MANAGING FATIGUE IN TRANSPORT
The Role of Obstructive Sleep Apnea

Summary

Many overseas studies have shown obstructive sleep apnea to be a major cause of excessive tiredness with transport drivers, and hence the cause of serious motor vehicle accidents.

There is no reason to believe that the position in Australia will be markedly different from elsewhere, but Australian data is sparse. There is a need for extensive study of the sleep practices of Australian truck drivers.

Obstructive sleep apnea is readily and successfully treated with benefit to the health and well-being of the sufferers, and a corresponding reduction in their motor vehicle accident rates.

A mechanism should be sought for issuing licenses only to drivers cleared of untreated sleep disordered breathing.

1. INTRODUCTION

Obstructive sleep apnea[1] is one of the commonest and most serious causes of sleep disruption. The first symptom obvious to the sufferer, is excessive daytime sleepiness, usually associated with heavy snoring during sleep. One consequence of daytime sleepiness is high accident proneness. For this reason, the subject is of the highest importance to the Committee.

Obstructive sleep apnea is a particularly dangerous condition for three reasons. First, the sufferer is usually totally unaware of the cause of his condition, which manifests itself during unconsciousness. Declining health and work performance is often blamed as natural, due to increasing age. Second, from an insignificant start of mild snoring, progress to obstructive sleep apnea is slow, subtle, and insidious, moving through heavy snoring, to increasing frequency of apneas, leading ultimately to debilitating and fatal consequences. Third, conditions in which vested interests can intervene to inhibit progress in improving work practices are created by the high prevalence, and the inconspicuous nature of early symptoms. Often the sufferer and his employer do not want to know about it. These are matters, which the Committee needs to address in addition to more obvious causes of fatigue, such as hours of work.

Snoring has been known for as long as records have been kept. That it can lead to potentially fatal conditions became widely appreciated only after 1981. In that year Professor Colin E Sullivan of Sydney University demonstrated a successful method of treatment of obstructive sleep apnea (then called snoring sickness), thus opening the area to meaningful research. It has become a popular medical research topic around the world. From this research, a clear picture is emerging to a level where knowledge of the consequences of obstructive sleep apnea, and to a large degree, its causes, is useful in practice and is not a subject of debate. As with any medical condition, complete understanding will require continuing research.

To better understand ramifications of obstructive sleep apnea in the workplace, it is necessary to have some basic knowledge of its origins, effects on the person, and how it may be treated. This submission does not set out to cover in detail the 7,000 studies reported since 1981 in the medical literature. It tries to briefly review obstructive sleep apnea, its consequences, and treatment with appended references and copies of some brief published reviews. More detail is given to the subject of accidents, with copies of recent relevant papers, and abstracts of older work. Should further published information be required, it can be provided.

A good background to sleep disorders is given in *Wake Up America: A National Sleep Alert*, the Report of the National Commission on Sleep Disorders Research submitted to the Secretary, US Department of Health and Human Services, Volume 1, Executive Summary and Executive Report, January 1993 (not appended). Despite this report, which highlights the lack of awareness of sleep disorders in the

[1] Publications from the UK tend to use the diphthong as in “apnoea”. Apnea, from the Greek, means “without breath”, or the cessation of breathing.

community, and much recent publicity, sleep disorders are still under-diagnosed in the USA[2]. The position is almost certainly no better in Australia.

In the USA, the Federal Highway Administration of the Department of Transportation, in its report *Hours of Service of Drivers*, Volume 61, No 215, Part VI, 5 Nov 96 (copy available, but not appended), mentioned a study to be made of obstructive sleep apnea in relation to drivers. A recent Editorial[3] reviews the US scene, with references to practices, regulations, and pending legislation, none of which are held here or are appended.

In Australia, relevant reports on fatigue and medical assessment of drivers have issued[4,5] and are not appended.

2. OBSTRUCTIVE SLEEP APNEA

Mechanism

Several comprehensive reviews of obstructive sleep apnea were published up to 1994. As the subject has matured, reviews have tended towards specialist interests. Good cover from a patient's viewpoint is in a book *Snoring and Sleep Apnea: Personal and Family Guide to Diagnosis and Treatment* by Ralph Pascualy and Sally Warren Soest, Raven Press, 1994 (not appended). Appended are two reviews[6] on epidemiology which include broad coverage of obstructive sleep apnea, and a list of more recent reviews of limited scope[7].

Briefly:– the anatomy of the region around the mouth, nose, throat, and neck is complicated. It has to accommodate airflow to and from the lungs through the trachea (windpipe), larynx (voice box), and pharynx, to the mouth and nose (parts of the upper airway). Nearby, but separate, solids and liquids are processed in the mouth, followed by flow to the stomach through the esophagus (gullet) aided by the large tongue muscle. Thus there must be valving functions to keep the two pathways separate. There is no skeletal structure to maintain the airway open (patent). This is achieved by a series of dilator muscles in the pharynx.

