disturbance index (RDI). Daytime fatigue and sleepiness from respiratory-related sleep disruption (AHI >5 episodes per hour (>5/h)) are commonly referred as the OSA syndrome (OSAS). According to an updated International Classification of Sleep Disorders, the diagnosis is also made with an RDI ≥ 15 , irrespective of symptoms.¹ OSAS is now the best-recognised and most prevalent breathing disturbance in sleep,² affecting between 2% and 26% of the general population, depending on sex, age and criteria for syndrome definition.^{3,4}

The syndrome has attracted even more interest recently, as it was recognised as an independent cardiovascular risk factor and studies on the treatment of OSAS have postulated a risk reduction of fatal and non-fatal cardiovascular events.^{5,6} Nonetheless, it is estimated that 90% of people with the condition remain undiagnosed.⁷ Therefore, the primary objective of clinical pre-test evaluation and overnight testing should focus on a timely, cost-effective and targeted diagnostic approach to identify those who will benefit from treatment. Ideally, diagnosis would lead physicians to identify those patients with potential benefit from treatment and avoid

trying it on those who will not.⁸ Focusing on symptoms rather than respiratory parameters may better address outcome parameters that are relevant for patients, which should be adopted as the gold standard of OSAS diagnosis instead of number counts of respiratory disturbance parameters, oxygen dip rates or arousals.

Pre-test Evaluation for Suspected OSAS

Patient History

The diagnosis of OSAS is first suspected on clinical grounds based on a typical history. Patients complain of non-restoring sleep, daytime fatigue and sleepiness, sometimes even sleep attacks. Sleepiness is frequently reported in situations of reduced attention, such as driving on motorways, and at times of rest or inactivity. Some patients also complain of morning symptoms such as headaches and fatigue, others suffer from mood disturbance. Loud snoring, apnoeas and gasping or choking are witnessed by bed partners. Notably, partners often ask patients to seek medical help because they better recognise the loss of attention, concentration and interest, as the disease evolves gradually and patients become accustomed to their sleepiness, unaware of their evolving symptoms. Some patients even report previous workplace or driving accidents, or near misses. Quality of life and social contacts are often seriously impaired. Subjective rating tests of sleepiness include the Epworth Sleepiness Scale, Profile of Mood States and the Stanford Sleepiness Scale.⁹⁻¹¹ Of these, the Epworth Sleepiness Scale is most commonly used as, in different studies, a more significant effect on the extent of impairment with OSAS was shown, compared to normal subjects.^{12,13} Impaired-health-related quality of life may be assessed by the SF-36 questionnaire.¹⁴

Clinical Findings

Middle age and male gender are strong predictors of OSA.¹⁵ Although the male predisposition of airway collapse in sleep has been known for some years, patho-anatomic and pathophysiological reasons for this are not fully elucidated.¹⁶⁻¹⁹ Many patients with OSAS have an anatomically small airway due to obesity, enlarged tonsils and adenoids or narrowing by bony structure such as retrognathia.²⁰ A high Mallampati score, which is assessed by simple inspection of the oral cavity, represents an important predisposing factor for OSAS.²¹ Neck circumference has been shown to correlate even better with oxygen-saturation dip rates than general obesity, which itself is also a significant predictor for OSAS.^{15,22} A variety of upper-airway imaging modalities have shown potential to gain insight into the pathogenesis of sleep apnoea and prediction for successful treatment outcomes, but are not yet routinely part of the basic diagnostic approach in most sleep laboratories.²³ Arterial hypertension is common, the association of OSAS with hypertension having been demonstrated with large, population-based studies.²⁴ As a consequence



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of nocturnal sympathetic activation, the normal night-time 'dipping' of blood pressure is blunted.²⁵ If this is suspected, 24-hour blood-pressure monitoring is recommended.

