REVIEW ARTICLES

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Obstructive Sleep Apnea and Oxygen Therapy: A Systematic Review of the Literature and Meta-Analysis

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Background: Hypoxemia is an immediate consequence of obstructive sleep apnea. Oxygen (O_2) administration has been used as an alternative treatment in patients with obstructive sleep apnea (OSA) who do not adhere to continuous positive airway pressure (CPAP) in order to reduce the deleterious effects of intermittent hypoxemia during sleep. This systematic review aims to investigate the effects of O_2 therapy on patients with OSA.

Method: We conducted a systematic search of the databases Medline, Embase, Cochrane Central Register of Controlled Trials (1st Quarter 2011), Cochrane Database of Systematic Reviews (from 1950 to February 2011). Our search strategy yielded 4,793 citations. Irrelevant papers were excluded by title and abstract review, leaving 105 manuscripts. We reviewed all prospective studies that included: (1) a target population with obstructive sleep apnea, (2) O_2 therapy and/or CPAP as a study intervention, (3) the effects of O_2 on the apnea-hypopnea index (AHI), nocturnal hypoxemia, or apnea duration.

Results: We identified 14 studies including a total of 359 patients. Nine studies were of single cohort design, while 5 studies were randomized control trials with 3 groups (CPAP, oxygen, and placebo/sham CPAP). When CPAP was compared to O_2 therapy, all but one showed a significant improvement in AHI. Ten studies demonstrated that O_2 therapy improved oxygen saturation vs. placebo. However, the average duration of apnea and hypopnea episodes were longer in patients receiving O_2 therapy than those receiving placebo.

Conclusion: This review shows that O_2 therapy significantly improves oxygen saturation in patients with OSA. However, it may also increase the duration of apnea-hypopnea events.

Keywords: OSA, CPAP, oxygen therapy

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Obstructive sleep apnea (OSA) is the periodic reduction (hypopnea) or cessation (apnea) of airflow due to narrowing of the upper airway during sleep, often accompanied by hypoxemia and sleep disturbance.[1] The prevalence of OSA is estimated to be between 2% and 25% in the general population. OSA is linked to hypertension, ischemic heart disease, stroke, premature death, and motor vehicle crash.[2-7]

Oxygen desaturation is an immediate consequence of obstructive sleep apnea. Intermittent hypoxemia increases sympathetic activity and norepinephrine levels and leads to hypertension.[8,9] It has also been associated with an increased risk of diabetes.[10] Indeed, most of the sequelae of obstructive sleep apnea are more strongly linked to the degree and duration of oxygen desaturation than to the numbers of apneas and hypopneas or disruptions in sleep architecture.[11] The resolution of nocturnal intermittent hypoxemia associated with sleep apnea is a major goal of the treatment of patients with obstructive sleep apnea.

Many treatment approaches have been employed for the treatment of moderate to severe OSA, but CPAP is the treatment of choice and has been widely prescribed.[12,13] In placebo-controlled and uncontrolled studies, CPAP has been shown to reduce apnea-hypopnea index (AHI) and to improve hypoxemia associated with respiratory events during sleep.[14,15] CPAP adherence has been reported to be as low as 50%, at least in part because it is a burdensome treatment.[16]

Oxygen administration has been used as an alternative treatment in patients with OSA who are not somnolent or not compliant with CPAP; the purpose of supplemental oxygen in this situation is to reduce the deleterious effects of transient hypoxemia during sleep.[17] Supplemental oxygen has been shown to be effective in improving the AHI, respiratory arousal index, and nocturnal desaturation during apneic episodes.[18] However, oxygen therapy may lengthen apnea duration, thus accelerating CO_2 retention.[19]

This systematic review aims to investigate the effects of CPAP and oxygen on patients with OSA. This review addresses the following questions: (1) Does evidence from controlled trials support the preferential use of CPAP over oxygen for improving OSA symptoms? (2) Can oxygen therapy be safely used in patients who are non-adherent with CPAP?

METHODS

For purposes of this analysis, the target population consisted of adult humans with a diagnosis of obstructive sleep apnea defined as an AHI > 5 events per hour. The diagnosis of OSA was made using polysomnography (PSG). The study intervention included

Table 1—Cochrane risk of bias in included studies

Study ID	Adequate Sequence Generation	Allocation Concealment	Blinding	Incomplete Outcome Data Assessed	Free of Selective Outcome Reporting	Free of Other Biases
Phillips	Unclear	Unclear	Yes	Yes	Yes	No
Loredo	Yes	Unclear	Yes	Yes	Yes	No
Norman	Yes	Unclear	Yes	Yes	Yes	No
Mills	Yes	Unclear	Yes	Yes	Yes	Unclear
Bardwell	Yes	Unclear	Yes	Yes	Yes	No
Lim	Yes	Unclear	Yes	Yes	Yes	No

either the CPAP and oxygen therapy or oxygen therapy compared with the placebo. Outcomes of interest included the effects on AHI, nocturnal hypoxemia, apnea duration, and arousal index.

