Acta Oto-Laryngologica. 2014; Early Online, 1–6

informa healthcare

ORIGINAL ARTICLE

The effect of the prone sleeping position on obstructive sleep apnoea

ARMIN BIDARIAN-MONIRI[1,2], MICHAEL NILSSON[3,4], LARS RASMUSSON[5], JOHN ATTIA[4] & HASSE EJNELL[1]

[1]*Department of Otorhinolaryngology, Institute of Clinical Sciences, Sahlgrenska Academy at the University of Gothenburg, Sahlgrenska University Hospital, Gothenburg, Sweden,* [2]*Regenerative Medicine Program, Department of Biomedical Sciences and Medicine, University of Algarve, Faro, Portugal,* [3]*Center for Brain Repair and Rehabilitation, Institute of Neuroscience and Physiology, University of Gothenburg, Gothenburg, Sweden,* [4]*Hunter Medical Research Institute and University of Newcastle, Callaghan, NSW, Australia and* [5]*Department of Maxillofacial Surgery, Institute of Clinical Sciences, Sahlgrenska Academy at the University of Gothenburg, Gothenburg, Sweden*

Abstract

Conclusions: Prone positioning reveals promising results in improving the apnoea-hypopnoea index (AHI) and oxygen desaturation index (ODI) in patients with obstructive sleep apnoea (OSA). *Objective:* To evaluate the effect of the prone position on OSA. *Methods:* Thirty-two patients with mild to severe OSA were included in the study. This was a two-night study to evaluate the effect of the prone position on OSA; a first night in a normal bed with optional positioning and a second night on a mattress and pillow facilitating prone positioning. *Results:* A total of 27 patients, 22 males and 5 females, with a mean age of 51 years, 15 patients with positional OSA (POSA) and 12 patients with non-POSA with a total median AHI of 23 (min 5, max 93) completed the study protocol. The median AHI decreased from 23 to 7 ($p < 0.001$) and the median ODI from 21 to 6 ($p < 0.001$). The median time spent in the supine position decreased from 142 to <1 min ($p < 0.0001$) and the median time in the prone position increased from <1 to 330 min ($p < 0.0001$). In all, 17 of 27 patients (63%) were considered to be responders to prone positioning, 12 of 15 (80%) with POSA and 5 of 12 (42%) with non-POSA. Five patients did not complete the study protocol due to sleep time <4 h.

Keywords: *Positional treatment, prone, lateral and supine sleep positions, non-invasive, conservative, non-surgical treatment, mattress and pillow for prone positioning, polysomnographic sleep study, respiratory parameters*

Introduction

Obstructive sleep apnoea (OSA) is characterized by recurrent episodes of upper airway collapse, which cause a reduction (hypopnoea) or cessation (apnoea) of breathing despite respiratory effort during sleep [1]. Current guidelines in the management of OSA recommend continuous positive airway pressure (CPAP) as the first-line treatment and mandibular advancement devices (MADs) as an alternative treatment [2,3]. Many of the patients who are prescribed CPAP are non-adherent and use their CPAP for less than 4 h per night [4,5].

The number and duration of respiratory disturbances in patients with OSA depend on body position and sleep stage [6]. The lateral position is believed to reduce the tendency for the tongue to fall backward, making the collapse of the pharynx less likely, as compared with the supine position. Cartwright suggested a categorization of the patients suffering from OSA into positional and non-positional [6]. The patients with positional OSA (POSA) were recognized

Correspondence: Armin Bidarian-Moniri, Department of Otorhinolaryngology, Institute of Clinical Sciences, Sahlgrenska Academy at the University of Gothenburg, Sahlgrenska University Hospital, SE-413 45 Gothenburg, Sweden. Tel: +46 31 342 10 00. Fax: +46 31 341 11 25. E-mail: armin.bidarian@vgregion.se

(Received 17 July 2014; accepted 31 August 2014)

ISSN 0001-6489 print/ISSN 1651-2251 online © 2014 Informa Healthcare
DOI: 10.3109/00016489.2014.962183

as having twice as many apnoeas in the supine position compared with the lateral positions [6].