Tests for Cognitive Performance

Objective assessment of cognitive performance in OSAS can be conducted with a variety of tests that are capable of assessing for attention, memory and learning, as well as planning skills and problem solving. Relevant impairment of all cognitive areas has been documented in population-based studies, including patients with an AHI as high as 30/h.²⁶ However, effects of OSAS on sleepiness seem to be higher than on cognitive dysfunction, which was also supported by experimental evidence.²⁷

Objective Tests for Sleepiness

Sleepiness can be quantified to some extent by polysomnographic tests – the Multiple Sleep Latency Test (MSLT) and the Maintenance of Wakefulness Test (MWT).²⁸ During the MSLT, the subjects' tendency to fall asleep during four daytime nap opportunities is measured, while the MWT tests the subjects' capability to stay awake for as long as possible in repetitive trials in a darkroom. Both the MSLT and MWT do not discriminate well between patients with sleep disorders and the normal population, but both tests show appropriate changes between pre- and post-treatment testing and subsequent testing after manipulations intended to alter sleepiness or alertness. Additionally, the presence of two or more sleep-onset rapid eye-movement periods on the MSLT is a common finding in narcolepsy patients.²⁸

Daytime vigilance can also be measured by the Oxford Sleep resistance (OSLER(r)) test.^{29,30} The OSLER test and environment are comparable to the MWT. The mean time until seven successive responses to a light signal of three seconds are missed and the mean number of missed stimuli per minute are recorded during four test sessions on the same day.³¹ As a most important advantage, the test can be performed unattended with no electroencephalogram (EEG) electrodes attached, making it a less expensive and less time-consuming option.

Measurement Techniques for Respiratory Disturbance in Sleep

Polysomnography

The confirmation of the OSAS diagnosis requires the documentation of sleep-related breathing disturbances. According to current standards this is performed by polysomnography, an overnight study in a quiet room using techniques to assess sleep and wakefulness – electroencephalography, electro-oculography and electromyography. Simultaneously, cardiorespiratory function (i.e., air flow, chest-wall motion, pulse oximetry, electrocardiogram (ECG)) is monitored. Nasal air flow is best measured with a nasal cannula, and thoraco-abdominal movement with inductive respiratory plethysmography (RP).³² Audiovisual recordings are included in most studies and polysomnography is supervised by a technician.

Analysis requires tedious manual scoring, however, the technique has indisputable merits and advantages compared to limited diagnostic systems. With the inclusion of an EEG, sleep disruption caused by apnoeas and hypopnoeas and even more subtle respiratory effort-related arousals are registered. The average number of apnoeas and hypopnoeas occurring per hour of sleep are commonly referred as the AHI or RDI. Periodic limb

movements are also routinely recorded with EMG electrodes to the fibular muscles. Limb movements may provoke repeated arousals, which are easily recognised on the EEG and may also cause daytime sleepiness. However, in patients evaluated for OSAS, periodic leg movements are often incidental findings and are unlikely to contribute to daytime fatigue and sleepiness.³³ With the custom addition of video surveillance, even more information is taken from in-laboratory sleep studies, e.g., the occurrence of parasomnias, epilepsy or sleep choking. In 'split-night' studies, the night is split in two: the first hours are for diagnosis and the second half is used for supervised nasal continuous positive airway pressure (nCPAP) titration. Polysomnography is therefore regarded as the gold standard for the diagnosis of OSAS by many authorities.

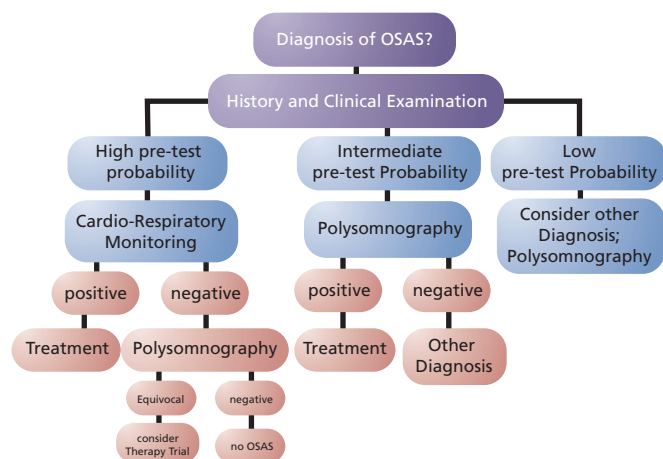
Several studies have shown that variables derived from polysomnography cannot accurately predict which patients will benefit from CPAP therapy and polysomnography has not been proven to be any more accurate and cost-effective than limited cardiorespiratory monitoring (CRM) in a randomised trial.^{34,35} Moreover, it remains unclear which level of severity of sleep-disordered breathing recorded during a polysomnography warrants treatment. Thus, symptomatic patients with mild to moderate OSAS (AHI 5/h-30/h) have experienced improvements in sleepiness and other outcomes. Conversely, asymptomatic subjects with high AHIs (>30/h) did not improve their quality of life, symptoms, objective vigilance or blood pressure during CPAP therapy.³⁶ This may be explained, in part, by a lack of strong relationships between conventional nocturnal measures such as arousals or respiratory events and daytime function in patients with OSAS.³⁷

