Sleep Medicine Reviews 15 (2011) 301–310

Contents lists available at ScienceDirect

Sleep Medicine Reviews

journal homepage: www.elsevier.com/locate/smrv

CLINICAL REVIEW

Nasal continuous positive airway pressure (nCPAP) treatment for obstructive sleep apnea, road traffic accidents and driving simulator performance: A meta-analysis

Constantine N. Antonopoulos [a,*], Theodoros N. Sergentanis [a], Styliani S. Daskalopoulou [b], Eleni Th. Petridou [a]

[a] Center for Research and Prevention of Injuries (CEREPRI), Department of Hygiene, Epidemiology and Medical Statistics, Athens University Medical School, 75 Mikras Asias Str., 11527 Athens, Greece
[b] Division of Internal Medicine, Department of Medicine, McGill University, McGill University Health Centre, Montreal, Québec, Canada

ARTICLE INFO

Article history:
Received 29 July 2010
Received in revised form
27 October 2010
Accepted 28 October 2010
Available online 30 December 2010

Keywords:
Obstructive sleep apnea
Nasal continuous positive airway pressure
nCPAP
Road traffic accidents
Driving simulator
Meta-analysis

SUMMARY

We used meta-analysis to synthesize current evidence regarding the effect of nasal continuous positive airway pressure (nCPAP) on road traffic accidents in patients with obstructive sleep apnea (OSA) as well as on their performance in driving simulator. The primary outcomes were real accidents, near miss accidents, and accident-related events in the driving simulator. Pooled odds ratios (ORs), incidence rate ratios (IRRs) and standardized mean differences (SMDs) were appropriately calculated through fixed or random effects models after assessing between-study heterogeneity. Furthermore, risk differences (RDs) and numbers needed to treat (NNTs) were estimated for real and near miss accidents. Meta-regression analysis was performed to examine the effect of moderator variables and publication bias was also evaluated. Ten studies on real accidents (1221 patients), five studies on near miss accidents (769 patients) and six studies on the performance in driving simulator (110 patients) were included. A statistically significant reduction in real accidents (OR = 0.21, 95% CI = 0.12–0.35, random effects model; IRR = 0.45, 95% CI = 0.34–0.59, fixed effects model) and near miss accidents (OR = 0.09, 95% CI = 0.04–0.21, random effects model; IRR = 0.23, 95% CI = 0.08–0.67, random effects model) was observed. Likewise, a significant reduction in accident-related events was observed in the driving simulator (SMD = −1.20, 95% CI = −1.75 to −0.64, random effects). The RD for real accidents was −0.22 (95% CI = −0.32 to −0.13, random effects), with NNT equal to five patients (95% CI = 3–8), whereas for near miss accidents the RD was −0.47 (95% CI = −0.69 to −0.25, random effects), with NNT equal to two patients (95% CI = 1–4). For near miss accidents, meta-regression analysis suggested that nCPAP seemed more effective among patients entering the studies with higher baseline accident rates. In conclusion, all three meta-analyses demonstrated a sizeable protective effect of nCPAP on road traffic accidents, both in real life and virtual environment.

Introduction

Obstructive sleep apnea (OSA) is a common chronic disorder that affects approximately 20% of the general population if defined as an apneae hypopnea index (AHI) ≥ 5 events/h, or 2–9% if defined as an AHI ≥ 5 events/h accompanied by at least one symptom that is known to respond to treatment, such as daytime sleepiness.[1–3] The high prevalence rates are disturbing taking under consideration that OSA patients have an increased risk of morbidity and mortality, particularly due to cardiovascular disease or involvement in road traffic accidents. Indeed, OSA patients are often sleepy during daytime causing traffic accidents and work injuries.[4,5] If left untreated, OSA leads to excessive daytime sleepiness, cognitive dysfunction, impaired work performance, and decrements in quality of life.[6]

Many treatment modalities have been proposed for the treatment of OSA including dietary and lifestyle management, pharmacological agents, oral appliance devices and surgical interventions (nasal reconstruction, various uvulopalatopharyngoglossoplasty techniques, maxillomandibular manipulations, and tracheotomy). Despite the variety of alternative choices, nasal

* Corresponding author. Tel.: +30 210 7462187; fax: +30 210 746 2105.
E-mail addresses: kostas.antonopoulos@gmail.com (C.N. Antonopoulos), tsergentanis@yahoo.gr (T.N. Sergentanis), stella.daskalopoulou@mcgill.ca (S.S. Daskalopoulou), epetrid@med.uoa.gr (E.Th. Petridou).