Literature Search

The literature search was performed according to the PRISMA (Preferred Reporting Items for Systematic reviews and meta-analysis) guidelines.[20] The databases Medline, Embase, Cochrane Central Register of Controlled Trials (1st Quarter 2011), Cochrane Database of Systematic Reviews (from 1950 to Feb 2011) were thoroughly searched to include all available evidence for the systematic review. We developed and executed the search strategy with the help of an expert librarian familiar with the literature search protocol of the Cochrane Collaboration. The following target population keywords were used for the literature search: "obstructive sleep apnea," "obstructive sleep apnea syndrome," "obstructive sleep apnea-hypopnea syndrome," "sleep disordered breathing," "obesity hypoventilation syndrome" and "apnea-hypopnea," "sleep apnea syndrome and "apnea." The target intervention keywords used were "oxygen", "oxygen therapy," "oxygen inhalational therapy," "CPAP," "positive airway pressure," and "continuous positive airway pressure." The results of the target population were combined with the target intervention results (using an "and"). Studies focusing on central sleep apnea were excluded by including "NOT central sleep apnea" in the search strategy. The search strategy was limited to English language abstracts and adult human population. Duplicate records, if any were removed from the final search result. We also reviewed the reference lists of relevant articles to retrieve potentially relevant articles.

1. Medline (Ovid SP) (1948 to Feb 2011)
2. EMBASE (1980 to Feb 2011)
3. Cochrane Database of Systematic Reviews (1st quarter 2011)
4. Cochrane Central Controlled Trials Registry (1st quarter 2011)

The databases of the Cochrane Library were used to confirm the completeness of the search. The time period searched was 1948 to 2011.

Study Selection

The search results were evaluated by two independent reviewers (VM, TSV). First, irrelevant papers were excluded by reviewing the title of the records. Next, the abstract and/or full text articles of the remaining papers were retrieved and carefully evaluated to determine if they met the eligibility criteria.

All prospective studies, including randomized and non-randomized placebo controlled trials were included if they reported the effects of CPAP treatment or oxygen therapy on AHI, oxygen saturation, apnea duration, and arousal index in patients with OSA. Studies not reporting at least one of these outcomes were excluded. All observational studies were graded for strength of evidence according to the Oxford level of evidence.[21] We used the Cochrane risk of bias tool to assess the risk of bias for 6 randomized controlled trials (**Table 1**).[22]

Data Extraction

Data extraction was completed by two reviewers (VM, TSV) and validated by the senior author (FC). Various data extracted from these studies included the type of study, level of evidence, number of patients receiving the study intervention, type of study intervention, duration and effects of intervention on AHI, SpO_2, arousal index, and apnea duration. We divided the studies into 2 groups: the first group included studies which used CPAP and O_2 treatment; the second group included studies which used only O_2 therapy as an intervention. The methodological qualities of the included studies were independently evaluated by the first author (VM), if any doubt the senior author was consulted (FC). Individual authors were contacted via emails for the details of the results

Statistical Analysis

We performed the meta-analyses by using fixed-effects model if no heterogeneity was present. In order to assess the heterogeneity between studies, we used χ^2 tests and estimated the I^2 statistic. We considered the heterogeneity to be present if the p value on the χ^2 test was < 0.05. In the presence of heterogeneity, we pooled the results by using random-effects (DarSemonian and Laird method) model. The standardized mean difference was used to pool continuous variables that used different scales. We performed separate random-effects meta-analyses among randomized controlled studies comparing CPAP, placebo CPAP, and oxygen. We did not correct for multiple comparisons.

RESULTS

The Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines were followed for the description of the search strategy. Our search strategy yielded 4,793 citations (**Figure 1**). In the first session of screening, most studies were eliminated based on the predetermined eligibility criteria, leaving 105 articles. In the second session, 105 articles were evaluated and 14 articles were identified as

meeting the inclusion criteria, with subsequent exclusion of 91 articles. Articles were excluded for the following reasons: Non-pertinent papers—excluded by abstract/full-text review (n = 64), O_2 therapy in pediatric OSA (n = 11), reviews papers (n = 10), correspondence (n = 4), and case reports (n = 2).

Study Characteristics

Tables 2 and **3** summarize study characteristics included in the systematic review. There were 6 studies[23-28] that used a randomized control design with 3 groups, each group being assigned to CPAP, placebo CPAP, or O_2 to evaluate the effects of CPAP and O_2 on AHI, O_2 saturation, and arousal indices. Eight studies[29-36] used a single cohort in which the outcome was measured in the same study population before and after the study intervention. All of these observational studies compared the effects of room air with O_2 on mean oxyhemoglobin saturation, sleep disordered breathing (SDB) events, and SDB event duration. These 8 studies were graded according to Oxford level of evidence and had a 2b level of evidence. We could not pool the results from the study by Block et al.[33] because the authors did not provide the standard deviation for the outcome of interests.