CRM

Access to polysomnography has been restricted due to its cost and limited availability,³⁸ which has been recognised by US and European experts.³⁹ Bearing in mind the evidence that untreated sleep apnoea is deleterious to patients and expensive to the healthcare budget,^{40,41} limited in-laboratory and even portable home-based sleep study devices, henceforth CRM, have emerged. Other terms that have been used instead of CRM include portable diagnostic system, portable monitoring device, modified portable sleep apnoea testing or type-3 monitors. CRM incorporates a minimum of four channels, including signals of air flow (at least two channels of respiratory movement or respiratory movement and air flow, measured with thermistors or pressure curves as surrogates of air flow), heart rate or ECG, and oxygen saturation. Some CRM devices also register snoring sounds, body position and leg movements. CRM may be performed attended or unattended in a hospital room or as an outpatient study in the patient's home, which offers a potential advantage in terms of improved sleep quality in the patient's habitual environment.⁴²

In 2003, a systematic review identified 12 studies comparing diagnostic performance of polysomnography and CRM.⁴³ In a recent update, another six studies were added.⁴⁴ The diagnostic accuracy was defined as the ability of respiratory polygraphy to modify the probability that a patient had an AHI >15/h by polysomnography. Based on a pre-test probability of 64%, the post-test probability after a negative test result would range from 8% (negative likelihood ratio of 0.05) to 23% (negative likelihood ratio of 0.20). The positive likelihood ratios ranged from 1.8 to 23.8 for all studies, and from 5.7 to 23.8 for the evidence level-I studies. The post-test probability after a positive test result would range from 98% (positive likelihood ratio of 23.8) to 90% (positive likelihood ratio of 5.7). However, no outcome-oriented scientific evidence for polysomnography as the best

Figure 1



diagnostic tool to decide which patient will benefit from treatment has been published so far. Thus, it has not been shown that symptom relief, daytime vigilance, quality of life, risk for accidents or cardiovascular disease are superior if the diagnosis is based on polysomnography compared to CRM and the question remains as to how much polysomnography contributes to treatment decision compared to pure clinical judgement or less-expensive tools such as CRM.^{35,42,45}

In a study on outcomes of different nCPAP modes, patients diagnosed by CRM showed treatment effect sizes in respect of respiratory parameters, subjective and objective sleepiness that were comparable to earlier studies with OSAS diagnosed by polysomnography.^{34,46} In a recent trial, CRM performed as well as polysomnography in the selection of patients who would benefit from nCPAP therapy, challenging polysomnography as the only possible way to diagnose OSA.⁸ Further research on indications of different diagnostic pathways has been strongly encouraged.^{43,47}

Pulse Oximetry

Pulse oximetry is non-invasive, convenient and widely used in sleep medicine. The technique performs well in tracking fluctuations in arterial oxygen saturation that are characteristic for repetitive breathing disturbance in patients with sleep apnoea. It is regularly integrated into polysomnography and CRM and, by itself, is commonly used in 'screening' for sleep apnoea.

