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Original Research

SLEEP MEDICINE

Obesity Hypoventilation Syndrome*

Hypoxemia During Continuous Positive Airway Pressure

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Background: **Polysomnography findings between matched groups with obstructive sleep apnea (OSA) and OSA plus obesity-hypoventilation syndrome (OHS) before and after continuous positive airway pressure (CPAP), particularly in the extremely severe obese (body mass index [BMI] ≥ 50 kg/m^2), are unclear.**

Design: **Prospective study of subjects (BMI ≥ 50 kg/m^2) undergoing diagnostic polysomnography. Subjects with an apnea-hypopnea index (AHI) ≥ 15/h underwent a second polysomnography with CPAP. The effect of 1 night of CPAP on sleep architecture, AHI, arousal indexes, and nocturnal oxygenation was assessed. OHS was defined as those subjects with obesity, $Paco_2$ > 45 mm Hg, and Pao_2 < 70 mm Hg in the absence of lung disease.**

Results: **Twenty-three subjects with moderate-to-severe OSA and 23 subjects with moderate-to-severe OSA plus OHS underwent a 1-night trial of CPAP. Both groups were matched for spirometry, BMI, and AHI, but oxygen desaturation was worse in the OSA-plus-OHS group. CPAP significantly improved rapid eye movement (REM) duration ($p < 0.005$), AHI ($p < 0.005$), arousal indexes ($p < 0.005$), and percentage of total sleep time (TST) with oxygen saturation (Spo_2) < 90% ($p < 0.005$) in both groups. In subjects with OSA plus OHS, 43% continued to spend > 20% of TST with Spo_2 < 90%, compared to 9% of the OSA group, despite the adequate relief of upper airway obstruction.**

Conclusions: **Extremely severe obese subjects (BMI ≥ 50 kg/m^2) with moderate-to-severe OSA plus OHS exhibit severe oxygen desaturation but similar severities of AHI, arousal indexes, and sleep architecture abnormalities when compared to matched subjects without OHS. CPAP significantly improves AHI, REM duration, arousal indexes, and nocturnal oxygen desaturation. Some subjects with OHS continued to have nocturnal desaturation despite the control of upper airway obstruction; other mechanisms may contribute. Further long-term studies assessing the comparative role of CPAP and bilevel ventilatory support in such subjects with OHS is warranted.**

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Key words: continuous positive airway pressure; obesity-hypoventilation syndrome; obstructive sleep apnea; severe obesity

Abbreviations: AHI = apnea-hypopnea index; BMI = body mass index; CPAP = continuous positive airway pressure; non-REM = non-rapid eye movement; OHS = obesity-hypoventilation syndrome; OSA = obstructive sleep apnea; REM = rapid eye movement; Spo_2 = oxygen saturation; TST = total sleep time

Levels of obesity are increasing in all age groups, and studies[1,2] have indicated a high prevalence of obstructive sleep apnea (OSA) in the extremely obese population (body mass index [BMI] ≥ 50 kg/m^2). The majority of obese subjects with OSA have normal alveolar ventilation when awake. However, in a subgroup of subjects, hypoventilation while awake will be present. The term *obesity-hypoventilation syndrome* (OHS) describes those subjects with obesity, daytime hypercapnia ($Paco_2$ > 45 mm Hg), and hypoxia (Pao_2 < 70 mm Hg) in the absence of significant lung or respiratory muscle disease.[3] Subjects with OSA plus OHS also exhibit severe prolonged oxygen desaturations during sleep. The mechanisms that contribute toward the development of OHS are multiple, and include abnormal pulmo-

nary mechanics, altered hypoxic and hypercapnic ventilatory responses (possibly explained by the chronic hypoxemia and poor sleep quality), upper airway obstruction, and possibly the influence of leptin.[4,5]

The treatment of choice for OSA is continuous positive airway pressure (CPAP). Two studies[6,7] in

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subjects with OHS have demonstrated that 1 year of treatment with bilevel ventilation improves arterial blood gas levels. In a proportion of subjects, bilevel ventilation may be replaced by long-term CPAP therapy.[7] However, few studies have been performed to determine the short-term effect of CPAP on sleep-disordered breathing, sleep architecture, arousal indexes, and nocturnal desaturation in clinically stable subjects with OSA plus OHS. One of the aims of CPAP therapy is to correct nocturnal oxygen desaturation, but anecdotal observations suggest that CPAP may not result in normalizing oxygen saturations during sleep in subjects with OSA and OHS, compared with OSA alone.[8] If hypoxemia persists while treating the OSA, recovery from hypoventilation may be limited, as ventilatory responsiveness may continue to be blunted. It may be possible that the results of an initial night trial of CPAP would determine who would benefit from long-term CPAP or bilevel ventilation, depending on whether sleep architecture and oxygen desaturation are corrected during sleep.