Patient Characteristics

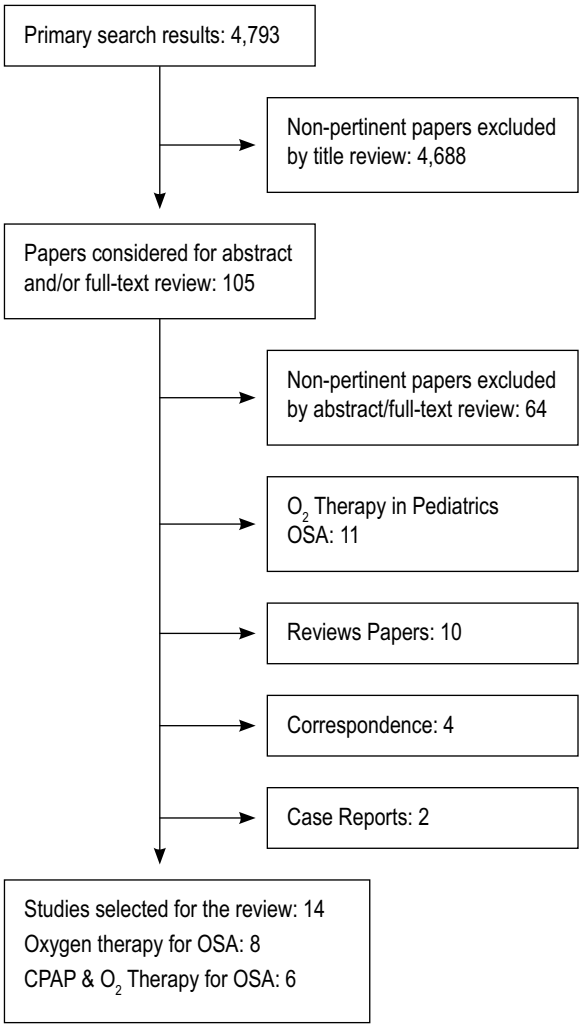
Table 2 represents a group of patients who received CPAP and O_2 intervention versus placebo CPAP. **Table 3** represents a group of patients who received O_2 intervention compared with control (air). A total of 359 patients were included in the 14 studies. All the patients had a diagnosis of OSA confirmed by in-laboratory polysomnography. The inclusion criteria of the patients differed among the studies selected for the review. Two studies[23,33] used AHI > 5; 5 studies[24-28] used AHI > 15; one study[32] used SDB event > 50/h, and one study[35] used RDI > 20 for OSA patient selection. Four studies[30,31,34,36] selected patients with a confirmed diagnosis of OSA following overnight PSG with no description of any specific AHI criteria. Most of the patients were male, accounting for 89% of the study population. All the patients in the reported studies had moderate to severe OSA with AHI ranging from 20.5 ± 5 to 88.2 ± 27. The duration of the study intervention across the different studies was in the range of 1 night to 3 months.

Effects on Oxygenation, Respiratory Events, and Sleepiness

Table 2 summarizes the effects of the different treatment modalities on AHI, SpO_2 and arousal events studied by 6 RCTs. The respiratory disturbances occurring during the nighttime in OSA patients were measured using AHI, respiratory disturbance index (RDI), or SDB events. When CPAP was compared with O_2, CPAP was significantly more effective in reducing AHI, while O_2 was shown to be more effective in elevating the mean SpO_2 and mean nadir SpO_2 during hypoxemic events. Both CPAP and O_2 improved the oxygenation as compared to placebo (sham) CPAP; this effect was statistically significant ($p < 0.05$). Four studies showed that CPAP versus O_2 therapy was more effective in improving the arousal events/total arousal index, but we could not pool the arousal events for the meta-analysis because of insufficient data.

The effects of CPAP and oxygen supplementation on the daytime somnolence was evaluated by 2 studies.[23,24] In one study, nasal CPAP was more effective in improving objectively measured daytime sleepiness than oxygen. This effect was apparent due to the significant efficacy of CPAP in lengthening the multiple sleep latency test (MSLT) time compared to baseline.[23] Similarly, another study showed the effectiveness of CPAP in reducing Epworth Sleepiness Scale score; however, it was not statistically different from placebo-CPAP or supplemental oxygen.[24]

Figure 1—Flowchart of the literature search indicating number of papers in each condition



Effects on Systemic Blood Pressure

Three studies showed the treatment outcome on systemic blood pressure in patients treated with CPAP, oxygen, and placebo-CPAP.[23,25,26] Two studies showed that CPAP effectively reduced both the systolic as well as the diastolic blood pressure as compared to oxygen ($p < 0.05$).[25,26] In one study, CPAP and oxygen both had the effects in lowering the systolic blood pressure as compared to diastolic blood pressure; however, the changes were not statistically significant.[23]

The effects of O_2 therapy on the oxygen saturation and SDB events are summarized in **Table 3**. Seven studies showed that oxygen therapy was effective in improving the oxygenation as compared to air (control) in OSA patients. The SDB events