More than 50% of the patients with OSA have a reduction of at least 50% in the apnoea-hypopnoea index (AHI) when altering the sleep position from the supine to the non-supine positions [7–9]. An additional 30% of the patients with OSA have a lesser reduction in AHI from the supine position to other positions [7,10]. This position dependency of OSA has had limited clinical impact in the treatment of patients [11]. The change in the severity of disease due to the sleep position has been observed but the studies have mainly been performed on the supine and lateral positions [11].

With the exception of a few case reports regarding the prone body position [12–14], there are no previous publications evaluating the effect of the prone head and body position on the severity of disease in adults with OSA. The aim of the present study was to evaluate the effect of prone positioning on the respiratory parameters in patients with OSA.

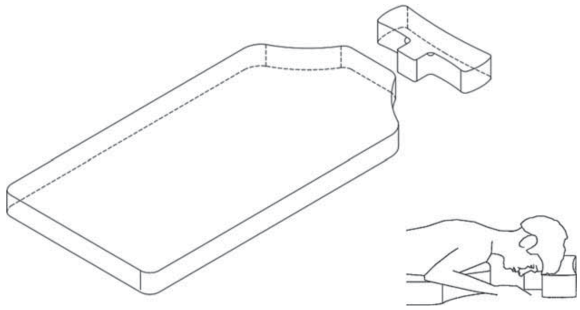

Figure 1. The mattress and pillow for prone positioning (MPP) of the body and the head with the nose mostly perpendicular to the underlying bed.

Figure 2. Subject in a prone body and head position with the nose mostly perpendicular to the underlying bed (left). Lateral sleep position with comfortable placement of the shoulder and the arm (right).

Material and methods

Participants

The patients included in the present study were referred to the Department of Otorhinolaryngology, Sahlgrenska University Hospital in Gothenburg, Sweden, from March 2010 to November 2011 due to sleep-disordered breathing. We recruited 32 OSA patients, regardless of position dependency, with AHI ≥5 and excessive daytime sleepiness [15]. Exclusion criteria were neurologic disease that might influence muscle tone, heart failure, uncontrolled high blood pressure, body mass index (BMI) >40, age <18 years, and pregnancy.

The study was approved by the Local Medical Ethics Committee for Clinical Trials, 2011/131-11. All patients gave written informed consent to participate in the study.

Mattress and pillow for prone positioning

To make it possible to sleep in a prone position, a mattress and a pillow for prone positioning (MPP) were developed (Figure 1). A true prone position was defined as the body and the head in the prone position with the nose mostly perpendicular to the underlying surface. The MPP consisted of a combination of visco-elastic (memory) and normal foam.

A T-shaped pillow with a height of 12 cm and a width of 40 cm would enable cheek and forehead support with a relatively well-aerated space for breathing, allowing for a prone head position. A body mattress with a height of 12 cm, width of 90 cm and length of 160 cm was provided to ensure a comfortable and stable prone body position during sleep. The mattress had excavations of the sides for positioning of the arms and anatomical angles in the shoulders and elbows. The support of the chin on the mattress was optional (Figure 1). The MPP could be placed on a normal bed and hence could be compatible with an existing bed at the hospital.

The main purpose of the MPP was to provide a comfortable sleep position that would make it possible for the patient to lie with his/her body and head in the prone position most of the night (Figure 2). After lying on the MPP, the temperature-sensitive visco-elastic material would transform the mattress into a mould of the body shape, which would help to maintain the subject in the prone position. It would be possible to also sleep in the lateral positions. However, due to the particular design of the mattress providing support for the chest and the hips and also the height of the pillow adapted especially to prone and lateral positioning, supine positioning would be difficult and/or uncomfortable. An instruction video was provided to ensure correct positioning on the MPP.

