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Sleep-related breathing disorders · 3

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How to reach a diagnosis in patients who may have the sleep apnoea/hypopnoea syndrome

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The sleep apnoea/hypopnoea syndrome is the commonest "new" disease to be discovered for decades. Respiratory clinicians are now frequently faced with the problem of how to achieve a diagnosis most cost effectively in patients who may have the sleep apnoea/hypopnoea syndrome. Their strategy must look beyond merely confirming or refuting the diagnosis of the sleep apnoea/hypopnoea syndrome, and must allow them to pursue a differential diagnosis until the cause of the patient's symptoms is identified and successful treatment initiated. This means that respiratory physicians involved in the care of such patients should have some expertise in the neurological, psychological, and drug-related causes of daytime sleepiness, direct or indirect access to the techniques required to make such a diagnosis, and must be sufficiently flexible to use different diagnostic techniques for patients with different collections of symptoms.

This review will examine the limitations of the techniques available for the diagnosis of the sleep apnoea/hypopnoea syndrome, highlight the deficiencies in our knowledge, and attempt to build up a rational scheme for achieving a diagnosis in such patients.

Clinical features

Unfortunately, the diagnosis of the sleep apnoea/hypopnoea syndrome can rarely, if ever, be made from history and examination alone. This contrasts sharply with the situation in many other common conditions such as angina, asthma, and chronic bronchitis and emphysema, where a confident diagnosis can be made in most patients on the basis of the history, with or without examination. In patients presenting to clinics because of possible sleep apnoea, the main symptoms found to be more common in those subsequently found to have the sleep apnoea/hypopnoea syndrome are sleepiness,[1] nocturnal choking,[1 2] impotence,[1] and bed partner's observation of apnoeas.[1 2] However, none of these are sufficiently specific to be diagnostically useful, the most helpful being the presence of apnoeas in 75% of patients with the sleep apnoea/hypopnoea syndrome but apnoeas were also present in about 60% of patients without it. Thus, symptoms alone cannot usefully predict which patient in a specialist clinic will turn out to have sleep apnoea.

Features on examination found to be suggestive of the sleep apnoea/hypopnoea syndrome include being male,[1 2] obese,[1 2] and hypertensive,[2] and the presence of a narrowed pharynx with an enlarged uvula.[1] Even when symptoms and examination were combined, only about 50% of patients with the sleep apnoea/hypopnoea syndrome and 70% of patients without it were correctly identified by an experienced clinician[1] and thus further investigation is essential.

Monitoring techniques

The sleep apnoea/hypopnoea syndrome was originally diagnosed by polysomnography which involved overnight recording of sleep, breathing patterns, and oxygenation (table). However, the need for this relatively expensive investigation has been questioned as a result of both the limitation of health care budgets and the flood of patients being referred for investigation. The diagnostic value of the separate components of polysomnography have therefore been examined.

The recording of sleep quality and duration appears to play little part in the clinical diagnosis of classical sleep apnoea/hypopnoea syndrome according to a study of 200 patients.[3] Restudying patients who either slept for <3 hours/night or had no rapid eye movement (REM) sleep did not change the clinical diagnosis, and the identification of early REM sleep was not diagnostically helpful either.[3] One of the major reasons quoted for recording sleep

Variables which may be recorded during polysomnography

- Sleep:
  - Electroencephalogram
  - Electro-oculogram
  - Electromyogram
- Oxygenation
  - Oxygen saturation, ear or finger
- Breathing pattern:
  - Airflow by:
    - thermocouples
    - thermistor
    - end tidal CO_2 pressure
  - Thoracoabdominal movement by:
    - inductance plethysmography
    - impedance
    - strain gauge
  - Snoring
  - Oesophageal pressure (optional)
- Miscellaneous:
  - Leg movement by EMG or movement detector
  - Position
  - Video

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is to use total sleep time as the denominator for the apnoea + hypopnoea frequency. However, 89 of 91 patients found to have >15 apnoeas + hypopnoeas/hour of sleep also had >10 apnoeas + hypopnoeas/hour in bed and only six of the 109 with <15 apnoeas + hypopnoeas/hour when asleep exceeded the 10 apnoeas + hypopnoeas/hour in bed threshold. All of these six had 10–13 apnoeas + hypopnoeas/hour of sleep.[3] The expense of recording sleep does not therefore appear to be justified on the grounds of providing the denominator for apnoea + hypopnoea frequency.

