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Obstructive Sleep Apnea in Elective Spine Surgery: National Prevalence and Inpatient Outcomes

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Abstract

Study Design: Retrospective cohort study.

Objectives: Epidemiologic studies suggest that the prevalence of moderate to severe obstructive sleep apnea (OSA) is increasing. OSA has been linked to increased rates of postoperative complications following surgery. Large studies, however, regarding surgical outcomes in this patient population, particularly in the spine literature, are limited. Consequently, the purpose of this study was to assess the prevalence of and postoperative risks conferred by OSA in the elective spine population.

Methods: Using data from the National Inpatient Sample from 2008 to 2012, an estimated 56 372 (5.1%) patients with OSA undergoing elective cervical and thoracolumbar spine surgery were selected and compared to 1 052 837 patients without OSA undergoing the same procedures. Our primary outcome measures included postoperative complication rates, inpatient mortality, length of stay, and total hospital charges.

Results: Patients with OSA were, on average 2.6 years older than those without OSA ($P < .001$) and had a higher comorbidity burden. The prevalence of OSA increased between 2008 and 2012 from 3.5% to 6.8%; $P < .001$. OSA was associated with a 3-fold increase in major complications ($P < .001$) and was confirmed as an independent risk factor for major complications based on multivariate analysis (odds ratio [OR] = 2.82; 95% CI = 2.59-2.79; $P < .001$). Rates of deep venous thrombosis were doubled in patients with OSA. OSA was determined to be an independent predictor of pulmonary complications (OR = 2.69; 95% CI = 2.59-2.79; $P < .001$). OSA did not increase the risk of postoperative mortality.

Conclusions: Patients with OSA often have multiple concomitant comorbidities and consequently are at increased risk of experiencing a more difficult postoperative course following elective spine surgery. Specifically, increased risks of pulmonary complications and deep venous thrombosis should be anticipated.

Keywords

obstructive sleep apnea, elective spine, fusion, cost, cervical, thoracolumbar

Introduction

Obstructive sleep apnea (OSA) is characterized by periods of airway narrowing or occlusion causing fragmented sleep patterns in patients. It is the most common sleep-breathing disorder and is associated with poor health status. Concomitant hypertension, heart failure, cardiac disease, stroke, diabetes, and psychiatric illnesses are common in patients with severe OSA.[1-8]

Epidemiologic studies suggest that the prevalence of moderate to severe OSA is increasing, with current rates reported at 10% to 20%.[9-11] It is estimated, however, that up to 80% of patients with moderate to severe OSA may remain undiagnosed and subsequently go untreated.[10] While OSA has been linked to increased rates of postoperative complications following surgery in numerous studies, many of these studies have been limited to small sample sizes and to single institutions. Large

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studies, regarding surgical outcomes in this patient population, particularly in the spine literature, are limited.

Despite existent guidelines for preoperative screening of this patient population, routine screening for OSA has traditionally been costly and is not common practice. With an increasingly cost-conscious health care environment, it is important to appropriately evaluate the risk of elective spine surgery in this patient population to help determine whether or not screening for OSA would be financially worthwhile.

The purpose of our study was to identify the national prevalence of OSA in the elective spine population and to contrast the outcomes of patients with OSA against outcomes in the normal population. Our hypothesis was that patients with OSA would have higher rates of postoperative complications and in-hospital mortality risk following elective spine surgery.

Materials and Methods

Study Population Selection

A retrospective cohort study was performed using the National Inpatient Sample (NIS) from 2008 to 2012. The NIS is a stratified survey of approximately 20% of all US hospitals that includes inpatient data for more than 7 million annual admissions. Sampling weights are provided to provide estimates of 100% of all US hospital discharges. All numbers presented in this study are national estimates based on NIS sampling weights. Institutional review board approval was not required for this study due to the de-identified nature of this national database.

Inclusion and Exclusion Criteria

All patients undergoing elective spine surgeries were selected using International Classification of Disease, Ninth Revision, Clinical Modification procedure codes (ICD-9-CM) codes.[12] All emergency admissions, transfers from outside facilities, infections, tumors, and fractures were excluded to isolate the typical elective population. Two cohorts were created based on the diagnosis of OSA. All ICD-9 codes used are presented in Table 1. Our finalized study group contained a total of 220 036 patients without OSA and 11 503 patients with OSA, representing a national estimate of 1 052 837 patients without OSA and 56 372 patients with OSA. All numbers presented in this study from hereafter are national estimates based on NIS sampling weights.