Table 2—Study characteristics and effects of CPAP vs. oxygen therapy in OSA patients

Study ID	Design / Total Population	Intervention	Duration	Baseline Data		Variables	CPAP	Oxygen	P-CPAP
				AHI	SpO_2				
Phillips 1990	Randomized crossover / 8	Nasal O_2 Nasal Air Nasal CPAP	3 month	20.5 ± 4.8	88.7 ± 2.8	AHI	3.0 ± 0.9*	16.8 ± 3.2	22.1 ± 5.7
						Mean low SpO_2	93.7 ± 0.9	95.9 ± 0.3*	89.9 ± 1.8
						Arousal events (n)	70.8 ± 16.6	110.6 ± 1.7	84.9 ± 21.8
						SSS	2.5 ± 0.3	2.5 ± 0.2	2.9 ± 0.3
						SBP (mm Hg)	140.8 ± 4.5	139.6 ± 5.2	144.6 ± 5.9
						DBP (mm Hg)	94.6 ± 2.9	96.4 ± 5.4	95.9 ± 2.6
Loredo 2006	RCT / 63	CPAP P-CPAP Oxygen	2 weeks	65.9 ± 28.6 57.5 ± 32.1 64.9 ± 33.7	93.2 ± 4.0 92.9 ± 4.4 92.6 ± 5.0	AHI	Results plotted on graphs‡		
						Mean SpO_2	Results plotted on graphs*		
						TAI	Results plotted on graphs‡		
						ESS	8.2 ± 4.4	10.6 ± 6.4	10.0 ± 4.5
Norman 2006	RCT / 46	CPAP P-CPAP Oxygen	2 weeks	66.1 ± 29.1 53.9 ± 29.8 60.7 ± 29.6	92.7 ± 4.5 94.0 ± 2.9 93.6 ± 4.8	AHI	3.4 ± 3.0†	43.6 ± 3.8	50.1 ± 32.1
						Mean SpO_2	95.6 ± 3.1*	96.2 ± 3.3*	92.1 ± 3.8
						Mean low SpO_2	93.6 ± 3.1*	93.2 ± 3.2*	90.1 ± 3.0
						ODI	1.3 ± 1.9*	15.7 ± 24.8	31.9 ± 33.0
						SBP (mm Hg)	Results plotted on graphs		
						DBP (mm Hg)	Results plotted on graphs		
Mills 2006	RCT / 50	CPAP P-CPAP Oxygen	2 weeks	65.0 ± 8.3 61.2 ± 8.2 61.8 ± 9.4	–	AHI	2.56 ± 0.57†	50.1 ± 10.7	57.3 ± 8.2
						SpO_2 < 90%	0.07 ± 0.08*	2.5 ± 1.3*	6.2 ± 2.0
						SBP (mm Hg)	145.1 ± 5.1+	144.5 ± 3.6	146.9 ± 5.3
						DBP (mm Hg)	79.5 ± 3.2+	79.9 ± 2.8	82.9 ± 3
Bardwell 2007	RCT / 38	CPAP P-CPAP Oxygen	2 weeks	59.4 ± 31.1 59.3 ± 28.1 67.2 ± 35.8	93.0 ± 4.8 94.0 ± 3.1 92.6 ± 5.5	RDI	3.6 ± 3.9‡*	55.8 ± 40.9	51.0 ± 30.5
						Mean SpO_2	95.9 ± 3.3*	95.5 ± 3.6	91.3 ± 3.6
						SpO_2 < 90%	0.2 ± 0.4	2.1 ± 4.1	3.6 ± 4.1
						TAI	9.8 ± 4.8†	43.6 ± 33.1	38.7 ± 27.5
Lim 2007	RCT / 46	CPAP P-CPAP Oxygen	2 weeks	63.5 ± 7.8 65.8 ± 8.2 58.6 ± 8.3	93.1 ± 1.1 92.3 ± 1.3 93.2 ± 1.4	Mean SpO_2	96.2 ± 2.8*	95.9 ± 3.5*	91.2 ± 4.1

RCT, randomized controlled trial; CPAP, continuous positive airway pressure; P-CPAP, placebo CPAP; O_2, oxygen, n, number of patients; AHI, apnea-hypopnea index; SSS, Stanford Sleepiness Score; ESS, Epworth Sleepiness Score; ODI, oxygen desaturation index; TAI, total arousal Index; RDI, respiratory disturbance index; SBP, systolic blood pressure; DBP, diastolic blood pressure. *Statistically significant change from placebo ($p < 0.05$). †Statistically significant change from oxygen ($p < 0.05$). +Statistically significant change from baseline ($p < 0.05$). ‡Statistically significant change from oxygen or P-CPAP ($p < 0.001$).

showed a decreasing trend in the number of events when the patients received O_2 therapy after breathing room air. One study demonstrated an improved cardiovascular status in OSA patients following oxygen enrichment night.[34] Similarly, another study showed an improvement in daytime somnolence in patients receiving oxygen therapy.[35]

Meta-Analysis of Randomized Controlled Trials

Effects on Apnea Hypopnea Index (Figure 2)

A pooled analysis of 5 randomized controlled trials demonstrated that the use of therapeutic CPAP lead to a statistically significant reduction in the AHI versus nocturnal administration of oxygen (SMD -3.37, 95% CI -4.79 to -1.96). There was also a statistically significant reduction in AHI in CPAP group versus placebo (SMD -3.65, 95% CI -5.31 to -1.98). Nocturnal oxygen did not show significant reduction in AHI compared to placebo CPAP (SMD -0.32, 95% CI -0.74 to 0.08).