In clinical practice, scoring of desaturations and pulse variation is performed by computed analysis on most occasions. When compared to polysomnography, the sensitivity of pulse oximetry ranged from 88% to 98%, and the specificity from 40% to 88% if an AHI of 10/h or 15/h measured was defined as the upper limit of normal.⁴⁸ Thus, pulse oximetry is not routinely recommended for the diagnosis of OSAS. Most importantly, a 'negative' pulse oximetry study should not preclude patients with suspected sleep apnoea from a comprehensive sleep study. However, pulse oximetry may be useful in the monitoring of treatment success in OSAS patients with documented oxygen desaturations prior to initiation of treatment.

An Alternative Approach to the Diagnosis of OSAS

Clinical prediction rules have been developed to diagnose OSAS.⁴⁹⁻⁵² Predictors of sleep apnoea included neck circumference, hypertension, habitual snoring and bed-partner reports of nocturnal gasping/choking, among others. In clinical practice, prediction rules can help to prioritise

patients for further testing but, by themselves, are rarely used to make a final diagnosis.

In a 2006 study, clinical judgement was compared to polysomnography in the prediction of success of nCPAP treatment.⁵³ A positive response to a two-week trial of empiric auto-CPAP therapy was superior to polysomnography in identifying snorers with excessive sleepiness who suffered from OSAS and successfully used CPAP for more than four months.⁵³ This study was the first to compare clinical judgement to polysomnography in the prediction of daytime symptoms. It was concluded that a trial of CPAP therapy may be able to identify patients who benefit from CPAP and reduce the need for polysomnography. Nonetheless, many physicians and patients prefer to establish a diagnosis before initiating a potentially long-lasting treatment.

Cost Utility of Diagnostic Approaches to the Diagnosis of Sleep Apnoea

Timely and adequate treatment of OSAS is crucial for patients in respect of daytime neuropsychological performance and vigilance, and in reducing arterial blood pressure and deleterious metabolic consequences.⁵⁴⁻⁵⁷ Recognition and treatment of OSAS also goes towards avoiding workplace and traffic accidents,⁵⁸ for example, in the high-risk population of long-haul lorry drivers and railway train engineers. Untreated OSAS patients are at risk of inability to work. This is important, as the highest prevalence of OSAS occurs in the middle-aged population.

In an analysis comparing polysomnography, CRM and no testing, it was concluded that the cost utility of polysomnography in the diagnosis of OSAS compared favourably with that of other procedures for which society judges the added utility per dollar spent to be worthwhile.⁵⁹ However, polysomnography has not been proven to be more cost-effective than 'limited' (e.g., CRM) diagnosis in randomised controlled trials on sleep-related respiratory disorders.³⁵

In Switzerland, pulmonologists have recorded 11,4875 CRM in a central database over 30 months. In cases of diagnostic uncertainty after CRM, additional polysomnography was performed. It was concluded that, in selected patients with clinically suspected OSAS, CRM allowed accurate and simple diagnosis of OSAS and that, according to the practice in Switzerland, additional polysomnography was required only in 3.5%.⁴⁴ In this registry, direct costs of RP have been compared to direct costs for polysomnography, suggesting relevant cost savings, still taking inconclusive RP studies into account. However, this assumption was limited by the lack of cost-utility analysis for both methods.

Clinical Implications

Daytime sleepiness, impaired cognitive performance and quality of life lead patients to seek medical help. OSAS is now well recognised by general practitioners, who will refer their patients to pulmonologists with experience in sleep medicine or specialised sleep laboratories. Tools to non-invasively diagnose OSA are available. A flow diagram to the diagnostic approach is proposed in Figure 1. As an increasing body of evidence points to an association of OSAS and adverse cardiovascular risk, the question remains whether screening could benefit patients with the condition as the evidence supporting the favourable effects of treatment is steadily growing. Recently, screening using nocturnal oximetry for the detection of sleep-related breathing disturbances was recommended for patients with heart failure.⁶⁰ However, indications to

screen for OSA and target subgroups remain to be defined. In a clinical update, experts in the field recommended considering OSA in high-risk patients, especially obese (body mass index >30kg/m²) with refractory hypertension and 'non-dippers'.⁶¹