The aims of this study were to compare the degree of sleep-disordered breathing and oxygenation abnormalities present in untreated, very obese subjects with OSA plus OHS, and to compare these findings to that found in weight-matched OSA subjects without OHS. In addition, we studied the initial effect of CPAP on sleep architecture, arousal indexes, and sleep-disordered breathing parameters in these subjects.

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Materials and Methods

Subjects

A prospective study was undertaken of all subjects with extremely severe obesity (BMI $\geq$ 50 kg/m^2) consecutively presenting to and undergoing diagnostic overnight polysomnography at the Royal Prince Alfred Hospital, Sydney, between August 2001 and January 2004. All subjects were referred to the unit for the investigation of possible sleep-disordered breathing. Any subject with a history or clinical examination suggestive of neuromuscular disease, chest wall disease (*eg*, kyphoscoliosis or polio), or interstitial lung disease was not considered in the study. All patients were clinically stable for $>$ 6 weeks up to the diagnostic polysomnography. OHS was determined by the presence of daytime hypercapnia ($Paco_2$ $>$ 45 mm Hg) and hypoxia (Pao_2 $<$ 70 mm Hg) in the presence of obesity (in this study, all patients had a BMI $\geq$ 50 kg/m^2) and the absence of obstructive airways disease (FEV_1/FVC ratio $<$ 70%). Approval for the study was obtained by the Ethics Committee of the Central Sydney Area Health Service (Eastern Division), and consent was obtained from patients to review their clinical data

Measurements

BMI and spirometry were obtained on the day of the diagnostic polysomnography. Measurements of spirometry were performed using a handheld spirometer (MicroLab; Micro Medical; Rochester, UK), using a digital volume transducer (accuracy +/− 3% for flow and volume). Arterial blood gas measurements were performed while the subject was seated and breathing room air on the afternoon of the diagnostic polysomnography.

Sleep Study Recordings

During the polysomnography, continuous recordings were made on a computerized system (Sleepwatch; CompuMedics; Melbourne, Australia) using standard EEG, electromyography, and electrooculography methodology. Oxygen saturation (Spo_2) was measured with a finger probe (model 3700e; Ohmeda; Boulder, CO). Sleep stages were scored in 30-s epochs according to standard criteria.[9] Sleep efficiency was defined as total sleep time (TST) as a percentage of the total time available for sleep. Apnea was defined as cessation of airflow for $\geq$ 10 s, or a cessation of airflow for $<$ 10 s with an oxygen desaturation of $\geq$ 3% and / or an arousal. Hypopnea was defined as a reduction in amplitude of airflow, or thoracoabdominal wall movement of $>$ 50% for $\geq$ 10 s, or a reduction in airflow or thoracoabdominal wall movement of $<$ 50% for $>$ 10 s if it was accompanied by an oxygen desaturation of $\geq$ 3% and/or an arousal. The number of apneas and hypopneas per hour of non-rapid eye movement (non-REM) and rapid eye movement (REM) and TST were calculated and reported as non-REM index, REM index, and total apnea-hypopnea index (AHI), respectively. The percentage of REM and non-REM during TST were calculated. Parameters of oxygenation measured included awake Spo_2 during the overnight polysomnography, absolute minimum Spo_2, and percentage of TST with Spo_2 $<$ 90% and $<$ 80%.