1087-0792/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.smrv.2010.10.002

Abbreviations

AHI	apnea–hypopnea index
BMI	body mass index
CI	confidence interval
ESS	Epworth sleepiness scale
FP	full polysomnography
ICER	incremental cost-effectiveness ratio
IR	incidence rate
IRR	incidence rate ratio
MSLT	multiple sleep latency test
nCPAP	nasal continuous positive airway pressure
NNT	number needed to treat
OR	odds ratio
OSA	obstructive sleep apnea
PRISMA	preferred reporting items for systematic reviews and meta-analyses
QALY	quality-adjusted life-year
RD	risk difference
RDI	respiratory disturbance index
RP	respiratory polygraphy
SMD	standardized mean difference
SSS	Stanford sleepiness scale

continuous positive airway pressure (nCPAP) device remains the gold standard of treatment.[1,7] It is indicated for mild to severe OSA patients, and it has proved to be efficient in improving symptoms and reducing the severity of a pleiad of medical conditions related to upper airway obstruction during sleep.[8]

The purpose of this meta-analysis is to estimate the extent to which nCPAP treatment affects real and near miss road traffic accident rates in OSA patients, as well as the extent to which nCPAP affects their performance in driving simulator. We also sought to estimate the number needed to treat (NNT) to avoid road traffic accidents.

Materials and methods

Data collection

The present meta-analysis was conducted in accordance to the "preferred reporting items for systematic reviews and meta-analyses" (PRISMA) guidelines.[9] A combined computerized and manual systematic database search of medical literature was performed and the respective publications were retrieved from electronic search engines (Medline, Embase, Scopus, Google Scholar, Ovid and the Cochrane Library). "Bibliosleep", a subject specific electronic database including sleep and sleep-related publications, as well as a series of nine peer-reviewed journals focused on sleep medicine and eight on pulmonary medicine with interest in sleep were also searched. Reference lists were thereafter systematically examined for relevant articles.

Types of studies, search terms, eligibility and exclusion criteria

Publications of interest included randomized and non-randomized studies, editorials, systematic reviews, meta-analyses, short papers, case reports, case series, letters to the editor, personal views, special communications and unpublished data. Mesh terminology used for search purposes were "CPAP"[All Fields] AND ("accident"[All Fields] OR "injury"[All Fields] OR "crash"[All Fields] OR "automobile"[All Fields] OR "motor vehicle" [All Fields]), "sleep apnea"[All Fields] AND ("accident"[All Fields] OR "injury"[All Fields] OR "crash"[All Fields] OR "automobile"[All Fields] OR "motor vehicle" [All Fields]), " sleep apnea"[All Fields] AND "driving"[All Fields] and "simulator"[All Fields] and "CPAP"[All Fields] AND "driving"[All Fields] and "simulator"[All Fields]. We identified all studies that evaluated the effect of nCPAP on OSA patients with respect to real and/or near miss road traffic accidents or performance in the driving simulator. Given that CPAP was first introduced in 1981,[10] scientific papers published between April 1981 and July 2010 were examined and no restriction of publication language or participants' sex or age was applied.

The studies that did not refer to OSA patients or did not report road traffic accident-related or simulated driving-related outcomes before and after use of nCPAP and studies in which OSA patients only intermittently used nCPAP were excluded. When multiple publications on the same study population were identified or study populations overlapped, only the study of larger size was included, unless the reported outcomes were mutually exclusive. Data were independently extracted and analyzed and individual study quality was assessed by two of the authors (CNA, TNS) and final decision was reached by consensus.

Data extraction

Data extracted from eligible studies included authors, study year, journal, type of study, study quality[11] and characteristics for nCPAP users/non-users among OSA patients, including: 1) Study descriptives; namely sample size, time period of road traffic accidents monitoring before and after nCPAP treatment, 2) Demographic variables; namely age, sex, male to female ratio and anthropometrics such as weight or body mass index (BMI), 3) Sleep apnea related variables; namely AHI and respiratory disturbance index (RDI), defined as the total number of complete cessations (apnea) and partial obstructions (hypopnea) of breathing occurring per hour of sleep, nCPAP usage (number of hours used per night), sleep apnea diagnostic tools used for patient recruitment and sleepiness scores,[12] 4) Driving-related variables; namely number of patients with real and near miss road traffic accidents, 5) Driving simulator-related variables: number of accident-related events, tracking error (standard deviation from the center of the road) and vigilance reaction time, defined as average time needed to respond to visual stimulus for both before and after nCPAP treatment and 6) method used for data collection (self-report, state records or performance on driving simulator). The corresponding authors were contacted if the required data were not readily available in the published article and feedback was given by the authors of two studies.[13,14]

Statistical analyses

Data synthesis and treatment effects

Three separate meta-analyses were performed according to the outcome measures under investigation. Particularly, the effect of nCPAP on the occurrence of a) real road traffic accidents, b) near miss road traffic accidents and c) accident-related events in the driving simulator was tested.

With respect to real and near miss accidents, the pooled estimate of crude odds ratios (ORs) with corresponding confidence intervals (95% CIs) was initially calculated simply based on the number of patients reporting accidents in the individual studies. Consequently, an effort was made to take into account the observation period during which the reported accidents occurred before and after nCPAP treatment. To this end, the incidence rates (IR) of real or near miss accidents before and after nCPAP were calculated, by dividing the number of patients reporting road traffic accidents by the respective person-years; thereafter, the incidence rate ratios (IRRs) for real and near miss accidents were estimated in each study