The use of continuous positive airway pressure (CPAP).

Amongst the treatment options for **obstructive sleep apnoea syndrome** (disturbed breathing during sleep associated with poor daytime function, e.g. sleepiness) nasal continuous positive airway pressure (nCPAP) is the most successful treatment (Yamamoto et al 1999, Meslier et al 1998, Bolitschek et al 1998, Loub et al 1999). Although nCPAP is cumbersome and aesthetically unattractive success rate is around 70% in patients with moderate to severe sleep apnoea. The success is lower in patients with mild sleep apnea (less than 30 stopping breathing per hour)

Before the advent of nCPAP (Sullivan et al 1981) patients with severe obstructive sleep apnoea, often associated with hypercapnic respiratory failure during the day and cardiac failure (Pickwickian syndrome) required a permanent tracheostomy to be kept open at night in order to bypass the site of obstruction, the pharynx. In this group of severe obstructive sleep apnoea nCPAP is highly successful. However, with the availability of sleep studies and increased clinical awareness obstructive sleep apnoea is diagnosed much earlier. If research criteria for the diagnosis of OSA (an apnoea/hypopnoea index of more than 5 events/hour) are applied to clinical population the majority of the diagnoses are within with mild to moderate range (5-30 apnoea/hypopnoea per hour). In this large group of patients successful treatment and compliance with nCPAP are low (46%), even when compliance is defined as at least 4 hours of use per night (Neill AN and McEvoy RD 1997, Redline et al 1998, Engelman et al 1999).

Compliance can be improved by selection of the most appropriate pressure, delivery system (nasal mask, nasal prongs, facial mask), by education, training and follow-up over time (Likar et al 1997).

Setting the 'correct' pressure

The correct pressure is the one that abolishes obstruction of the upper airway. In practice this corresponds to the pressure that is able to eliminate snoring and apnoeas/hypopnoeas.

The best method to determine a adequate CPAP pressure is by overnight titration study. This is similar to a diagnostic sleep study but with application of CPAP, usually through a nasal mask or prongs, and less commonly by a full facial mask or mouth piece (Smith et al 2003). The technician slowly increases the pressure starting from low value (eg 4-5cm of water) in a stepwise fashion through the night until snoring is abolished and the flow of air is not obstructed. Although overnight titration is the most accurate way to determine nCPAP pressure, it is not without potential problems mostly related to subjective judgement and experience of the technician. A common problem is over-estimation of the final pressure. It is important that each level of increase is tested for and adequate amount of time and preferably through different stages of sleep before further increase is implemented. At the end of the night titration the pressure may also be higher because of increased nasal resistance due to mild mucosal swelling. It is therefore important that the study is carefully reviewed in the morning to determine the most appropriate pressure which not uncommonly is slightly lower than the final titration value.

Because overnight sleep studies are expensive other ways of setting nasal pressure have been tried including an attempt to titrate in the second half of the initial diagnostic study (split night study). Split night studies are adequate in case of severe, unequivocal sleep apnoea. However, in mild cases recording only the first part of the night may significantly underestimate the severity, because obstructed breathing tends to be more frequent during REM (when muscles are weaker and the probability of stopping breathing higher), which predominates in the second part of the sleep episode.

The use of CPAP machine with auto-setting capabilities has been recently used to simplify pressure determination even though careful review of the overnight trace is still needed.

Unattended auto-titration is, however, not advisable in patients with significant cardiorespiratory co-morbidities and in patients with previous palatal surgery such as uvulo-palato-pharyngoplasty (Levy P and Pepin J-L 1998). Previous palatal surgery makes application of nasal CPAP somewhat difficult at times because of palatal insufficiency and mouth leak (Mortimore et al 1996).

It is also of concern that different auto-titrating machines, when applied to the same patients, can yield significantly different levels of fixed CPAP (Kessler et al 2003).

Selection of nasal CPAP machine and delivery system.

The very first nasal CPAP machines were off the shelves, industrial blowers adapted for medical use, and the nasal masks were custom made for the individual patients (fig1 and 2). Nowadays they are progressively smaller machines with integrated electronic circuit that allows a variety of features such as ‘ramp’, optional humidification, usage recording capability for compliance assessment.

Fig 1 The very first CPAP machine (right) was and off the shelf compressor.

Fig 2 The very first nasal mask very made from the patient' nose mould

The **'ramp'** is standard in almost all current machines and consists of a mechanism that allows the pressure to slowly increase to the set value over a period of 5-20 minutes, so that the patient can slowly adjust to it.