Effects on Mean Nocturnal Oxyhemoglobin Saturation (Figure 3)

A pooled analysis of 4 studies that reported mean oxyhemoglobin saturation showed that both therapeutic CPAP and nocturnal administration of oxygen lead to significant improvement in oxyhemoglobin saturation compared to placebo CPAP. Comparison of CPAP to nocturnal oxygen did not demonstrate

Table 3—Study characteristics and effects of oxygen therapy in OSA patients

Study ID	Design	Study Population (n) Type / Total	Intervention	Baseline Data		Variables	Oxygen	Air
				AHI	SpO_2			
Kearley 1980	Single Cohort	OSA with COPD / 11	1st half of night: Air(Control) ↓ 2nd half of night: O_2	–	–	O_2 desaturation episodes/h	0.7*	4.5
						SDB events/h	6.3	13.7
						SDB event duration (sec)	30.9	23.6
Smith 1984	Single Cohort randomized study	OSA with EDS / 12	1 night: Air(Control) ↓ 1 night: O_2	69 ± 10	94 ± 0.06	SaO_2 (%)	96 ± 0.6†	94 ± 0.06
						SDB events/h	56 ± 11*	69 ± 10
						SDB event duration (sec)	Same in both groups	
						Arousal Events	2.3 ± 1.8†	3.6 ± 2.5
Gold 1986	Single Cohort nonrandomized trial	OSA / 8	1 month: Air(Control) ↓ 1 month: O_2	77 ± 16	86 ± 2	SaO_2 (%)	94 ± 2*	87 ± 3
						SDB events/h	51 ± 9*	71 ± 7
						SDB event duration (sec)	36 ± 4*	29 ± 3
Alford 1986	Single Cohort Crossover Study	OSA (SDB > 50/h) with COPD / 20	1 night: Air(Control) ↓ 1 night: O_2	88.2 ± 27	87.7 ± 6.0	SaO_2 (%)	94.6 ± 3.5§	87.7 ± 6
						SDB events/h	67.4 ± 21.8§	88.2 ± 26.9
						SDB event duration (sec)	31.4 ± 9.8§	25.7 ± 7.9
Block 1987	Single Cohort nonrandomized nonblinded study	OSA (AHI > 5) / 20	1st half of night: Air(Control) ↓ 2nd half of night: O_2	–	94.7 ± 1.7	O_2 desaturation < 90%	36*	91
						SDB events/h	14	11
						SDB event duration (sec)	29†	22
Pokorski 2000	Single Cohort Single blind trial	Pre-surgical OSA patients / 5	1 night: Air(Control) ↓ 1 night: O_2	52.7 ± 10.4	89.4 ± 0.93	SaO_2 (%)	92.0 ± 1.1†	89.4 ± 0.93
						SDB events/h	38.9 ± 9.3*	52.7 ± 10.4
						DBP (mm Hg)	75 ± 4†	82 ± 4
Friedman 2001	Single Cohort nonrandomized nonblinded study	OSA / 21	1st half of night: O_2 ↓ 2nd half of night: Air(Control)	28.6 ± 15.6	82.4 ± 4.73	SaO_2 (%)	93.3 ± 3.84*	82.4 ± 4.73
						SDB events/h (RDI)	28.6 ± 15.6	33.1 ± 8.7
						ESS	12*	14
Kumagai 2008	Single Cohort nonrandomized nonblinded study	OSA patients on PD / 11	1 month: O_2	31.1 ± 8.8	94.2 ± 1.2	SaO_2 (%)	97.7 ± 0.9*	94.2 ± 1.2
						SDB events/h (AHI)	12.7 ± 8.5*	31.1 ± 8.8

ID, identification; Dx, diagnosis; OSA, obstructive sleep apnea; n, number; M, male; F, female; O_2, oxygen; PSG, polysomnography; AHI, apnea-hypopnea index; RDI, respiratory disturbance index; PD, peritoneal dialysis. All data in mean or mean ± SD. *p < 0.01, §p < 0.001, †p < 0.05.