Sleep study

Polygraphy (PG) equipment (Embletta Gold, Flaga Medical, Reykjavik, Iceland) was used. Data collected included breathing efforts by chest and abdominal movements, airflow and snoring by oro-nasal flowmetry and thermistor, body position by a position sensor which differentiated between upright, left side, right side, prone and supine positions, and heart rate and oxygen saturation by finger pulse oximeter. The position of the body and the head was also monitored by camera during the whole night.

Analysis and definitions

The sleep studies were analyzed and scored by an independent technician blinded to the assignment of the patients. Apnoeas and hypopnoeas were manually scored according to the American Academy of Sleep Medicine (AASM) 2007 [15]. An oxygen desaturation event was detected when the oxygen saturation fell ≥4% for ≥10 s. An apnoea was scored if the signal amplitude of airflow dropped ≥90% for ≥10 s. A hypopnoea was scored if the signal amplitude of airflow dropped ≥30% for ≥10 s with a concomitant oxygen desaturation event. The sleep time was estimated from the patient's sleep diary and trace patterns. The total number of apnoeas and hypopnoeas was divided by the estimated sleep time to give the AHI. The oxygen desaturation index (ODI) was calculated in the same manner based on the total number of desaturations divided by the estimated sleep time.

The respiratory parameters, sleep time and the time slept in the supine, lateral and prone positions were compared for each patient without and with the MPP. As defined by Cartwright [6], subjects with a reduction of AHI ≥50% in the lateral positions compared with the supine position during the first night were considered to have POSA. According to the CPAP definition of compliance [5], patients with a sleep time <4 h with the MPP were considered non-compliant to treatment. In line with Sher's criteria for surgical treatment success [16], responders were defined as AHI <20 and ≥50% AHI reduction from baseline.

Statistical analysis

Statistical analysis was performed using Stata (version 13, StataCorp. 2013, College Station, TX, USA). Quantitative data are reported as mean (min;max) if normally distributed, and median (min;max) if skewed. Comparison of data between the baseline (without treatment) and with treatment was carried out using the paired *t* test in the case of normally distributed data and the Wilcoxon matched pairs sign-rank test in the case of skewed data. All statistical tests were two-tailed and conducted at 5% significance level.

Table I. Characteristics of the 27 eligible subjects.

Characteristic	Value
Age, mean (min; max)	51 (33;72)
Gender, male/female	22 M/5 F
BMI, mean (min;max)	28 (23;36)
AHI, mean (min;max)	31 (5;93)
POSA, *n* (%)	15 (56)

AHI, apnoea-hypopnoea index; BMI, body mass index; F, female; M, male; POSA, positional obstructive sleep apnoea.

Results

Twenty-seven (84%) patients completed the study protocol. Five patients (16%) did not complete the study protocol; one patient withdrew, and one patient had insufficient sleep time (<4 h) during the first night and three patients during the second night. The characteristics of the 27 participants are summarized in Table I.

Respiratory events

The median AHI decreased from 23 to 7 ($p < 0.001$) and the median ODI from 21 to 6 ($p < 0.001$) (Figure 3). For the POSA patients, the median AHI decreased from 20 to 5 ($p < 0.001$) and the median ODI from 19 to 5 ($p < 0.001$). For the non-POSA-patients, median AHI and ODI were reduced from 45 to 22 and 22 to 11, respectively.

Seventeen of 27 patients (63%) were considered responders [16] and reduced their baseline AHI ≥50% and achieved AHI <20 with MPP, of whom 16 patients achieved an AHI <10 and 10 patients an AHI <5. In general POSA patients had greater effect of the MPP, with a responder rate of 80%;

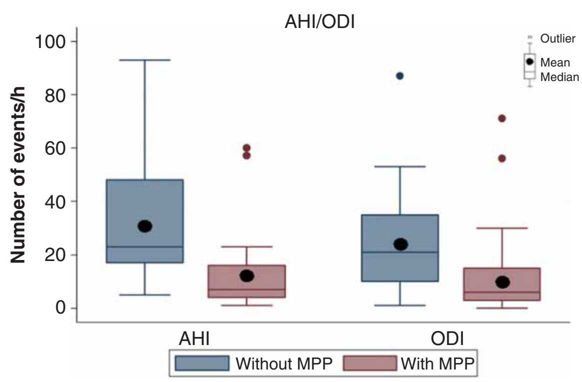

Figure 3. Distribution of apnoea-hypopnoea index (AHI) and oxygen desaturation index (ODI) during the first night without treatment (blue) and the second night with the mattress and pillow for prone positioning (MPP) (red).