Patient Characteristics

Basic demographic information including age, sex, and race as well as payer status were extracted from the NIS database. Preoperative comorbidities were identified using ICD-9 and DRG (Diagnosis-related Group) coding with the use of the Healthcare Cost and Utilization Project (HCUP) Comorbidity Software. This software package identifies 29 patient comorbidities based off of an Elixhauser Comorbidity Index. A Charlson Comorbidity Index (CCI) score was then created with higher cumulative scores representing a higher comorbidity burden.[13-17]

Table 1. International Classification of Diseases, Ninth Revision (ICD-9) and Clinical Classification Codes (CCS).

	ICD-9 Code
Procedure codes	
Laminectomy, discectomy	03.09, 80.50, 80.51
Cervical fusion	81.01 – 81.03, 81.31 – 81.33
Thoracolumbar fusion	81.04-81.08, 81.34-81.38
Multilevel (>3 level) fusion	81.62-81.64
Relevant diagnosis codes	
Obstructive sleep apnea	327.23
Infection	722.93
Fracture	805.2-805.9, 733.13 730.28
	Clinical Classification Codes (CCS)
Postoperative complication	
Acute myocardial infarction	100
Cardiac arrest	107
Septicemia	2
Shock	249
Stroke	109
Pulmonary embolism	103
Adult respiratory distress syndrome	221
Acute renal failure	157
Deep venous thrombosis	118
Pneumonia	122
Complications of procedure	238
Complications of device	237
Acute posthemorrhagic anemia	60
Urinary tract infection	159

Outcomes

Primary outcomes assessed included postoperative complications, inpatient mortality, and length of stay. Complications were identified using the clinical classifications software (CCS) provided by HCUP. The clinical classifications software groups together related ICD-9 coded postoperative complications to facilitate statistical analysis. These codes are provided in Table 1. Complications were classified as major or minor similar to previously published work.[14,18,19] Major complications included cardiac complications (acute myocardial infarction and cardiac arrest), septicemia, septic shock, stroke, respiratory failure, need for reintubation or mechanical ventilation, and pulmonary embolism. Minor complications included deep venous thrombosis, pneumonia, surgical complications, postoperative anemia, and urinary tract infections. Pulmonary complications were separately defined any of the following: postoperative respiratory failure, pneumonia, or need for reintubation or mechanical ventilation. Finally, a comparison of total hospital charges between the 2 cohorts was made.

Statistical Analysis

Patient characteristics and inpatient outcomes for both groups were analyzed with the use of chi-square and Student *t* tests. A chi-square test was used for categorical variables, and an

independent Student *t* test was used to assess continuous variables. Only more commonly occurring comorbidities (occurring in >1% of our sample population) were found to have statistically significant associations with the outcome of interest based on univariate analyses and were consequently included in our multivariate analyses. Multivariate logistic regression analysis was then used to identify independent predictors of postoperative complications and inpatient mortality and to control for potential confounders including age, sex, race, hospital size, and hospital type. These calculated associations were reported as multivariate odds ratios (OR) with 95% confidence intervals (CIs). $P < .05$ was set as our measure of statistical significance.

Results

Patient Characteristics and National Prevalence of OSA

A total of 1 052 837 patients without OSA, and 56 372 (5.1%) patients with OSA underwent elective spine surgery from 2008 to 2012 ($P < .001$). The prevalence of OSA increased from 3.5% in 2008 to 6.8% in 2012 ($P < .001$). Patients with OSA were slightly older; 60.3 years (SD = 11.9), compared with mean age of 57.6 years (SD = 15.0) in patients without OSA ($P < .001$). Patients with OSA were more likely to be male (65.5% with OSA compared with 50.1% without OSA; $P < .001$). Overall, 22% of the patient population underwent elective cervical procedures while the remaining 78% underwent thoracolumbar surgeries ($P < .001$). These and additional figures are presented in Table 2.