Figure 2—Effect of CPAP versus oxygen on apnea hypopnea index (AHI)

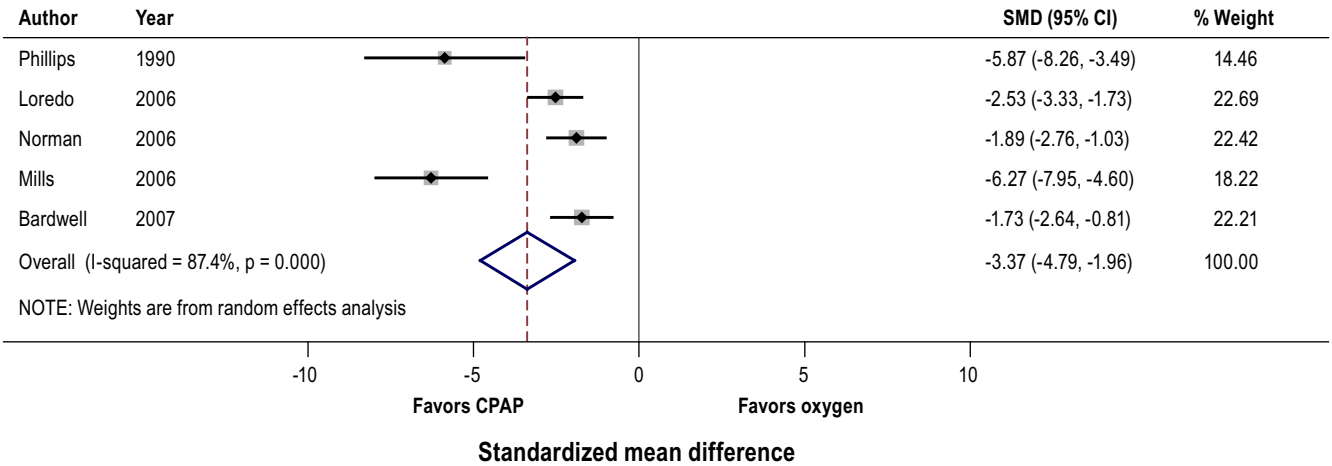


Figure 3—Effect of CPAP versus oxygen on nocturnal mean oxyhemoglobin saturation (SpO_2)

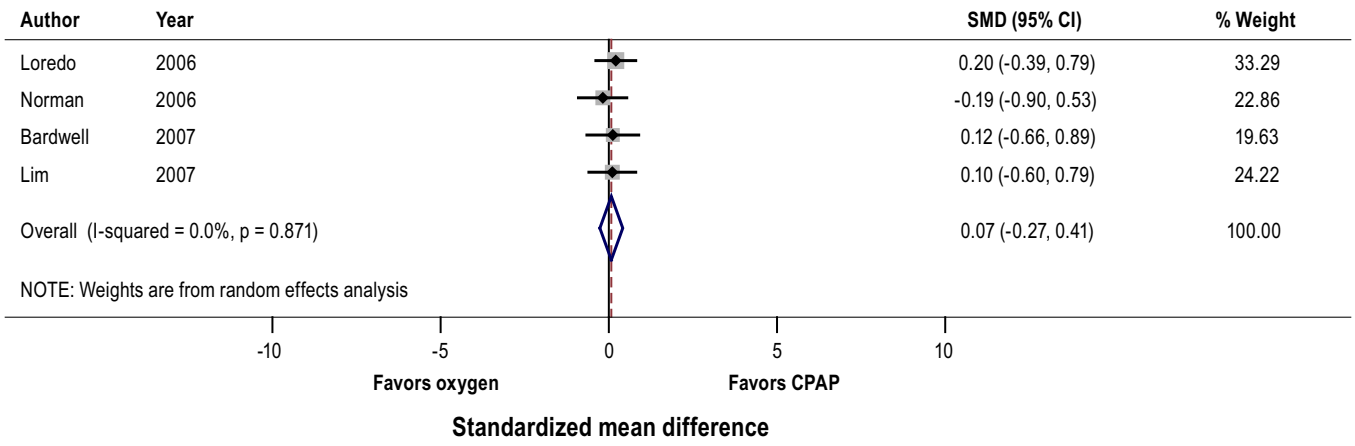
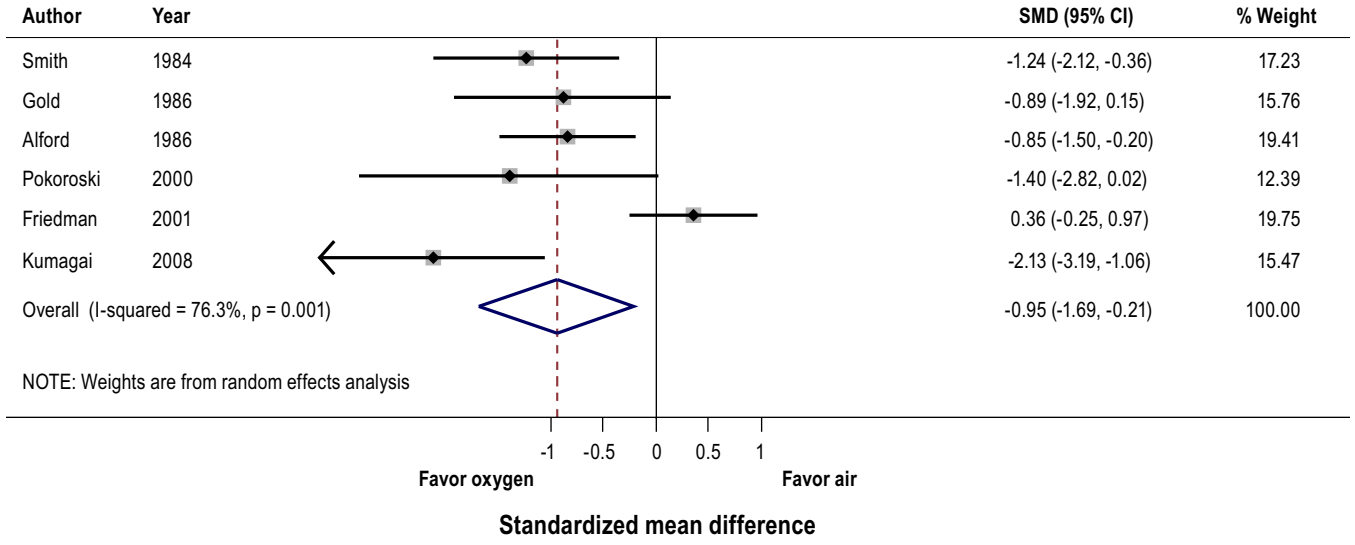