CPAP Treatment

A CPAP trial was offered to those subjects with an AHI $\geq$ 15 events per hour (*ie*, at least moderate OSA). The subject attended the unit at a later date for a CPAP pressure titration study (*ie*, repeat polysomnography with CPAP). Titration of CPAP was performed by manually adjusting pressure in response to upper

airway dysfunction by use of an auto-CPAP machine. Increasing the airway positive pressure aimed to normalize the inspiratory airflow pattern on the flow trace to a pressure at which the cessation of all obstructive events was achieved. Airflow limitation was identified by a flattening of the inspiratory flow-time contour followed by an abrupt return to a normal sinusoidal contour once the obstruction was relieved or arousal had occurred. Increasing the airway positive pressure aimed to unload the upper airway and normalize the inspiratory airflow pattern on the flow trace. Most subjects generally reached a near-optimum level of CPAP delivery within 1 hour of sleep onset. Pressures were increased by no more than 3 cm H_2O if the flow trace had normalized but low baseline Spo_2 or frequent arousals were still evident. The presence of a leak was checked for first and then corrected. Significant mouth leaks were addressed by means of a chin strap or full face mask. All subjects underwent an educational session with the specialist nurse during the afternoon before the overnight polysomnography to familiarize themselves with the machine and mask (nasal or full face). Subjects with mild OSA (*ie*, AHI $<$ 15/h) but very severe obesity (BMI $\geq$ 50 kg/m^2) were referred to local weight loss services.

Statistical Analysis

Continuous data were tested for normality using the one-sample Kolmogorov-Smirnov test. Data normally distributed are represented by mean (SE), and data that are not normally distributed are represented by median (interquartile range). When analyzing differences between means of two different populations, normally distributed data were tested using the parametric Student *t* test and data not normally distributed by the nonparametric Mann-Whitney *U* test. Two tailed tests were used, and $p < 0.05$ was regarded as being statistically significant. Data were analyzed using statistical software (Version 10.0; SPSS; Chicago, IL).

Results

Sleep Study Population and Recordings

Eighty subjects (34 men) with a BMI $\geq$ 50 kg/m^2 presented to the sleep-disordered breathing clinic. All patients underwent polysomnography. Mild OSA (AHI, 5 to 14.9/h) was demonstrated in 10 subjects, moderate OSA (AHI, 15 to 29.9/h) was demonstrated in 14 subjects, and severe OSA (AHI $>$ 30/h) was demonstrated in 50 subjects. All subjects had $>$ 80% obstructive or mixed apneas and hypopneas. Six (7.5%) subjects did not demonstrate OSA (*ie*, an AHI $<$ 5/h).

Exclusions

The 10 subjects with mild OSA were excluded from further study, as were the 6 subjects without evidence of any apnea activity. Five patients were excluded from the subsequent CPAP trial study because they underwent bilevel ventilation therapy, including one subject who had severe bronchiectasis; four subjects went onto CPAP and supplemental oxygen therapy. No subjects had a clinical diagnosis of neuromuscular, chest wall, or interstitial lung diseases. At the time when the study was stopped, five subjects had not undergone their CPAP trial. From the remaining 50 subjects, blood gas levels were not obtainable from four subjects due to technical reasons. The remaining 46 subjects (with moderate and severe OSA) underwent the CPAP study trial without supplemental oxygen therapy.

Demographic, Spirometry, Blood Gas, and Sleep Study Variables

Table 1 demonstrates the general demographics, and blood gas and spirometry measurements for patients with OSA only and OSA plus OHS. There were 23 subjects in each group (10 men in the OSA-only group, and 15 men in the OSA-plus-OHS group). There were no significant differences in weight, BMI, spirometry, and comorbidities (smoking, antihypertensive therapy, and presence of dia-

Table 1—*Demographics, Spirometry, and Blood Gas Analysis for Subjects With OSA (n = 23) and OSA Plus OHS (n = 23)

Parameters	OSA	OSA Plus OHS	p Value
Age, yr	45.3 (2.4)	43.0 (2.2)	NS
Weight, kg	167.3 (6.1)	173.0 (5.5)	NS
BMI, kg/m^2	59.9 (1.9)	58.7 (1.1)	NS
FEV_1, L	2.34 (0.24)	2.13 (0.16)	NS
FEV_1, % predicted	71.0 (5.40	63.9 (3.40	NS
FVC, L	2.92 (0.28)	2.69 (0.21)	NS
FVC, % predicted	74.1 (5.2)	69.2 (3.3)	NS
FEV_1/FVC ratio	79.8 (1.9)	80.4 (1.6)	NS
Pao_2, mm Hg	83.2 (2.2)	60.9 (1.2)	$<$ 0.001
$Paco_2$, mm Hg	42.9 (0.9)	54.3 (1.5)	$<$ 0.001
Receiving antihypertensive therapy	17	12	NS
Presence of diabetes mellitus	9	7	NS
Current smoker	11	7	NS

*All data were normally distributed and represented as mean (SE) or No. NS = not significant.

betes) between both groups. Blood gas analyses confirmed that the OSA-plus-OHS group had worse $PaCO_2$ and PaO_2 levels while breathing room air than the OSA-only group.