As expected, OSA was associated with a higher CCI severity score (Table 2; $P < .001$). A significantly higher proportion of patients with OSA carried the following diagnoses when compared to patients without OSA: hypertension (71% compared with 48.5%; $P < .001$), obesity (36.5% compared with 10.3%; $P < .001$), diabetes (33.7% compared with 16.5%; $P < .001$), chronic obstructive pulmonary disease (COPD) (25.1% compared with 13.6%; $P < .001$), psychiatric illnesses (23% compared with 13.4%; $P < .001$), and congestive heart failure (4.4% compared with 1.4%; $P < .001$). The remaining comorbidities and their associations are shown in Table 3.

Table 2. Patient Characteristics by Obstructive Sleep Apnea (OSA) Status.

Parameter	Patients Without OSA (n = 1 052 837), n (%)	Patients With OSA (n = 56 372), n (%)	*P*
Age, years	57.6 (SD = 15.0)	60.3 (SD = 11.9)	<.001
Sex, female	523 546 (49.9)	19 460 (34.5)	<.001
Race			<.001
White	730 517 (83.4)	39 974 (85.2)	
Black	63 677 (7.3)	3586 (7.6)	
Hispanic	41 910 (4.8)	1591 (3.4)	
Asian/Pacific Islander	12 763 (1.5)	337 (0.7)	
Native American	4288 (0.5)	276 (0.6)	
Other	22 404 (2.6)	1146 (2.4)	
Procedure performed			
Cervical	238 964 (22.7)	12 354 (21.9)	<.001
Thoracolumbar	813 872 (77.3)	44 018 (78.1)	<.001
Payer			<.001
Medicare	404 140 (38.5)	24 558 (43.6)	
Medicaid	53 912 (5.1)	2132 (3.8)	
Private	486 523 (46.3)	25 309 (45.0)	
Self	13 652 (1.3)	436 (0.8)	
Other	1637 (0.2)	45 (0.1)	
Missing	90 864 (8.6)	3809 (6.8)	
Charlson			<.001
Comorbidity Index severity			
Low (0-2)	850 094 (80.7)	30 204 (53.6)	
Medium (3-4)	173 209 (16.5)	19 591 (34.8)	
High (≥5)	29 534 (2.8)	6578 (11.7)	

Postoperative Morbidity and Mortality

OSA was associated with a 3-fold increase in major postoperative complications (7.9% compared with 2.0%; $P < .001$). Please refer to Table 4 for rates of specific complications. Multivariate analysis identified OSA as an independent predictor for major complications (OR = 2.82; 95% CI = 2.59-2.79; $P < .001$). Minor postoperative complication rates were also increased in patients with OSA (Table 4). Notably, the rate of deep venous thrombosis was higher in patients with OSA when compared with those without OSA (4.0% compared with 2.2%; $P < .001$).

Pulmonary complications were also higher in patients with OSA (7.4% compared with 2.1%; $P < .001$). There was a 5-fold increase in risk of postoperative respiratory failure in patients with OSA (6.0% compared with 1.2%; Table 4). OSA was identified as an independent predictor of pulmonary complications based on multivariate logistic regression (OR = 2.69; 95% CI 2.59-2.79; $P < .001$; Table 5).

While univariate analysis determined that mortality rates were doubled in the OSA group (0.2% compared with 0.1%; $P < .001$), multivariate analysis did not identify OSA as an independent predictor of inpatient mortality (Table 5).

Length of Stay and Hospital Charges

Average length of stay was slightly longer for patients with OSA (3.2 days compared with 2.6 days; $P < .001$), and there was a moderate increase in overall hospital charges in the OSA cohort when compared with patients without OSA ($55 153 compared with $48 082; $P < .001$; Table 4).

Discussion

OSA is characterized by episodic upper airway obstruction and consequent hypoxia that leads to fragmented sleep patterns. While OSA is most commonly associated with obesity, there are a multitude of conditions that are inherently associated with

Table 3. Comorbidities by Obstructive Sleep Apnea (OSA) Patients.