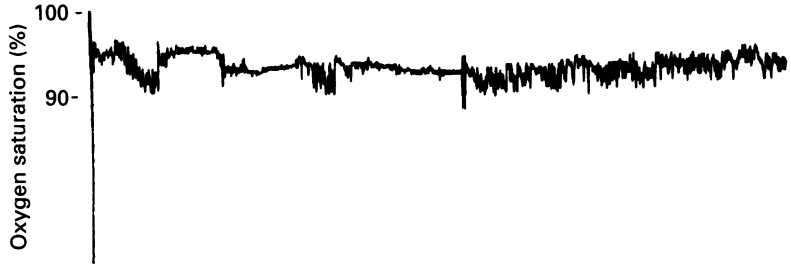
The major use of sleep recording may be in the identification of transient arousals. At present, however, there is no agreement on the definition of arousal,[4 5] and it is probable that cortical electroencephalographic (EEG) changes are not needed to produce the pathophysiological consequences of arousal.[6] This is an area of major research activity at present but, from the clinical point of view, it is not a reason for recording sleep quality overnight. Indeed, it may well be that arousals will be better detected by looking at changes in blood pressure[6] or respiratory pattern than by EEG.

The neuromuscular variable that should be recorded during a sleep study is limb movement, as periodic limb movement disorder (PLMD) may result in daytime sleepiness. PMLD is found in at least 5% of patients referred to a respiratory sleep clinic[3] and patients may benefit from treatment of this condition. The classical way of diagnosing PLMD has been by recording leg electromyography (EMG) but, more recently, limb movement detectors or video have been used, although these have not yet been adequately validated against EMG measurement. Another area requiring clarification is the relationship that PLMDs have with arousal and with symptoms. Many patients diagnosed as having this condition are not sleepy and the frequency of leg jerks can vary enormously from night to night.

Many different respiratory sensors have been used to detect the sleep apnoea/hypopnoea syndrome, including oximetry, airflow signals, snoring detectors, thoracoabdominal movement, and oesophageal pressure. The system most widely available is oximetry which, in experienced hands, can be extremely useful. When tested against detailed polysomnography, oximetry alone can detect about two thirds of patients with the sleep apnoea/hypopnoea syndrome. This is best done by a trained observer looking at the pattern of desaturation.[3 7] Current computerised systems to detect recurrent desaturations do not give such useful results, with a sensitivity of about 40% but a specificity of 97%.[3 8] The positive predictive value was 86–93% (depending on the criteria used), with a negative value of 66–77%. It has been suggested that patients who spend less than 1% of the night at a saturation of below 90% do not have the sleep apnoea/hypopnoea syndrome,[8] but this has not been confirmed in other large studies.[3 7] These figures refer to the use of oximetry in the sleep apnoea/hypopnoea syndrome, and it must be remembered that oximetry will be less useful in detecting patients with the upper airways resistance syndrome in which there may be recurrent arousal associated with upper airway narrowing but no change in ventilation and little or no saturation (see below).[9] Patients whose sleep apnoea/hypopnoea syndrome is not detected by oximetry tend to be younger and better oxygenated.[3] In such individuals long apnoeas are required before any detectable desaturation occurs. It is important to realise that the deterioration in daytime function[4] and the apnoea-related increase in blood pressure relates to the frequency of arousals and not to the extent of desaturation. Thus, patients frequently have severe apnoea/hypopnoea syndrome but normal oximetry traces (figure). One third of the patients who had more than 15 apnoeas + hypopnoeas/hour of sleep (median 28, maximum 47/hour) had fewer than five 4% desaturations/hour.[3] It is imperative that this limitation of oximetry is realised by all who use this technique in isolation, and that patients who are symptomatic but have normal oximetry values are investigated further.