Conclusion

As in many other diseases, patient history is still the most important diagnostic tool for the diagnosis of sleep apnoea. Fatigue and a high subjective propensity to fall asleep during the daytime, a history of snoring and breathing pauses during sleep, combined with

anthropometric risk factors, make the diagnosis most probable. With a high index of suspicion, simple CRM is appropriate and probably cost-effective to confirm the diagnosis. Patients with an equivocal history or inconclusive result after CRM should be offered a full night of polysomnography. In experienced hands, pulse oximetry may be used for screening purposes in well-selected patients; the method also has value in the control of patients under CPAP treatment, providing oxygen desaturations have been documented prior to treatment. In diagnostic uncertainty after equivocal sleep studies, a therapeutic trial should be warranted. ■

- American Academy of Sleep Medicine (AASM), International Classification of Sleep Disorders, Westchester, AASM 2005.
- Kryger MH, Diagnosis and management of sleep apnea syndrome, *Clin Cornerstone*, 2000;2(5):39–47.
- Young T, Palta M, Dempsey J, et al., The occurrence of sleep-disordered breathing among middle-aged adults, *N Engl J Med*, 1993;328(17):1230–5.
- Young T, Peppard PE, Gottlieb DJ, Epidemiology of obstructive sleep apnea: a population health perspective, *Am J Respir Crit Care Med*, 2002;165(9):1217–39.
- Peppard PE, Young T, Palta M, Skatrud J, Prospective study of the association between sleep-disordered breathing and hypertension, *N Engl J Med*, 2000;342(19):1378–84.
- Marin JM, Carrizo SJ, Vicente E, Agusti AG, Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study, *Lancet*, 2005;365(9464):1046–53.
- Young T, Evans L, Finn L, Palta M, Estimation of the clinically diagnosed proportion of sleep apnea syndrome in middle-aged men and women, *Sleep*, 1997;20(9):705–6.
- Whitelaw WA, Brant RF, Flemons WW, Clinical usefulness of home oximetry compared with polysomnography for assessment of sleep apnea, *Am J Respir Crit Care Med*, 2005;171(2):188–93.
- Bloch KE, Schoch OD, Zhang JN, Russi EW, German version of the Epworth Sleepiness Scale, *Respiration* 1999;66(5):440–7.
- Beutler LE, Ware JC, Karacan I, Thornby JI, Differentiating psychological characteristics of patients with sleep apnea and narcolepsy, *Sleep*, 1981;4(1):39–47.
- Kribbs NB, Pack AI, Klein LR, et al., Effects of one night without nasal CPAP treatment on sleep and sleepiness in patients with obstructive sleep apnea, *Am Rev Respir Dis*, 1993;147(5):1162–8.
- Hardinge FM, Pitson DJ, Stradling JR, Use of the Epworth Sleepiness Scale to demonstrate response to treatment with nasal continuous positive airways pressure in patients with obstructive sleep apnoea, *Respir Med*, 1995;89(9):617–20.
- Engleman HM, Asgari-Jirhandeh N, McLeod AL, et al., Self-reported use of CPAP and benefits of CPAP therapy: a patient survey, *Chest* 1996;109(6):1470–6.
- Ware JE, Snow KK, Kosinski M, Gandek B, SF-36 health survey, manual and interpretation guide, Boston: The Health Institute, New England Medical Center; 1993.
- Viner S, Szalai JP, Hoffstein V, Are history and physical examination a good screening test for sleep apnea?, *Ann Intern Med*, 1991;115(5):356–9.
- White DP, Lombard RM, Cadieux RJ, Zwillich CW, Pharyngeal resistance in normal humans: influence of gender, age, and obesity, *J Appl Physiol*, 1985;58(2):365–71.
- Thurnheer R, Wraith PK, Douglas NJ, Influence of age and gender on upper airway resistance in NREM and REM sleep, *J Appl Physiol*, 2001;90(3):981–8.