Table 2 demonstrates the diagnostic polysomnography data for both groups. There was no statistically significant difference in sleep apnea severity and arousal indexes between the two groups, although there was a tendency for the total AHI and arousal index to be greater in the OSA-plus-OHS group. Spo_2 levels $< 90\%$ were present for a median time of 75% of TST in the OSA-plus-OHS group, compared to 15% in the OSA group ($p = 0.001$). In addition, $Spo_2 < 80\%$ was present for a median time of 9% of TST in the OSA-plus-OHS group but on average did not occur in the OSA group ($p = 0.035$).

Response to CPAP

The effects of 1 night of CPAP on sleep parameters in both groups are demonstrated in Table 3. During the first night of CPAP, both groups showed an improvement in the total amount of REM sleep (with a reduction in non-REM sleep duration), arousal indexes, apnea/hypopnea severity, minimum Spo_2, and percentage of TST with $Spo_2 < 90\%$ and $< 80\%$. Although the OSA-plus-OHS group had a worse persisting total AHI, this did not reach statistical significance. However, the OSA-plus-OHS group had statistically worse levels of percentage of TST with $Spo_2 < 90\%$ and $< 80\%$, minimum Spo_2, and Spo_2 while awake. The optimal pressures to eliminate apneas and hypopneas were comparable between both groups. Mean ± SE optimum pressure attained in the OSA group was 12.9 ± 2.4 cm H_2O and 13.9 ± 3.1 cm H_2O in the OSA-plus-OHS group. Only one patient (OSA-only group) did not achieve any REM sleep during the CPAP night.

Figures 1, 2 show the scatter plots for percentage of TST with $Spo_2 < 90\%$ and the effect of 1 night of CPAP on this parameter in both groups, respectively. Although the overall trend was an improvement in percentage of TST with $Spo_2 < 90\%$ for subjects with OSA and OHS, the scatter plot does demonstrate that 10 subjects (43%) continue to desaturate (spend $> 20\%$ of TST with $Spo_2 < 90\%$) despite adequate treatment of the upper airway obstruction by CPAP, compared to 2 subjects (9%) in the OSA group (Fig 1, 2).

Comparing those OHS patients who continue to spend $> 20\%$ of TST with $Spo_2 < 90\%$ with those who spend $< 20\%$ TST with $Spo_2 < 90\%$ (Table 4), the former group were more obese (from BMI), and spent more time with $Spo_2 < 90\%$ while asleep during the diagnostic polysomnography. Blood gas levels and spirometry were comparable. There were more apneas and hypopneas during CPAP in those who continue to desaturate, particularly in REM sleep. The amount spent in REM was comparable in both groups.

Discussion

The present study has shown that 1 night of CPAP therapy improves upper airway obstruction, arousal indexes, sleep architecture, and nocturnal oxygen desaturation in subjects with extremely severe obesity (BMI > 50 kg/m^2) and moderate-to-severe OSA, with or without OHS. However, the response of nocturnal oxygen desaturation to CPAP was strikingly different in those with OSA and OHS, despite adequately treating the apneas and hypopneas, with 43% of these subjects continuing to desaturate with $Spo_2 < 90\%$ for $> 20\%$ of TST.