Restorative sleep is rated equally with nutrition and exercise as necessary prerequisites for good health. Sleep has a number of stages indicated by changing shape of the electrical signals from the brain. The deepest sleep stage is called REM (rapid eye movement) sleep, when brain activity is high and muscles are most relaxed. It is necessary to go through complete cycles several times during the night for restorative sleep.

When the pharyngeal dilator muscles relax in the later sleep stages, the airway which they support narrows. To maintain the air volume needed by the lungs, the velocity must then increase. In so doing, there is a reduction of pressure (venturi effect), which reinforces the tendency for the airway to collapse. Under abnormal circumstances, collapse is excessive, causing soft tissues (palate) to vibrate (snore), and the airway may eventually close (apnea due to obstruction), though the muscles of breathing (mainly diaphragm) are still functioning. When this happens, blood oxygen levels plummet from the normal 98% saturation (hypoxia) with build-up of carbon dioxide (hypercapnia), leading to arousal, gasping, and resumption of breathing to restart the cycle. Usually the cycles repeat without awakening to consciousness.

The number of such events per hour is calculated as the apnea/hypopnea index (AHI). In severe cases, such events can occur hundreds of times each night. Treatment is usually considered necessary when the AHI is about 10.

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[2] Appendix 1

[3] Appendix 11

[4] Edited transcripts of a seminar held at Parliament House, Sydney, 14 Nov 94 have been published as *Staysafe 28 (1995) Sleep Disorders, Driver Fatigue and Safe Driving. First Report of the Joint Standing Committee on Road Safety of the 51st Parliament*, Sydney, NSW: Parliament of New South Wales

[5] *Medical Examinations of Commercial Vehicle Drivers*, prepared for the national Road Transport Commission and the Federal Office of Road Safety by the Australasian Faculty of Occupational Medicine ISBN 0 642 21209 0 November 1994

[6] Appendix 2 and 3

[7] Appendix 4

Other, less common sources of apnea are known. With central sleep apnea, the airway is open, but the muscles of breathing do not function. The condition often occurs along with obstructive sleep apnea (mixed apneas).

Prevalence

Numerous studies made on prevalence are reviewed in Appendices 2 and 3. The most complete report[8] on 602 employed people in the USA found that 24% of men and 9% of women had an AHI≥5.

Predisposing factors are male gender, post-menopausal female gender, obesity, and genetic predisposition (bone structure such as short neck or cranium shape providing a space too small to accommodate the tongue). Contributing factors include alcohol consumption.

Consequences

Cessation of breathing with arousals during sleep has the obvious consequence of reducing effective sleep time, thereby causing excessive daytime sleepiness. There are more subtle effects, because apneas tend to predominate when the latter sleep stages are entered (particularly REM). It is in these stages that the important hormones testosterone and growth hormone are produced. Deficiency of these results in sexual dysfunction and premature aging. Other hormone effects occur with natriuretic protein and endothelin; both involved in control of the cardiovascular system.

Such biochemical abnormalities could account for the recorded associations of obstructive sleep apnea with hypertension, stroke, congestive heart failure, pre-eclampsia in pregnancy, impotence, short-term memory loss, renal disease, diabetes, and glaucoma. These are not considered further here.

Diagnosis

Diagnosis is usually made by an overnight study (polysomnography or PSG) supervised by a technician in a sleep laboratory. Recordings are made of video, sound, airflow through the nose, blood oxygen levels (oximetry), movement of chest, abdominal, and leg muscles, and other functions such as electrocardiogram and electroencephalogram. The eight-hour recordings are then reviewed by a sleep specialist for diagnosis, and a treatment recommended. The study costs in the order of $1000.

Attempts to simplify this procedure include split night studies, when only half the night is spent in diagnostic mode and half in treatment mode with CPAP (continuous positive airways pressure).

Oximetry alone is simple and may give an indication of apneas.

Body mass index (BMI = Body weight in kg divided by height in metres) is a measure of obesity and an indicator of susceptible individuals.

Computer analysis of sound recorded by a microphone near the sleeper, or through a mask can be interpreted as a measure of measure apneas.

Neither sound recordings, oximetry, or BMI alone are adequate for specialist medical assessment, but may be useful screens.

Recently, ResMed Limited has released a device in their AutoSet™ series, which is suitable for home diagnosis. Tubes held in the nostrils overnight register airflow against time. Normal breathing is shown by a series of regular rounded curves. As the airway narrows, the shape of the curve changes with flattening at the top. When apnea occurs, the curve disappears completely, to leave a straight line. This is by far the most sensitive method of detection, and has been verified[9,10] as comparable to PSG.