- Carden K, Malhotra A, The debate about gender differences in obstructive sleep apnea, *Sleep Med*, 2003;4(6):485–7.
- Collop NA, Adkins D, Phillips BA, Gender differences in sleep and sleep-disordered breathing, *Clin Chest Med*, 2004;25(2):257–68.
- Isono S, Remmers JE, Tanaka A, et al., Anatomy of pharynx in patients with obstructive sleep apnea and in normal subjects, *J Appl Physiol*, 1997;82(4):1319–26.
- Liistro G, Rombaux P, Belge C, High Mallampati score and nasal obstruction are associated risk factors for obstructive sleep apnoea, *Eur Respir J*, 2003;21(2):248–52.
- Davies RJ, Stradling JR, The relationship between neck circumference, radiographic pharyngeal anatomy, and the obstructive sleep apnoea syndrome, *Eur Respir J*, 1990;3(5):509–14.
- Ahmed MM, Schwab RJ, Upper airway imaging in obstructive sleep apnea, *Curr Opin Pulm Med*, 2006;12(6):397–401.
- Nieto FJ, Young TB, Lind BK, et al., Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study, Sleep Heart Health Study, *JAMA*, 2000;283(14):1829–36.
- Portaluppi F, Provini F, Cortelli P, et al., Undiagnosed sleep-disordered breathing among male nondippers with essential hypertension, *J Hypertens*, 1997;15(11):1227–33.
- Engleman HM, Douglas NJ, Sleep, 4: sleepiness, cognitive function, and quality of life in obstructive sleep apnoea/hypopnoea syndrome, *Thorax*, 2004;59(7):618–22.
- Martin SE, Engleman HM, Deary IJ, Douglas NJ, The effect of sleep fragmentation on daytime function, *Am J Respir Crit Care Med*, 1996;153(4)(Pt 1):1328–32.
- Arand D, Bonnet M, Hunwitt T, et al., The clinical use of the MSLT and MWT, *Sleep*, 2005;28(1):123–44.
- Bennett LS, Stradling JR, Davies RJ, A behavioural test to assess daytime sleepiness in obstructive sleep apnoea, *J Sleep Res*, 1997;6(2):142–5.
- Mazza S, Pepin JL, Deschaux C, et al., Analysis of error profiles occurring during the OSLER test: a sensitive mean of detecting fluctuations in vigilance in patients with obstructive sleep apnea syndrome, *Am J Respir Crit Care Med*, 2002;166(4):474–8.
- Priest B, Brichard C, Aubert G, et al., Microsleep during a simplified maintenance of wakefulness test: a validation study of the OSLER test, *Am J Respir Crit Care Med*, 2001;163:1419–25.
- Thurnheer R, Xie X, Bloch KE, Accuracy of nasal cannula pressure recordings for assessment of ventilation during sleep, *Am J Respir Crit Care Med*, 2001;164(10)(Pt 1):1914–9.
- Chervin RD, Periodic leg movements and sleepiness in patients evaluated for sleep-disordered breathing, *Am J Respir Crit Care Med*, 2001;164(8)(Pt 1):1454–8.
- Kingshott RN, Vennelle M, Hoy CJ, et al., Predictors of improvements in daytime function outcomes with CPAP therapy, *Am J Respir Crit Care Med*, 2000;161(3)(Pt 1):866–71.
- Douglas NJ, Home diagnosis of the obstructive sleep apnoea/hypopnoea syndrome, *Sleep Med Rev*, 2003;7(1):53–9.
- Barbe F, Mayorals LR, Duran J, et al., Treatment with continuous positive airway pressure is not effective in patients with sleep apnea but no daytime sleepiness, a randomized, controlled trial, *Ann Intern Med*, 2001;134(11):1015–23.
- Kingshott RN, Engleman HM, Deary IJ, Douglas NJ, Does arousal frequency predict daytime function?, *Eur Respir J*, 1998;12(6):1264–70.
- Pack AI, Sleep-disordered breathing: access is the issue, *Am J Respir Crit Care Med*, 2004;169(6):666–7.
- Flemons WW, Douglas NJ, Kuna ST, et al., Access to diagnosis and treatment of patients with suspected sleep apnea, *Am J Respir Crit Care Med*, 2004;169(6):668–72.
- Kapur V, Blough DK, Sandblom RE, et al., The medical cost of undiagnosed sleep apnea, *Sleep*, 1999;22(6):749–55.