We are not aware of data comparing the response to

Table 2—*Sleep Variables From the Diagnostic Overnight Polysomnography for Subjects With OSA (n = 23) and OSA Plus OHS (n = 23)

Parameters	OSA	OSA Plus OHS	p Value
Percentage of non-REM of total sleep	87.1 (1.6)	90.9 (2.0)	NS
Percentage of REM of total sleep	12.9 (1.6)	9.1 (2.1)	NS
Sleep efficiency, %	72.2 (2.6)	73.2 (3.9)	NS
Arousal index/h of sleep	37.5 (5.0)	53.2 (6.7)	NS (0.07)
Apnea/hypopnea arousal index/h of sleep	39.4 (8.50	49.6 (6.7)	NS
Spo_2 average awake, %	93.8 (0.6)	89.9 (1.1)	0.004
Spo_2 minimum, %	67.6 (4.4)	61.9 (3.9)	NS
Non-REM AHI, events/h	58.9 (7.6)	77.9 (8.8)	NS (0.11)
REM AHI, events/h	45.6 (6.1)	45.8 (8.6)	NS
Total AHI, events/h	61.9 (7.6)	78.0 (8.4)	NS
Percentage of TST with $Spo_2 < 90\%$†	15 (4–38)	75 (31–96)	0.001
Percentage of TST with $Spo_2 < 80\%$†	0 (0–11)	9 (0–31)	0.035

*Data were normally distributed and presented as mean (SE). See Table 1 for expansion of abbreviation.
†Data are not normally distributed and are presented as median (interquartile range).

Table 3—*The Effect of 1 Night of CPAP Therapy on Overnight Sleep Parameters for Subjects With OSA (n = 23) and OSA Plus OHS (n = 23)

Parameters	OSA	OSA Plus OHS	p Value
Percentage of non-REM of total sleep	77.7 (2.1)	75.9 (2.5)	NS
Percentage of REM of total sleep	22.2 (2.2)	24.1 (2.5)	NS
Sleep efficiency, %	75.3 (3.3)	78.7 (2.8)	NS
Arousal index/h of sleep	8.9 (1.2)	9.3 (1.6)	NS
Apnea/hypopnea arousal index/h of sleep	3.7 (0.9)	3.7 (1.2)	NS
Spo_2 average awake, %	95.4 (0.4)	92.4 (0.8)	0.003
Spo_2 minimum, %	86.6 (1.0)	75.4 (4.2)	0.015
Non-REM AHI, events/h	6.5 (1.6)	16.0 (7.1)	NS
REM AHI, events/h	6.9 (1.7)	9.6 (1.7)	NS
Total AHI, events/h	8.5 (2.4)	16.4 (6.1)	NS
Percentage of TST with Spo2 < 90%†	1 (0–5)	18 (1–54)	0.015
Percentage of TST with Spo2 < 80%†	0 (0–0)	0 (0–6)	0.05

*Data were normally distributed and presented as mean (SE). See Table 1 for expansion of abbreviation.
†Data are not normally distributed and are presented as median (interquartile range).

CPAP in subjects with OSA vs subjects with OSA plus OHS with similar degrees of obesity and lung function. It is not certain why oxygen desaturation in some individuals responds well to initial CPAP compared to others. Both the OSA and OSA-plus-OHS groups had similar BMI, spirometry, and AHI parameters, although those with OSA plus OHS had more severe desaturation during sleep. In the current study, 1 night of CPAP reached optimum pressure to treat airway obstruction within 1 hour of commencement of CPAP in the majority of patients, and both groups achieved similar reductions in apnea and hypopnea episodes, with significant improvements in sleep architecture (an