Diagnosis	Patients Without OSA (n = 1 052 837), n (%)	Patients With OSA (n = 56 372), n (%)	P
Alcoholism	10 789 (1.0)	687 (1.2)	<.001
Anemia	48 967 (4.7)	3837 (6.8)	<.001
Inflammatory arthritis	28 829 (2.7)	2163 (3.8)	<.001
Congestive heart failure	14 974 (1.4)	2465 (4.4)	<.001
Chronic pulmonary disease	143 456 (13.6)	14 128 (25.1)	<.001
Coagulopathy	11 191 (1.1)	1033 (1.8)	<.001
Depression	121 990 (11.6)	11 266 (20.0)	<.001
Diabetes	173 201 (16.5)	18 990 (33.7)	<.001
Electrolyte disorders	44 694 (4.2)	4501 (8.0)	<.001
Hypertension	510 364 (48.5)	40 003 (71.0)	<.001
Hypothyroidism	99 208 (9.4)	6885 (12.2)	<.001
Neurologic disorders	54 610 (5.2)	5253 (9.3)	<.001
Obesity	108 252 (10.3)	20 588 (36.5)	<.001
Renal failure	22 697 (2.2)	2831 (5.0)	<.001
Peripheral vascular disease	22 737 (2.2)	1851 (3.3)	<.001
Psychiatric illness	140 617 (13.4)	12 987 (23.0)	<.001
Valvular disease	25 114 (2.4)	1877 (3.3)	<.001

Table 4. Univariate Analysis: Outcomes by Obstructive Sleep Apnea (OSA) Status.

Parameter	Patients Without OSA (n = 1 052 837), n (%)	Patients With OSA (n = 56 372), n (%)	P
Major complications[a]			
Cardiac complication	2941 (0.3)	301 (0.5)	<.001
Septicemia	2755 (0.3)	185 (0.3)	.003
Septic shock	1035 (0.1)	67 (0.1)	.128
Stroke	2155 (0.2)	160 (0.3)	<.001
Pulmonary embolism	3613 (0.3)	916 (1.6)	<.001
Overall	20 699 (2.0)	4470 (7.9)	<.001
Pulmonary complications			
Ventilated/ Intubated	4898 (0.5)	383 (0.7)	<.001
Respiratory failure	12 639 (1.2)	3390 (6.0)	<.001
Pneumonia	5943 (0.6)	692 (1.2)	<.001
Overall	21 611 (2.1)	4184 (7.4)	<.001
Minor complications[a]			
Deep venous thrombosis	22 782 (2.2)	2279 (4.0)	<.001
Acute renal failure	8027 (0.8)	1201 (2.1)	
Surgical complications	135 692 (12.9)	9632 (17.1)	<.001
Postoperative anemia	46 229 (4.4)	4002 (7.1)	.001
Urinary tract infection	17 749 (1.7)	1255 (2.2)	<.001
Overall	198 775 (18.9)	15 256 (27.1)	<.001
Mean length of stay (days)	2.6	3.2	<.001
Inpatient mortality	1132 (0.1)	95 (0.2)	<.001
Hospital charges,[b] $	48 082	55 153	<.001

[a] Include some pulmonary complications in the overall complication rate, however, specific complication rates are listed under "Pulmonary complications."
[b] Hospital charges calculated irrespective of procedure type.

decreased airway size and consequently increase the risk of OSA. These include connective tissue disorders, advanced age, alcohol consumption, and various congenital craniofacial deformities. Consequences of OSA include but are not limited to an increased risk of: cerebrovascular events, myocardial infarction, cardiac arrhythmias, congestive heart failure, insulin resistance, and psychiatric illness.[20]

Epidemiologic data suggests that the prevalence of moderate to severe OSA is increasing, with current rates reported at 10% to 20%.[9-11] Additionally, it is estimated that approximately 80% of patients with severe OSA may go undiagnosed.[10] While our data suggests that the prevalence of OSA increased from 2008 to 2012, the overall prevalence was less (5.1%) than rates published in the literature. This may be due to limited screening for the disease on a national level. Ultimately, the epidemiology of OSA still remains to be fully clarified.