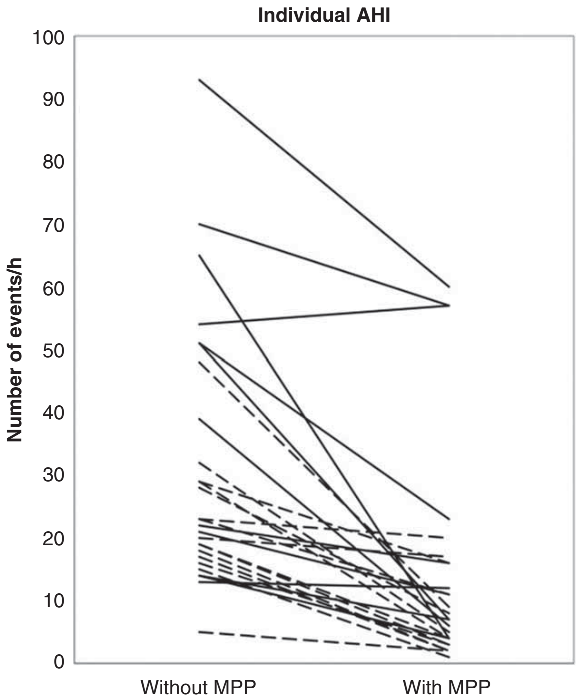

Figure 4. Individual apnoea-hypopnoea index (AHI) during the first night without and the second night with the mattress and pillow for prone positioning (MPP) in patients with positional obstructive sleep apnoea (POSA, dashed) and non-POSA patients (solid).

nevertheless, 5 of 12 non-POSA patients (42%) were also responders (Figure 4).

Sleep position and AHI

The median estimated sleep time was 416 min during the first night and 379 min ($p = 0.1$) during the second night with treatment. The median time spent in the

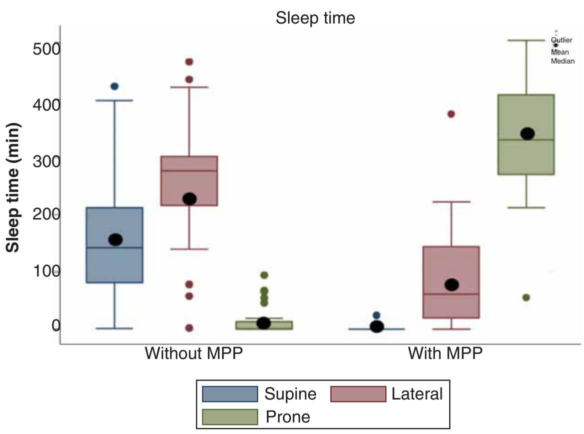

Figure 5. Time (in minutes) spent in each position without and with the mattress and pillow for prone positioning (MPP).

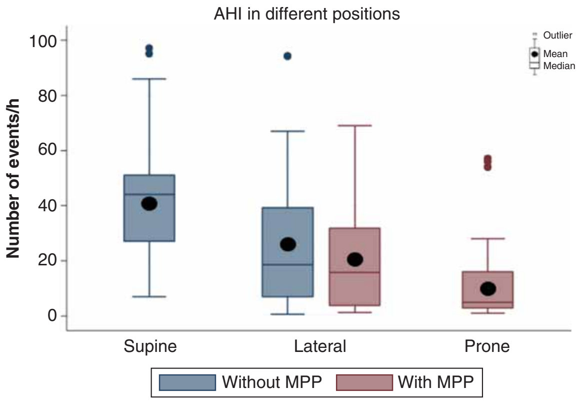

Figure 6. Apnoea-hypopnoea index (AHI) in different positions without and with the mattress and pillow for prone positioning (MPP).

supine position decreased from 142 to <1 min ($p < 0.0001$) and the median time spent in the prone position increased from <1 min to 330 min ($p < 0.0001$) during the second night with the MPP (Figure 5).