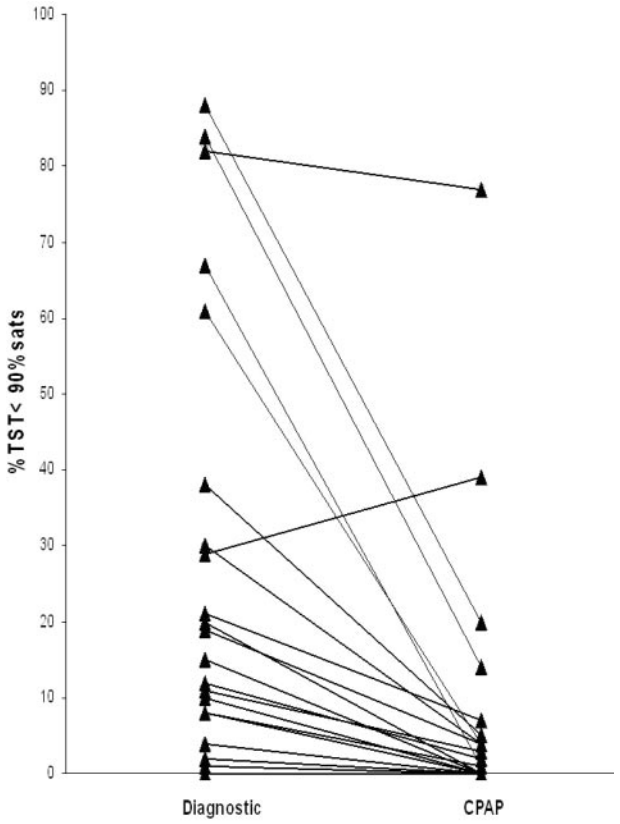

FIGURE 1. The response to 1 night of CPAP on percentage of TST with Spo_2 < 90% (%TST<90%sats) in 23 subjects with OSA.

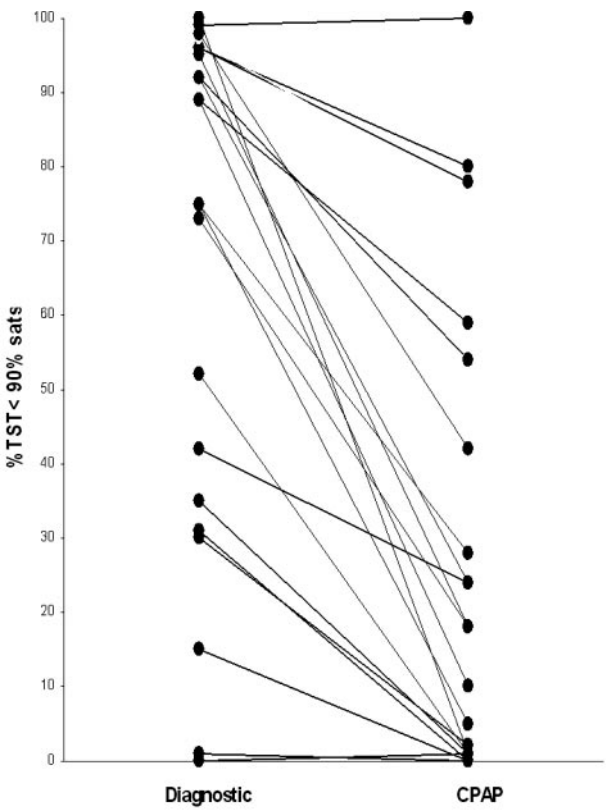

FIGURE 2. The response to 1 night of CPAP on percentage of TST with Spo_2 < 90% in 23 subjects with OSA plus OHS. See Figure 1 legend for expansion of abbreviation.

Table 4—*Comparison of OHS Subjects Who Spend > 20% of TST With Spo_2 < 90% (n = 10) With Those Who Spend ≤ 20% of TST With Spo_2 < 90% (n = 13) During CPAP***

Parameters	>20% of TST With Spo_2 < 90%	≤ 20% of TST With Spo_2 < 90%	p Value
BMI	61.6 (1.7)	56.5 (1.2)	0.02
Percentage of TST with Spo_2 < 90%	87 (5)	46 (10)	0.004
Pao_2, mm Hg	59.4 (2.1)	62.3 (1.5)	NS
$Paco_2$, mm Hg	55.5 (3.0)	53.3 (1.4)	NS
FEV_1, L	2.07 (0.23)	2.17 (0.23)	NS
FVC, L	2.55 (0.32)	2.79 (0.30)	NS
Percentage of REM (CPAP)	26.6 (5.0)	22.1 (2.3)	NS
REM AHI, /h	15.3 (2.9)	5.3 (0.8)	0.009
Total AHI, /h	25.1 (12.5)	9.8 (5.0)	NS
Percentage of TST with Spo_2 < 90% (CPAP)	56.5 (8.4)	4.4 (1.8)	0.0001

*Data were normally distributed and presented as mean (SE). See Table 1 for expansion of abbreviation.

increase in time spent in REM) and arousal indexes. The authors acknowledge while the CPAP delivery is being optimized in the first hour of the CPAP night, oxygen desaturations and apneas do occur. However, the optimal pressures and time to reach this pressure in both groups were comparable and within the first hour.