Overnight polysomnography remains the gold standard for the diagnosis of OSA. The apnea-hypopnea index (AHI), the calculated number of apneic or hypopneic breathing events per hour, is derived during these sleep studies, with increasing AHI correlating with severity of OSA. This test requires an overnight stay in a specialized facility and as such, appointment availability and consequent high cost are limiting factors in its routine use. More recently, home sleep testing has also been introduced as a validated modality to diagnosis OSA. While cheaper than overnight polysomnography, costs of these home monitors are substantial, nonetheless. Furthermore, although overnight pulse oximetry alone has been suggested as an alternative and cost-effective screening option, its use has not been recommended to diagnose obstructive sleep apnea. To circumvent the high cost of these diagnostic tests, several questionnaires have been developed to screen for OSA. Examples of these questionnaires include the Berlin Questionnaire, Wisconsin Sleep Questionnaire, STOP-BANG questionnaires, and Haraldsson questionnaires.[10,21]

The STOP-BANG questionnaire is one screening tool that has more recently been validated. It consists of 8 yes or no questions regarding clinical features of OSA (snoring, tiredness, observed apnea, elevated blood pressure) as well as patient demographic information, including body mass index (BMI), age, neck circumference, and gender. The questionnaire itself takes approximately 1 to 2 minutes to complete. BMI >35 m/kg^2, age >50 years, neck circumference >40 cm, and male gender are considered positive responses. A patient with a score of 3 or greater is considered to be at higher risk for having OSA. The STOP-BANG model has been shown to have a sensitivity of 84.1% and specificity of 40.3% in detecting OSA in surgical patients. For moderate to severe OSA, the sensitivity of the STOP questionnaire increases to 92%. For the most severe cases of OSA, the sensitivity is 100% and specificity is 37%.[10] While certainly not perfect, the use of a validated and

Table 5. Logistic Regression Analysis of Comorbidities and Outcomes.

	Minor Complication		Major Complication		Pulmonary Complication	
	Odds Ratio (95% CI)	*P*	Odds Ratio (95% CI)	*P*	Odds Ratio (95% CI)	*P*
Comorbidities[a]						
Obstructive sleep apnea	1.25 (1.22-1.28)	<.001	2.82 (2.71-2.93)	<.001	2.69 (2.59-2.79)	<.001
Alcoholism	1.19 (1.13-1.24)	<.001	1.42 (1.31-1.55)	<.001	1.62 (1.49-1.77)	<.001
Anemia	1.44 (1.41-1.47)	<.001	1.11 (1.06-1.16)	<.001	1.37 (1.31-1.43)	<.001
Coagulopathy	3.06 (2.94-3.18)	<.001		<.001	2.90 (2.72-3.08)	<.001
Congestive heart failure	1.62 (1.57-1.68)	<.001	2.52 (2.40-2.66)	<.001	2.91 (2.75-3.07)	<.001
Chronic obstructive pulmonary disease	1.31 (1.12-1.15)	<.001	1.49 (1.44-1.54)	<.001	2.12 (2.05-2.18)	<.001
Diabetes	1.03 (1.02-1.05)	<.001	0.75 (0.73-0.78)	<.001	0.98 (0.95-1.02)	.389
Electrolyte disorder	4.13 (4.05-4.22)	<.001	4.08 (3.93-4.23)	<.001	5.56 (5.36-5.77)	<.001
Hypothyroidism	1.15 (1.13-1.17)	<.001	0.71 (0.68-0.74)	<.001	0.90 (0.86-0.94)	<.001
Hypertension	1.04 (1.03-1.05)	<.001	0.65 (0.63-0.68)	<.001	0.78 (0.76-0.81)	<.001
Inflammatory arthritis	1.29 (1.26-1.33)	<.001	0.82 (0.77-0.88)	<.001	1.04 (0.97-1.11)	.238
Neurologic disorder	1.45 (1.42-1.48)	<.001	1.62 (1.55-1.69)	<.001	1.77 (1.70-1.85)	<.001
Obesity	1.16 (1.14-1.18)	<.001	0.90 (0.87-0.94)	<.001	1.12 (1.08-1.16)	.360
Peripheral vascular disease	1.18 (1.14-1.22)	<.001	1.25 (1.19-1.33)	<.001	1.52 (1.43-1.61)	<.001
Psychiatric disorder	1.30 (1.28-1.32)	<.001	0.70 (0.67-0.72)	<.001	0.95 (0.912-0.99)	.008
Renal failure	1.59 (1.55-1.64)	<.001	1.10 (1.05-1.16)	<.001	1.29 (1.21-1.36)	<.001
Valvular heart disease	1.15 (1.11-1.18)	<.001	1.48 (1.40-1.56)	<.001	1.01 (0.94-1.08)	.864
Charlson Comorbidity Index severity						
Low	Ref		Ref		Ref	
Medium	1.09 (1.06-1.11)	<.001	3.31 (3.15-3.48)	<.001	1.57 (1.50-1.65)	<.001
High	0.92 (0.89- 0.96)	<.001	6.45 (5.93-7.03)	<.001	1.56 (1.43-1.70)	<.001