The overall time spent in the prone position during the first night and supine position during the second night were insufficient to draw any accurate conclusions regarding AHI. Without MPP the median AHI was 44 in the supine position and 18 in the lateral positions (Figure 6). With MPP the median AHI was 16 in the lateral positions and 5 in the prone position.

Discussion

Our observations indicate reduced airway collapse with improved AHI and ODI when sleeping in the prone position as compared with both lateral and supine positions. The median AHI for the whole group decreased from 23 to 7 and the median ODI from 21 to 6. This was achieved by reducing the median supine time from 142 to <1 min and increasing the median prone time from <1 to 330 min. No disruption in sleep duration was observed as judged by overall time.

Due to insufficient number of prototypes, no MPP could be provided to allow the participants to get used to the MPP or to evaluate the long-term compliance; this will have to be done in a separate study. Nevertheless, even without previous adaptation, only 4 of 31 patients (13%) had <4 h of sleep time [5] with the MPP.

Considering the improved gravitation vector from the supine to the lateral positions [17,18], an additional effect would be expected when moving from the lateral to the prone position. According to the 'balance of forces' model, gravitation, the Bernoulli equation and the Starling resistor model may explain the physiological factors causing the collapse of the airway lumen in patients with OSA [18]. According to this explanation model almost all subjects with OSA should respond positively to prone positioning. In the present study all but one patient improved their baseline AHI with MPP however 12 of 15 POSA patients (80%) and 5 of 12 non-POSA patients (42%) were responders [16].

The acknowledged night-to-night variability of OSA [8] and the established POSA definition applied in the study may have influenced the observed results to some extent. The POSA definition has primarily been based on observations of the respiratory events in the lateral and supine positions and requires a reduction of AHI ≥50% in non-supine compared with the supine position [6]. Another 30% of OSA patients have positional influence on disease [7,10] but are not considered to have POSA according to the definition. The definition does not include an evaluation of the prone body position nor the head position.

The occurrence of OSA does not depend solely on the position of the body but also on the position of the head [19]. The sleep study equipment used in the present study provided position sensors for the observation of the position of the trunk and not the head. Three POSA patients were non-responders to the positional treatment even though the supine time was efficiently reduced with an increase in the registered prone time. Subsequent study of the camera recordings anecdotally revealed a predominantly prone body but not a prone head position in these patients.

The positive effect on the respiratory parameters seemed maximized when sleeping with the head in the prone position. In the attached video-recording a non-POSA patient achieves regular breathing with the body and the head in the prone position. Seconds later an accentuated apnoea-hypopnoea breathing pattern emerges with desaturations due to alteration of the position of the head to a lateral position with the body remaining in the prone position.

Future studies should provide an individual MPP to all participants to evaluate the long-term effect and compliance of prone positioning. Monitoring of the position of the head as an additional parameter in PSG studies would provide valuable information in diagnostics of OSA patients.

Conclusions

Prone positioning reveals promising results in improving AHI and ODI in OSA patients. A significant improvement of the respiratory parameters is achieved compared with both the lateral and supine positions. Future studies are needed to assess the efficiency and compliance of prone positioning in patients with OSA.

Acknowledgments

We would like to thank Raquel Praça Silva and Arash Bidarian-Moniri for their important contributions to the design and the development of the MPP, Christopher Oldmeadow for his valuable feedback on the final draft, Carlos Praça for drawing the 3D models of the MPP, Fernando Molina for the production of the instruction video, Ann-Christin Mjörnheim and Henrik Söderström for their assistance in performance of the PSG registrations and the participating patients for their valuable feedback.

