Short Communication

The rationale behind a continous nasal positive airway pressure machine that approximates the nasal cycle during sleep

Abstract

Normal nasal airflow alternates in dominance between the two nostrils with an ultradian rhythm called the "nasal cycle." The nasal cycle is thought to enable the patent airway to perform the majority of the air-conditioning functions, while the congested side undergoes a period of recovery. Nasal-applied continuous positive airway pressure (n-CPAP) forces air equally up both sides of the nose disrupting the nasal cycle, which could contribute to nasal side-effects, such as nasal dryness, crusting and congestion. The development of a n-CPAP machine, which approximates physiological alternating nasal airflow during sleep, could reduce nasal side effects and improve n-CPAP adherence. A n-CPAP mask would need modification so that air under pressure could be independently directed to and received from each side of the nose. The system would allow for the pre-setting of both the nasal cycle duration time and the degree of airflow partitioning between each naris. A n-CPAP machine that approximates the normal physiological nasal cycle during sleep could reduce the incidence of adverse nasal symptoms and improve sleep quality leading to improved n-CPAP compliance.

Keywords: cpap, nasal cycle, nasal airflow partitioning, obstructive sleep apnoea

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Abbreviations: n-CPAP, nasal-applied continuous positive airway pressure; OSA, obstructive sleep apnea; OSAS, obstructive sleep apnoea syndrome

Introduction

Normal nasal airflow alternates in dominance through the two nostrils with an ultradian physiological rhythm called the "nasal cycle." Nasal-applied continuous positive airway pressure (n-CPAP), the clinical "gold standard" for the treatment of moderate to severe obstructive sleep apnea (OSA),[1] forces air under pressure down both sides of the nose. During awake breathing, n-CPAP disrupts normal inter-nasal airflow partitioning.[2] During sleep, n-CPAP could potentially alter the nasal cycle, disturbing the nose's normal air conditioning functions.

Nasal cycle

Normally, the airflow and resistance in each nasal airway alternates between a patent and partially congested state for periods ranging from 25minutes to greater than 4hours, with a mean of 2.5hours.[3–5] Some evidence suggests that the nasal cycle is longer during sleep compared to the waking state.[3,5,6] During sleep, changes in the nasal cycle often coincide with postural changes and may occur more often in transitions to REM sleep.[5–7]

Eccles[3] has proposed that the nasal cycle enables cells and glands on the congested side to rest and recover.[8] The nasal cycle probably controls the balance between the fluxes of heat and water vapour required to condition the inspired air, and the ability of nasal blood flow and mucus secretion to supply sufficient heat and water to the surface tissue.[9] White et al.,[10] has shown that the nasal cycle allows the anterior conducting airways to cope with the conflicting demands of air-conditioning and mucus clearance.[10]

The nasal cycle is related to REM and non-REM sleep.[7,11] Greater left hemisphere EEG power is coupled to REM sleep, and greater right hemisphere EEG power is coupled to non-REM stage 4 sleep.[12] In conscious people, greater EEG power is exhibited in the hemisphere contralateral to the nostril with the dominant airflow.[13,14] In awake people, unilateral forced nostril breathing leads to selective unilateral activation of the opposing cerebral hemisphere.[4] By forcing air under pressure equally down both sides of the nose during sleep, n-CPAP could potentially affect brain wave activity and sleep quality.

Nasal-applied continuous positive airway pressure

Despite n-CPAP's efficacy and substantial benefits, long-term n-CPAP adherence rates remain low.[15,16] Numerous reasons for suboptimal patient n-CPAP adherence have been explored.[15–17] The mask-nose interface, the discomfort of breathing against pressure and the irritation of pressurised air in the nose might all contribute to low n-CPAP adherence.[1,17–21] Up to 65% of obstructive sleep apnoea syndrome (OSAS) suffers receiving n-CPAP report adverse nasal symptoms such as a dry nose, nasal congestion, nasal crusting, rhinorrhoea, epistaxis and sneezing.[17,19, 22–25]

Modifications to improve n-CPAP compliance have included improved humidification and CPAP pressure adjustments. Heated humidification decreases nasal symptomatology and mucosal inflammation,[19,23] however the current evidence supporting the routine use of humidification to improve CPAP compliance is minimal[19–21,26,27] Delivery pressures have been adjusted in order to improve patient comfort.[19,21] Pressure reduction on exhalation (BiPAP) and auto-adjusting PAP has been trialled. No adherence improvement, change in the apnoea-hypopnea index or daytime sleepiness with BiPAP has been found.[21,26] With auto-adjusting PAP, the pressure changes in response to changes in airflow, respiratory events, and snoring throughout the night. Pressure reduction does not dramatically improve adherence.[19–21,26,28,29]

The nasal cycle appears important in the air conditioning functions of the nose and n-CPAP appears to disturb normal inter-nasal airflow partitioning in conscious subjects.[2] Modification of current n-CPAP technology to approximate normal nasal physiology during sleep would seem an option worth exploring.

Modifying a n-CPAP machine

A n-CPAP mask would need modification so that air could be directed to and received independently from each side of the nose. A n-CPAP machine would need modification so that the patent nasal airway could be detected and receive an initial higher air pressure than the congested nasal airway during the inhalation phase of breathing during sleep initiation. During exhalation, the patent nasal airway would have to receive a lower pressure than the congested nasal airway to maintain appropriate airflow partitioning. The system would have to allow for the pre-setting of both the nasal cycle duration time and the degree of airflow partitioning between each naris.

Conclusion

N-CPAP is an effective treatment for OSA, but long-term n-CPAP adherence rates remain low.[15,16] Unfortunately recent n-CPAP humidification and pressure modifications have not dramatically improved patient compliance. An n-CPAP machine that approximates the normal nasal cycle restoring normal nasal respiratory physiological processes could reduce the incidence of adverse nasal symptoms leading to improved n-CPAP compliance.

Conflicts of interest

Two of the authors (JRB and DEW) are patent holders in a CPAP device designed to approximate the nasal cycle during sleep. Patent Number 617543, a Patient Interface and Method of Treating Sleep Apnoea. New Zealand: Intellectual Property Office.

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