Figure 4—Effect of oxygen versus air on sleep disordered breathing (SDB) events



a significant difference in the degree of improvement in oxygenation (SMD 0.07, 95% CI -0.27 to 0.41).

Meta-Analysis of Observational Studies

Effects on SDB events (Figure 4)

A pooled analysis of 6 observational studies showed significant reduction in SDB events with oxygen compared to air (SMD -0.95, 95% CI -1.69 to -0.21).

Effects on Mean Nocturnal Oxyhemoglobin Saturation (Figure 5)

A pooled analysis of 6 observational studies showed significant improvement in mean oxyhemoglobin saturation with oxygen compared to air (SMD 2.45, 95% CI 1.49 to 3.4).

Effects on Sleep Disordered Breathing (SDB) Event Duration

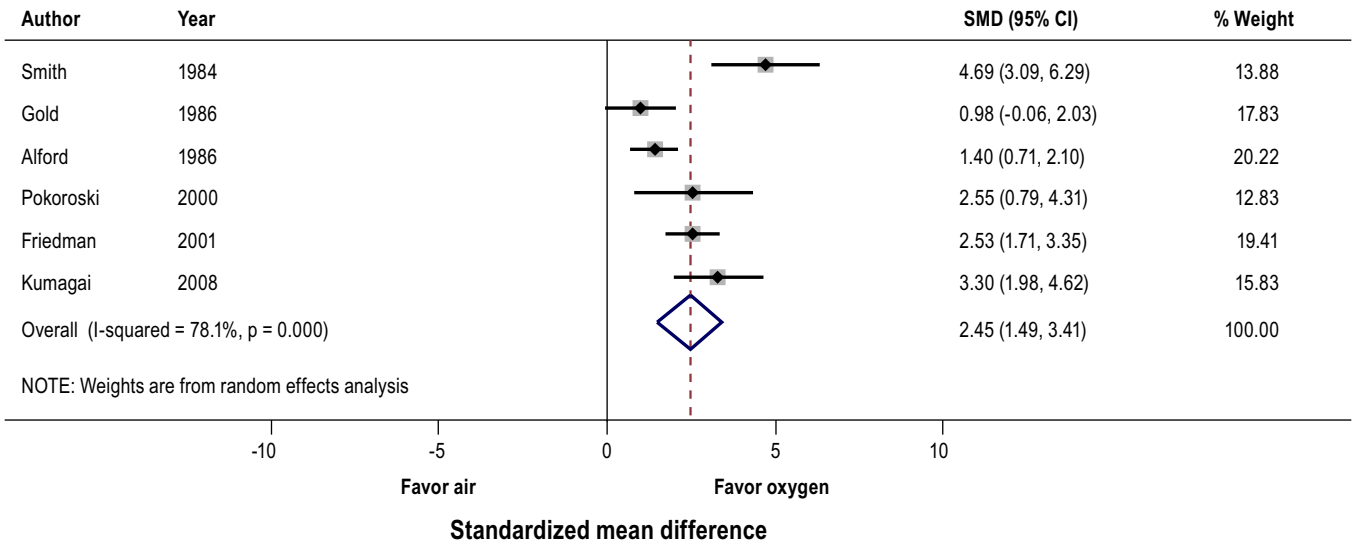
We identified 5 observational studies reporting the SDB event duration as an outcome.[30-33] We could not pool the results of these studies for statistical analysis due to the lack of sufficient data. However, 3 of these studies reported that administration of oxygen lead to the prolongation of SDB event duration.[31-33]

DISCUSSION

In this systematic review, we identified and reviewed 14 studies evaluating the effects of oxygen supplementation for the treatment of intermittent nocturnal hypoxemia in patients with OSA. We performed a meta-analysis of the six randomized controlled trials that evaluated the effect of CPAP, placebo CPAP, versus oxygen on AHI and SpO_2. In this analysis, patients with obstructive sleep apnea who used CPAP had significant reduction in AHI compared to those who used nocturnal oxygen. However, both nocturnal oxygen and CPAP improved oxyhemoglobin saturation equally.