Declaration of interest: This study was partially financed by Acta Otolaryngologica Foundation, Sweden. The sponsor had no role whatsoever in the study design, in the collection, analysis and interpretation of data, or in the writing of the manuscript and the decision to submit the manuscript for publication. Armin Bidarian Moniri is the patent-holder for the 'Pillow and Mattress for Reducing Snoring and Sleep Apnoea'.

References

[1] Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328:1230–5.
[2] Qaseem A, Holty JE, Owens DK, Dallas P, Starkey M, Shekelle P. Management of obstructive sleep apnea in adults: a clinical practice guideline from the American College of Physicians. Ann Intern Med 2013;Epub ahead of print.
[3] Franklin KA, Rehnqvist N, Axelsson S. [Obstructive sleep apnea syndrome – diagnosis and treatment. A systematic literature review from SBU]. Lakartidningen 2007;104: 2878–81; in Swedish.
[4] Weaver TE, Grunstein RR. Adherence to continuous positive airway pressure therapy: the challenge to effective treatment. Proc Am Thorac Soc 2008;5:173–8.
[5] Kribbs NB, Pack AI, Kline LR, Smith PL, Schwartz AR, Schubert NM, et al. Objective measurement of patterns of nasal CPAP use by patients with obstructive sleep apnea. Am Rev Respir Dis 1993;147:887–95.
[6] Cartwright RD. Effect of sleep position on sleep apnea severity. Sleep 1984;7:110–14.
[7] Richard W, Kox D, den Herder C, Laman M, van Tinteren H, de Vries N. The role of sleep position in obstructive sleep apnea syndrome. Eur Arch Otorhinolaryngol 2006;263:946–50.
[8] Sunnergren O, Brostrom A, Svanborg E. Positional sensitivity as a confounder in diagnosis of severity of obstructive sleep apnea. Sleep Breath 2013;17:173–9.
[9] Oksenberg A, Gadoth N. Are we missing a simple treatment for most adult sleep apnea patients? The avoidance of the supine sleep position. J Sleep Res 2014;23:204–10.

[10] Oksenberg A, Silverberg DS, Arons E, Radwan H. Positional vs nonpositional obstructive sleep apnea patients: anthropomorphic, nocturnal polysomnographic, and multiple sleep latency test data. Chest 1997;112: 629–39.
[11] Ravesloot MJ, van Maanen JP, Dun L, de Vries N. The undervalued potential of positional therapy in position-dependent snoring and obstructive sleep apnea – a review of the literature. Sleep Breath 2013;17:39–49.
[12] Kavey NB, Blitzer A, Gidro-Frank S, Korstanje K. Sleeping position and sleep apnea syndrome. Am J Otolaryngol 1985; 6:373–7.
[13] Matsuzawa Y, Hayashi S, Yamaguchi S, Yoshikawa S, Okada K, Fujimoto K, et al. Effect of prone position on apnea severity in obstructive sleep apnea. Intern Med 1995; 34:1190–3.
[14] Menon A, Kumar M. Influence of body position on severity of obstructive sleep apnea: a systematic review. ISRN Otolaryngol 2013;2013:670381.

Supplementary materials available online

Supplementary Video 1

[15] Iber C, Ancoli-Israel S, Chesson A, Quan SF. The AASM manual for the scoring of sleep and associated events: rules, terminology, and technical specification. Westchester, IL: American Academy of Sleep Medicine. 2007.
[16] Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996;19:156–77.
[17] Beaumont M, Fodil R, Isabey D, Lofaso F, Touchard D, Harf A, et al. Gravity effects on upper airway area and lung volumes during parabolic flight. J Appl Physiol (1985) 1998; 84:1639–45.
[18] Woodson BT, Franco R. Physiology of sleep disordered breathing. Otolaryngol Clin North Am 2007;40:691–711.
[19] van Kesteren ER, van Maanen JP, Hilgevoord AA, Laman DM, de Vries N. Quantitative effects of trunk and head position on the apnea hypopnea index in obstructive sleep apnea. Sleep 2011;34:1075–81.