The sleep apnoea syndrome was initially diagnosed from recurrent episodes of flow cessation. More recently, however, it has been realised that events in which there is continued airflow but reduced thoracoabdominal movement – so called hypopnoeas – are also associated with recurrent arousals and similar clinical sequelae.[10] Indeed, even hypoventilation may not be necessary for the clinical features of the syndrome,[9] giving rise to the term the upper airways resistance syndrome. There is considerable confusion between centres with some diagnosing hypopnoeas, others partial airways obstruction, and others the upper airways resistance syndrome in similar patients. In some ways this difference is semantic, but it is important that the prevalence of the upper airways resistance syndrome in the absence of hypoventilation is clarified so that a rational plan for diagnosing such patients can be made. If upper airways resistance-induced arousals in the absence of hypopnoeas are common, then the diagnostic strategy must centre on proving the coincidence of an arousal with some relatively subtle respiratory change. This may be achieved by invasive recording techniques such as oesophageal pressure along with EEG monitoring[9] or, less invasively, by detecting inspiratory flow limitation or by static charge sensitive bed[11] or thoracoabdominal phase angle,[12] but these techniques need to be validated.

Many different methods are used to record flow during sleep studies. These include temperature based systems (thermocouples and thermisters), expired carbon dioxide detectors, tracheal sounds, or measurement of true flow using a face mask and pneumotachograph system. All are capable of detecting apnoeas with ease. However, it is important to realise that the duration of events will differ with differing detectors – temperature based devices gradually drifting to ambient in the absence of flow – and that the amount of change in flow signal permitted during an "apnoea" is rarely defined in studies and varies considerably from centre



Oxygen saturation over an eight hour night (x axis = time) in a patient with moderately severe sleep apnoea/hypopnoea syndrome with 23 apnoeas + hypopnoeas/hour of sleep, 25 arousals/hour of sleep, and a mean sleep latency of 1·4 minutes over five daytime sleep opportunities. This shows the relative normality of an oxygen saturation trace in a patient with severe consequences of respiratory related arousals.

to centre. We have recently queried whether there is any need to record a flow signal at all, and believe that apnoeas are detected adequately by inductance polysomnographic scoring of hypopnoeas.[13]

There are many different techniques used to record thoracoabdominal movement including inductance plethysmography, impedance pneumography, mercury strain gauges, piezoelectric systems, and static charged sensitive beds.[14] These give quantitatively very different results, although the differences are frequently glossed over when comparisons are made between studies. Indeed, often the technique used to determine thoracoabdominal movement may not be recorded at all. Thoracoabdominal movement can be used to classify apnoeas into central or obstructive, although this may not be a useful classification since many apnoeas classified as central respond to continuous positive airway pressure therapy.[15] This may either be because the events are initiated by upper airways occlusion reflexly inhibiting subsequent ventilatory effort, or because relatively poor thoracoabdominal signals are obtained from some individuals, particularly the grossly obese. The very rare true central apnoea can only be diagnosed by oesophageal manometry or respiratory muscle electromyography. The major use of the thoracoabdominal signal is to identify hypopnoeic events. Hypopnoeas are much better defined from inductance plethysmography than from conventional flow sensors as temperature based flow sensors do not provide a quantitative estimation of ventilation, there being little difference between the temperature of an expired volume of 100 ml compared with 1000 ml.[10] There is certainly no need to include in the definition of a hypopnoea any degree of desaturation as, like apnoeas, hypopnoeas which result in arousal produce pathophysiological sequelae even in the absence of desaturation.

Many different devices have been developed to record snoring,[16,17] and loud intermittent snoring has been seen as one of the pathognomonic features of the sleep apnoea/hypopnoea syndrome. However, the sensitivity of devices based on snoring alone has been poor at around 27% although the specificity has been high.[16] Thus, these devices should not be used in isolation to exclude the sleep apnoea/hypopnoea syndrome.

Limited sleep study equipment

A confusing array of limited sleep study devices is available which use varying combinations of the above sensors. It is beyond the scope of this article to compare and contrast their advantages and disadvantages and, indeed, in a rapidly changing market any such review would be outdated by the time it was published. The common factor between most of these systems is that they are relatively poorly validated and potential purchasers need to ensure that they realise the limitations of the system being considered, and carefully examine independent data on the false positives and false negatives produced by the system under consideration. Most such systems contain oximeters but, in some, the validation data suggest that little additional advantage is obtained from the other sensors.[16] This should clearly not be the case as adequate thoracoabdominal signals and leg movement signals will give rise to diagnostically useful information.[3]

Conclusions

It is difficult and dangerous to draw too many firm conclusions in this area when there are rapid changes occurring both in the definition of the disease and in the technology available. Nevertheless, clinical guidelines must be produced, however imperfect they may soon appear to be.