Obstructive sleep apnea is a prevalent disorder with its serious health related consequences.[37] Many patients with sleep apnea have intermittent episodes of hypoxemia at night secondary to the periods of the upper airway obstruction. These episodes have been shown to be associated with harmful se-

Figure 5—Effect of oxygen versus air on nocturnal mean oxyhemoglobin saturation (SpO_2)



quelae including insulin resistance, cognitive deficit, and the development of other cardiovascular morbidity.[38-40] Both nasal CPAP and nocturnal administration of oxygen improve oxyhemoglobin saturation, but nocturnal oxygen has little effect on the blood pressure surge following apneas in patients with sleep apnea.[41-43] On the other hand, CPAP has been shown to lower the blood pressure variability in patients with sleep apnea.[25,26] This suggests that there might be some other factors such as hypercapnia, arousals, respiratory efforts, intrathoracic pressure changes, or fragmented sleep contributing to the increase in the blood pressure seen in sleep apnea.[44-47] In a study in human adults, the arousals from NREM sleep was shown to increase the sympathetic discharge with increase in the systolic blood pressure.[48]

Patients with OSA frequently have cognitive dysfunction and excessive daytime sleepiness (EDS), possible secondary to the combination of hypoxemia and fragmented sleep. These symptoms worsen with increasing severity of hypoxemia and increasing frequency of arousals. Nasal CPAP improves both the arousals and hypoxemia and thereby has been shown to improve the sleepiness in contrast to the nocturnal administration of oxygen.[23,49-51] On the other hand, both CPAP and oxygen supplementation have been shown to improve psychological symptoms, including depression.[27]

CPAP is clearly the treatment of choice in patients with OSA due to its immediate efficacy. It has been shown to improve AHI, hypoxemia, and arousals, thereby improving sleepiness and hypertension in contrast to the nocturnal administration of oxygen. However, patient adherence to CPAP is less than optimum.[52] In one study, adherence to CPAP was reported to be higher in patients who had consultation with the sleep physician prior to undergoing the sleep study,[53] but adherence to CPAP is between 50% and 70%, even with excellent management.[54]

Hypoxemia is a major problem for patients with OSA in the postoperative period and hypoxemic episodes have been reported to occur mostly between the postoperative nights two to five.[55] Up to 40% of patients undergoing abdominal or thoracic surgery may experience postoperative hypoxemia.[56] In particular, surgical patients with OSA are at high risk of having postoperative complications.[57,58] A recent cohort study showed that oxygen desaturation with SpO_2 < 90% was the most common postoperative complication in patients with OSA.[59] These hypoxemic episodes have been shown to have serious consequences, including poor wound healing, cardiac arrhythmias, and delirium.[60,61] The use of supplemental oxygen in the perioperative period has been shown to reduce nausea and vomiting and hospital length of stay, and to improve wound healing.[62-64]

Long-term oxygen therapy (LTOT) has been shown to improve survival and quality of life in patients with COPD.[65-67] However, its role in obstructive sleep apnea treatment is more controversial. The administration of nocturnal oxygen leads to the improvement of intermittent hypoxemia in patients with OSA. It may be considered in hypoxemic patients with OSA who are intolerant to the other treatment modalities for sleep apnea. However, the long-term consequences of chronic nocturnal administration of oxygen are unknown in patients with OSA. Further nocturnal oxygen has been shown to prolong apnea duration in patients with OSA, perhaps as a result of the suppression of the hypoxic respiratory drive.[31-33] In an observational study, the rise in blood pressure following each apneic episode was primarily linked to apnea duration and was not linked to hypoxemia.[42] Prolonged apnea duration may also increase the severity of hypercarbia and acidosis in patients with OSA.[19,31,32] This potential risk mandates careful monitoring for arrhythmias and other consequences of hypercarbia, especially in those with comorbid lung disease.

In conclusion, the evidence from the controlled trials does support the preferential use of CPAP over oxygen in patients with OSA since CPAP significantly improves the oxyhemoglobin saturation and reduces AHI and systemic blood pressure with improvement in daytime sleepiness. On the other hand, oxygen therapy is a double-edged sword, which not

only lengthens the apnea duration but potentially increases the risk of hypercarbia with minimal to no effect on blood pressure and daytime sleepiness. Hence, at present it is difficult to recommend oxygen therapy for patients who are non-adherent with CPAP until the results of a multicenter clinical trial, Heart Biomarker Evaluation in Apnea Treatment, are available.

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