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[8] Appendix 5
[9] Appendix 6
[10] Appendix 7

Treatment

Cutting a hole in the throat (tracheotomy) was the first and remains a successful, though unpopular treatment, except in emergencies.

Drugs (for example theophylline) have been tried with minimum effect.

Surgery is effective when the cause is an anatomic abnormality, as with enlarged adenoids or tonsils. Removal of tissue at the back of the mouth and/or tongue, by scalpel (for example, UPPP=uvulopalatopharyngoplasty), laser beam (for example, LAUP=laser-assisted uvuloplatoplasty), or radiofrequency has application in special cases. A fundamental limitation is that the location of the blockage can vary from place to place in the upper airway during the night.

Oral devices are being promoted. These either hold the tongue forward to stop it collapsing into the throat, or force the lower jaw forward to provide more space for the tongue.

Sullivan's nasalCPAP (continuous positive airway pressure) remains the method of choice, being non-invasive, and essentially 100% effective[11]. In operation, the airway is held open by pressure of air from a small blower, applied to the nose through a mask. The major limitation to reduced compliance due to discomfort. Generally the more severe the symptoms, the better the compliance.

Nasal CPAP

The standard method for prescribing nCPAP, is to follow the diagnostic night in the sleep laboratory with another technician-supervised night. The patient wears a CPAP device through which the technician manually increases the pressure to a level, which removes apneas, or reduces the number to an insignificant level. This pressure is then prescribed by the medical specialist to be the therapeutic pressure - usually in the range 5-20 cm water gauge.

Two further major developments need to be noted.

Bilevel CPAP (ResMed's VPAP for variable positive airways pressure) senses the wearers breathing cycle to raise the pressure during inhalation to the therapeutic level, then lower pressure during exhalation. This minimises the effort of breathing out against the therapeutic pressure. In practice the major use has been for non-Obstructive indications where ventilatory assistance is required.

Autosetting CPAP (ResMed's AutoSet) begins with the minimum pressure required to keep the device operable, say 4cm, which incurs minimum discomfort. The device then senses airflow on a breath-by-breath basis. By comparing the flow versus time curve on the current breath with the previous few breaths, it can determine when airway narrowing commences, well before symptoms develop. Then, and only then, does it increase pressure until the airflow curve returns to normal. With normal breathing restored pressure is reduced to the low level.

Note that this device does away with the need for sleep laboratory diagnosis. In fact it is clinically more effective than fixed level CPAP, because pressure is only applied when needed, and to the level required to restore normal breathing. In a given individual, apneas differ in severity and frequency from night to night and within one night's sleep.

To address the problem of discomfort, much effort has been put into design of the patient interface with the device (mask), and the provision of humidified air supply. These important developments are not considered further here.

To conclude the section on OSA, we may note that, unless permanent brain damage has occurred, most of the adverse consequences of OSA (including hypersomnolence and motor vehicle accident rate) are quickly reversible on successful treatment. Note also that CPAP is a treatment not a cure.

3. MOTOR VEHICLE ACCIDENTS AND OBSTRUCTIVE SLEEP APNEA

[11] Appendix 8

Appendix 9 lists 31 references, most with abstracts, going back to 1986, on studies relating motor vehicle accidents to obstructive sleep apnea in USA, Canada, France, Sweden, Switzerland, Germany, and Japan. Not all full text articles are held, but they can be obtained if requested. These articles are not reviewed in depth, but it might be noted that it was early recognised (last reference) that accidents due to sleepiness were generally more severe than those due to other causes of loss of consciousness, when there was often a premonition of trouble.

Of the more recent papers, reference 1[12] is an editorial giving an overview, with mention of recent US developments (the latter not appended). Reference 2[13] is a well structured Spanish study linking AHI to accidents. Full text is provided for studies in USA[14] and Germany[15]. Benefits of treating OSA are demonstrated (Appendix 9; ref 6, 12, 15, 19).

Truck drivers in the USA have a high incidence of sleep disordered breathing[16] and obesity (Appendix 9; ref 18[17]).

Australia

There have been few studies reported from Australia, apart from those mentioned in the Introduction.

An article in the magazine *Truck and Bus* January 1999 page 21-3[18] reported a high incidence of OSA in the sample studied, and a mixed reception from the authorities concerned.

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[12] Full text Appendix 10
[13] Full text Appendix 11
[14] Appendix 12
[15] Appendix 13
[16] Full text Appendix 14
[17] Full text Appendix 15
[18] Appendix 16