The first guideline must be that it is imperative that those performing sleep studies of whatever type are fully trained in the techniques employed. They must be aware of the advantages and disadvantages of the approach used, and particularly be alert to the frequency of and reasons for false positive and false negative studies. They must be fully conversant with all other conditions which enter into the differential diagnosis, and know how these should be investigated, even if they themselves are not going to treat these conditions. They must always put the results of studies into the clinical context of the patient's complaints.

Few centres can afford the luxury of performing polysomnography on all patients referred and, indeed, polysomnography is clearly not required for the clinical management of most patients. The approach adopted will depend upon the patient's presenting features and the facilities available. It is useful to divide new patients into at least four categories on the basis of their presenting features, as follows:

(1) Patients highly likely to have sleep apnoea.
(2) Simple snorers with no features of sleep apnoea.
(3) Patients with a moderate likelihood of having sleep apnoea.
(4) Patients who may have other diagnoses.

The diagnostic strategy used differs between the groups.

Patients highly likely to have sleep apnoea

In patients who fall asleep at least once a day when not in bed and are loud snorers with witnessed apnoeas and have no features suggestive of periodic limb movement disorder or narcolepsy, a limited sleep study will usually

suffice. The system used at present by the author records thoracoabdominal movement, airflow, oximetry, and leg movement. Many other systems, however, exist and all require further validation. Nevertheless, this approach allows patients with severe sleep apnoea to be diagnosed rapidly and then to pass on to a trial of continuous positive airway pressure.

Simple snorers with no features of sleep apnoea
Patients who snore but have no other features of the sleep apnoea syndrome who are considering upper airways surgery should have an overnight sleep study. As these patients are highly unlikely to have significant breathing disorders at night a limited sleep study will suffice, and only if this limited study is equivocal should a more detailed sleep study be carried out. This study should be able to document snoring, and the absence of snoring or its presence for only a short duration should lead to questioning of whether any intervention for the patient's alleged snoring is required.

Patients with moderate likelihood of sleep apnoea
It is the author's practice to perform overnight polysomnography in patients who give a fair but not totally convincing story of the sleep apnoea/hypopnoea syndrome. There is no good scientific validation for this stance, but these patients are often difficult to treat and it may be helpful to show an improvement in sleep quality and a reduction in arousal frequency with CPAP in patients who have mild sleep apnoea/hypopnoea syndrome and, equally, it may be helpful to show patients with normal results, who deny that they sleep adequately, precisely how well they slept.

Patients who may have other diagnoses
In patients with significant daytime sleepiness with no obvious drug or psychological cause who do not give a good history of the sleep apnoea/hypopnoea syndrome or of narcolepsy it is reasonable to perform overnight polysomnography, perhaps combined with a daytime multiple sleep latency test, both to quantify the severity of the daytime sleepiness and to help with the diagnosis of narcolepsy through the documentation of early REM sleep.[18]

The other categories of patient in whom overnight polysomnography is reasonable are patients with equivocal limited studies and those found to have the sleep apnoea/hypopnoea syndrome on limited sleep studies but who do not have a symptomatic improvement on CPAP, despite objectively measured good compliance. Further investigation should be carried out in these individuals to see if there is an alternative diagnosis and sometimes also to determine whether the CPAP pressure used actually minimises arousals.

This is just one of many schemes that have been proposed to diagnose patients who might have the sleep apnoea/hypopnoea syndrome.[19 20] It has the virtue of simplicity and does not require the use of complex regression equations or complicated algorithms, neither of which are well followed by most clinicians.

This scheme supposes access to limited sleep study equipment capable of measuring breathing pattern, snoring, oxygenation and leg movement. Such systems should soon become available in all district general hospitals. It is reasonable for hospitals without them to use oximetry for patients with a high probability of having the sleep apnoea/hypopnoea syndrome. Those who are confirmed on oximetry to have the sleep apnoea/hypopnoea syndrome can then be referred for CPAP therapy rapidly, but all other patients will need to be referred for limited sleep studies or for overnight polysomnography.

Diagnosing the sleep apnoea/hypopnoea syndrome cost effectively remains a major challenge for respiratory medicine. Respiratory physicians have shown that the measurement of many of the neurophysiological variables hitherto regarded as essential for its diagnosis are not necessary. It is imperative that respiratory physicians now clarify which respiratory variables must be recorded and how they should be analysed to produce cheap, preferably domiciliary, sleep recordings with high reliability and high positive and negative predictive values.

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