- BaHammam A, Delaive K, Ronald J, et al., Health care utilization in males with obstructive sleep apnea syndrome two years after diagnosis and treatment, *Sleep*, 1999;22(6):740–7.
- Kingshott RN, Douglas NJ, The effect of in-laboratory polysomnography on sleep and objective daytime sleepiness, *Sleep*, 2000;23(8):1109–13.
- Flemons WW, Littner MR, Rowley JA, et al., Home diagnosis of sleep apnea: a systematic review of the literature, an evidence review cosponsored by the American Academy of Sleep Medicine, the American College of Chest Physicians, and the American Thoracic Society, *Chest*, 2003;124(4):1543–79.
- Thurnheer R, Bloch KE, Laube I, et al., Respiratory polygraphy in sleep apnea: report of the Swiss respiratory polygraphy registry and systematic review of the literature, *Swiss Med Wkly*, 2007; in press.
- Whittle AT, Finch SP, Mortimore IL, et al., Use of home sleep studies for diagnosis of the sleep apnoea/hypopnoea syndrome, *Thorax* 1997;52(12):1068–73.
- Nussbaumer Y, Bloch KE, Genser T, Thurnheer R, Equivalence of autoadjusted and constant continuous positive airway pressure in home treatment of sleep apnea, *Chest*, 2006;129(3):638–43.
- Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research, The Report of an American Academy of Sleep Medicine Task Force, *Sleep*, 1999;22(5):667–89.
- Bloch KE, Getting the most out of nocturnal pulse oximetry, *Chest*, 2003;124(5):1628–30.
- Flemons WW, Whitelaw WA, Brant R, Remmers JE, Likelihood ratios for a sleep apnea clinical prediction rule, *Am J Respir Crit Care Med*, 1994;150(5)(Pt 1):1279–85.
- Harding SM, Prediction formulae for sleep-disordered breathing, *Curr Opin Pulm Med* 2001;7(6):381–5.
- Kirby SD, Eng P, Danter W, et al., Neural network prediction of obstructive sleep apnea from clinical criteria, *Chest*, 1999;116(2):409–15.
- Hoffstein V, Szalai JP, Predictive value of clinical features in diagnosing obstructive sleep apnea, *Sleep*, 1993;16(2):118–22.
- Senn O, Brack T, Russi EW, Bloch KE, A continuous positive airway pressure trial as a novel approach to the diagnosis of the obstructive sleep apnea syndrome, *Chest*, 2006;129(1):67–75.
- Roehrs T, Merriam M, Pedrosi B, et al., Neuropsychological function in obstructive sleep apnea syndrome (OSAS) compared to chronic obstructive pulmonary disease (COPD), *Sleep*, 1995;18(5):382–8.
- Douglas NJ, Engleman HM, Effects of CPAP on vigilance and related functions in patients with the sleep apnea/hypopnea syndrome, *Sleep*, 2000;23(Suppl.):4):S147–9.
- Pepperell JC, Ramdassingh-Dow S, Crosthwaite N, et al., Ambulatory blood pressure after therapeutic and subtherapeutic nasal continuous positive airway pressure for obstructive sleep apnoea: a randomised parallel trial, *Lancet*, 2002;359(9302):204–10.
- Punjabi NM, Ahmed MM, Polotsky VY, et al., Sleep-disordered breathing, glucose intolerance, and insulin resistance, *Respir Physiol Neurobiol*, 2003;136(2-3):167–78.
- Findley L, Smith C, Hooper J, et al., Treatment with nasal CPAP decreases automobile accidents in patients with sleep apnea, *Am J Respir Crit Care Med*, 2000;161(3)(Pt 1):857–9.
- Chervin RD, Murman DL, Malow BA, Totten V, Cost-utility of three approaches to the diagnosis of sleep apnea: polysomnography, home testing, and empirical therapy, *Ann Intern Med*, 1999;130(6):496–505.
- Series F, Kimoff RJ, Morrison D, et al., Prospective evaluation of nocturnal oximetry for detection of sleep-related breathing disturbances in patients with chronic heart failure, *Chest*, 2005;127(5):1507–14.
- Wolk R, Kara T, Somers VK, Sleep-disordered breathing and cardiovascular disease, *Circulation*, 2003;108(1):9–12.