[a] The reference group was the absence of the specified comorbidity.

quick screening tool may be beneficial in the preoperative setting. Ultimately, until a standardized, cost-effective screening protocol is implemented, many patients with OSA will continue to go undiagnosed.

Recent studies have found that OSA imparts significantly higher odds of postoperative complications. Specifically, an increase in pulmonary-related complications such as a need for postoperative reintubation or mechanical ventilation has been demonstrated.[22-24] This may be secondary to a decrease in the pharyngeal cross-sectional area and a consequent increase in the risk of pharyngeal collapse conferred by general anesthesia and opioids.[25] While we did not appreciate a significant increase in the need for mechanical ventilation or intubation following surgery (a 0.1% increase), there was a noticeable difference in the rates of postoperative respiratory failure between our 2 cohorts (6.0% compared with 1.2%; $P <$ .001). The decrease in more severe pulmonary complications in our study may reflect an increased awareness in appropriate postoperative management of patients with OSA in more recent years.

Interestingly, OSA was associated with an approximate 2-fold increase in the development of a postoperative deep venous thrombosis in our patient population (4.0% compared with 2.2%; $P < .001$). A recent study by Chou et al[26] similarly showed a 3-fold increase in the incidence of deep venous thromboses in patients with OSA, and an even higher risk of deep venous thromboses in patients with OSA requiring continuous positive airway pressure (hazard ratio 9.58; 95% CI = 3.18-28.82; $P < .001$). It is thought that the intermittent nocturnal hypoxia and chronic systemic inflammation inherent to OSA ultimately induce endothelial dysfunction and create a physiologic environment that promotes thrombosis.[26]

OSA did not appear to be associated with a clinically meaningful increase in inpatient mortality or length of stay despite noticeable increasing complication rates. However, in our study, patients with OSA had more expensive hospital stays. As length of stay did not differ by much between the two cohorts, these increased costs may be secondary to more specific pulmonary monitoring required in this patient population. Furthermore, as patients with OSA tend to have a higher comorbidity burden, concurrent specialist management may also increase resource utilization.

There are several notable limitations to this study. First, data available in the NIS is limited to the duration of a single hospitalization and as such may underestimate the incidences of adverse events. Additionally, analysis of NIS data depends on ICD-9 coding, which does not allow for the discernment of the severity of the OSA. Furthermore, the use of ICD-9 coding does not allow for assessment of intraoperative factors or accurate evaluation of preoperative factors such as laboratory values. Several studies have also shown that ICD-9 coding may additionally lack in sensitivity and specificity. Miscoding and missing data have also been cited as sources of error in large database studies. However, the use of a large database like the NIS is also a major strength of this study, as it allows for the national analysis of rare outcomes in discrete populations such as ours.

Conclusion

In conclusion, OSA is associated with an increased rate of postoperative complications and hospital resource utilization in patients undergoing elective spine surgery. Specifically, special attention should be paid to mitigate the risk of postoperative pulmonary complications as well as deep venous thrombosis. Patients who carry a diagnosis of OSA or who may be at high risk of having OSA should be counseled accordingly regarding the increased risks of surgery. The use of screening questionnaires for OSA in the preoperative setting may be prudent. However, given the limited amount of data regarding OSA and outcomes in spine surgery, prospective studies are warranted to confirm our findings and to evaluate the cost-effectiveness of routine preoperative screening for this disease.

Authors' Note

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Declaration of Conflicting Interests

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