CPAP was shown > 20 years ago to be successful in treating two subjects with OHS.[10] More recent studies[8,11–13] have investigated the response of daytime hypercapnia in subjects with OHS to CPAP or bilevel therapy. These showed that both forms of ventilation can improve $Paco_2$. However, these studies were uncontrolled, small in numbers, and did not have a comparative group of subjects with OSA without OHS. The current study demonstrates that similarly matched groups of OSA and OSA plus OHS have equivalent CPAP responses with respect to ameliorating apneic and hypopneic events. However, this study also revealed the occurrence of continued oxygen desaturation in the OSA-plus-OHS group compared to the matched OSA-only group despite CPAP. Both groups were noted to have REM rebound, which may contribute to hypoventilation and oxygen desaturation. There may be some recovery of chemoreceptor function even in the first night of CPAP titration, but how this differs between both groups is unclear. Although there were small numbers in the subgroup analysis comparing those subjects with OSA plus OHS who continue to desaturate with CPAP compared to those that do not, one can hypothesize that continual desaturation despite CPAP may be determined by the degree of sleep-disordered breathing in REM sleep, independent of spirometry and baseline respiratory failure. Time spent with Spo_2 < 90% during sleep may be helpful in identifying those who may not respond, and further studies on this matter are warranted.

Two studies[6,7] have shown improvements in respiratory failure by treatment with bilevel ventilation over a period of at least 1 year. Although the response of sleep-disordered breathing in the long term may not be accurately extrapolated from 1 night of CPAP titration, the present study findings may help to choose initial treatment (*ie*, CPAP vs bilevel with possible switch over to CPAP once daytime respiratory failure has resolved). A previous study[14] has suggested that nocturnal noninvasive ventilation could be used as an interim measure in subjects with severe OSA and hypercapnia until ventilatory decompensation is reversed (possibly by alterations in ventilatory drive and ventilatory responses to hypercapnia and hypoxia) and CPAP therapy be resumed long term. Others[7] have shown that a proportion of patients may be switched over to CPAP once respiratory failure has been controlled. CPAP therapy from the start rather than bilevel ventilation followed by CPAP may be just as effective (particularly improving sleep architecture and arousals) and potentially more cost-effective in patients with OHS, even if blood gases are not corrected immediately. A recent large retrospective study[15] (with a comparable mean BMI to the current study) looked at the effect of CPAP adherence on respiratory failure in patients with OSA. This study found that good compliance with CPAP leads to an improvement in respiratory failure (comparable improvements to those subjects receiving bilevel ventilation), and there was a reduction in the need for oxygen supplementation with time. However, those patients who continue to spend significant percentage of TST with Spo_2 < 90% despite the elimination of upper airway collapse may do better using bilevel ventilation from the outset. At present, the long-term prognosis of patients who remain hypercapnic while treated with CPAP is also unclear. It may be possible that in individuals without daytime respiratory failure, the percentage of TST with Spo_2 < 90% may be a useful parameter to identify those with OSA at risk for OHS.

The current study had short outcome data, and therefore any future studies would need to have longer-term outcome measurements to answer whether persisting oxygen desaturation despite adequate CPAP therapy in subjects with OSA plus OHS is corrected with time. This study also lacked an intention-to-treat protocol due to some missing data from the outset and did not measure other formal scales of subjective sleepiness, lung volumes, ventilatory responsiveness, or other metabolic parameters such as leptin.

The factors that may determine which subjects will acquire subsequent daytime respiratory failure is intriguing. Residual desaturation in many OSA-plus-OHS subjects during initial CPAP probably reflects continued hypoventilation despite the reversal of apneic events. It is possible that incomplete occlusion is still present accompanied by defective ventilatory load compensation or that the ventilatory response to hypoxia and or hypercapnia is so depressed that inadequate alveolar ventilation is present accounting for the blood gas derangements. In many settings, oxygen supplementation is added to CPAP, leaving the probable hypercapnia untreated. Does this approach decrease the likelihood of eventually achieving normal gas exchange during wakefulness? A systematic investigation of this question seems indicated in view of the frequency of significant desaturation during "adequate" CPAP. Further controlled longitudinal studies comparing bilevel noninvasive ventilatory support against CPAP in obese subjects with OHS plus OSA are warranted.

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