The **humidification'** can be attached in-line to the CPAP machine as an extra piece of equipment, or can be an integral part of the machine itself (fig 3). The humidification can be by cold pass-over or through a heated water humidifier (Brown LK 2000, Massie et al 1999, Martins de Araújo et al 2000). The main indication for humidification is the presence of nasal symptoms, (blocked nose and pharyngeal dryness). These are frequent problems particularly with high pressures (>10cm) and in geographical areas where the air is dry and cold. In regions with high level of

humidity such as coastal areas in temperate climate humidification can in fact create problems with water condensation in the mask and the tubing.

Therefore the use of humidification (heated humidification) is appropriate in selected cases only.

Fisher & Pikel CPAP with humidifier

ResMed CPAP with humidifier

Fig 3

All the CPAP machines available on the markets are reliable and the choice is based on size, level of noise and individual preference. There is usually very little *medical* indication to use a more expensive machine. For example the use of auto-titrating machines for long term use at home, instead a simple basic one has to be questioned. Auto-titrating machines are significantly more expensive but in practice provide no additional benefit. The rationale to use auto-titrating machines is based on the variable degree of disturbed breathing that can occur during a sleep episode. That is, in REM for example, the severity of disturbed breathing is increased and a higher pressure may be needed to overcome the obstruction. However, irrespective of the auto-titrating algorithm used, pressure adjustments are not instantaneous and pressure/flow leaks from the mask can cause unnecessary adjustments. The high cost of auto-titrating machines at present does not justify the recommendation for routine use.

The use of CPAP machines which decrease pressure during the expiratory phase (2 level CPAP) are sometimes useful in patients who have major difficulty tolerating the continuous flow of air. This machines usually costs twice as much as the ordinary CPAP ones, even though cheaper varieties are now available on the market (C-Flex™).

Delivery system

The delivery system consists of a tubing and a part which interfaces with the patient's nose, mouth or full face. The tube and mask conform to one industry standard so that are independent of the CPAP machine used.

Delivery of CPAP through small nasal mask is the most common system (fig 4).

Alternatively to the nasal mask is the use of nasal prongs (fig 5).

Fig 5

A frequent technical problem is the presence of mouth leak when pressures are high or in the presence of previous palatal surgery. This problem can be overcome by the use of a chin strap or sometimes by the use of a mouth piece or full facial mask (fig 7).

Fig 7 Full facial mask

Education and follow-up of patients on nasal CPAP

Nasal CPAP is an effective treatment but intrusive and cumbersome. Its use and acceptance is proportionate to the perceived benefit which in turn depends on the patient's daytime symptoms.

In fact it seems that patients with severe sleep apnoea but who otherwise function well, that is a patient who have no daytime symptoms, do not benefit from nasal CPAP and its use has been questioned (Moran et al 1984, Barbé et al 2001). However, even patients who benefit from nasal CPAP encounter technical problems particularly at the beginning of treatment. It is therefore paramount that explanation of the rationale of nCPAP and possible initial difficulties are explained in detail. This can be done through the use of videos, written material and importantly by individual interaction with the sleep technician. Follow-up over the phone or in a sleep clinic for the first few weeks also increase treatment success.

Long term follow-up (3-6months and then yearly) is also important for the following reasons.

- assess compliance
- assess potential technical problems
- reinforce other treatment modalities such as weigh reduction and control of alcohol intake

Changes in weight are important as an increase may require a correspondent increase in nasal CPAP pressure and visa versa weight reduction may lead to a decrease.

Patients also have different questions which may require attention.

1. **Do I have to use this machine every night?** It should be explained that the nasal CPAP is a symptomatic treatment and does not provide a cure. If the machine is not used then there is no benefit (Kribbs et al 1993). That is to say that if the person is travelling and for a day or two does not sue the machine the overall impact is unlikely to be serious but the person may expect his function to deteriorate.

2. **Can I stop this treatment in 6 month's time or do I have to use it for the rest of my life?** Again it should be pointed out that even prolonged use of nasal CPAP does not bring about a cure and upon stopping treatment daytime symptoms will recur. The prospect of having to use nasal CPAP every night is certainly anxiety raising and that is the right time to reinforce the need to apply other strategies . More specifically weight reduction, reduction of alcohol intake and maintenance of nasal patency are strategies that should be encouraged and that in the long run could potentially reduce the need for nasal CPAP. However, short of such modifications usually nasal CPAP is a long term treatment.

3. **How can I use this machine where there is no electricity or on an aeroplane?** The nasal CPAP can usually be operated by a 12 volt battery and

therefore can be used where there is no direct electricity and even on a boat. It is important that specific arrangement with the machine providers is undertaken by the patient so the proper electrical interface is used.

There is no contraindication to use nCPAP on an aeroplane even though apart from very prolonged flights the use of the machine is probably not necessary, except for social reasons whereby the snoring may be disturbing other passengers. In this setting the concomitant use of a mandibular advancing device can be an appropriate strategy.

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