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Pulmonary complications in trauma patients with obstructive sleep apnea undergoing pelvic or lower limb operation

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ABSTRACT

Background Obstructive sleep apnea (OSA) is increasingly prevalent in the range of 2% to 24% in the US population. OSA is a well-described predictor of pulmonary complications after elective operation. Yet, data are lacking on its effect after operations for trauma. We hypothesized that OSA is an independent predictor of pulmonary complications in patients undergoing operations for traumatic pelvic/lower limb injuries (PLLI).

Methods Nationwide Inpatient Sample (2009–2013) was queried for International Classification of Diseases, Ninth Revision, Clinical Modification codes for PLLI requiring operation. Elective admissions and those with concurrent traumatic brain injury with moderate to prolonged loss of consciousness were excluded. Outcome measures were pulmonary complications including ventilatory support, ventilator-associated pneumonia, pulmonary embolism (PE), acute respiratory distress syndrome (ARDS), and respiratory failure. Multivariable logistic regression analysis was used, adjusting for OSA, age, sex, race/ethnicity, and specific comorbidities (obesity, chronic lung disease, and pulmonary circulatory disease). P<0.01 was considered statistically significant.

Results Among the 337 333 patients undergoing PLLI operation 3.0% had diagnosed OSA. Patients with OSA had more comorbidities and were more frequently discharged to facilities. Median length of stay was longer in the OSA group (5 vs 4 days, p<0.001). Pulmonary complications were more frequent in those with OSA. Multivariable logistic regression showed that OSA was an independent predictor of ventilatory support (adjusted odds ratio (aOR), 1.37; 95% CI,1.24 to 1.51), PE (aOR 1.40; 95% CI, 1.15 to 1.70), ARDS (aOR 1.36; 95% CI,1.23 to 1.52), and respiratory failure (aOR 1.90; 95% CI, 1.74 to 2.06).

Conclusion OSA is an independent and underappreciated predictor of pulmonary complications in those undergoing emergency surgery for PLLI. More aggressive screening and identification of OSA in trauma patients undergoing operation are necessary to provide closer perioperative monitoring and interventions to reduce pulmonary complications and improve outcomes.

Level of evidence Prognostic Level IV.

INTRODUCTION

Obstructive sleep apnea (OSA) is a condition in which the upper airway collapses during sleep with many clinical implications. This condition is present in 2% to 24% of the US population.[1] The adverse health outcomes of OSA are well described and include hypertension, ischemic heart disease, stroke, depression, and metabolic syndrome.[2–5] In addition to the health problems directly associated with OSA, it has also been shown to be a predictor of postoperative pulmonary complications after elective orthopedic operation including arthroscopic operations and joint replacements.[6 7] Nonetheless, the effect of OSA in patients undergoing operation for pelvic or lower extremity trauma is unknown.

Caring for trauma patients undergoing operation poses unique challenges that are not present in patients undergoing elective operation. Trauma patients often cannot provide their full medical history and rarely undergo preoperative optimization of their medical comorbidities. The added stress on the human body after a traumatic injury also adds to the differences between these patient groups. Despite these well-known aforementioned differences in the trauma population, the effect of OSA on adverse surgical outcomes in the orthopedic trauma population has rarely been studied. We hypothesized that OSA is an independent predictor of pulmonary complications in patients undergoing operations for traumatic pelvic/lower limb injuries (PLLI).

METHODS

Data source

To study this question, we used discharge data from the National Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.[8] The NIS is the largest all payer inpatient database in the USA. Annually, data are collected from approximately 7 million hospital stays from more than 1000 nonfederal community hospitals across the USA and represents roughly a 20% stratified sample of inpatient stays. The NIS is drawn from states participating in HCUP, which currently covers about 97% of the US population. It includes clinical and resource use information typically available from discharge abstracts. We analyzed data from 2009 to 2013. During this study period, a design change was introduced. Prior to 2012, the NIS was a sample of participating hospitals from where all discharge summaries were retained. In 2012, the database was redesigned to be a sample of all discharges from participating hospitals.

Table 1 ICD-9 codes for pelvic/lower limb injuries and operations of pelvis/lower limb

Pelvic/Lower limb injuries	ICD-9 codes
Fractures of lower limb (open or closed)	808, 820, 821, 822, 823, 824, 826, 827, 828
Dislocations of lower limb	835, 836, 837, 838
Open wound of lower extremities	890, 891, 892, 893, 894
Traumatic amputation	895, 896, 897
Crush injury/Compartment syndrome	928,958.92
Operations of pelvis/Lower limb	
Reduction of fracture and dislocation	79.1, 79.2, 79.3, 79.5, 79.6, 79.8, 79.9 4th digit subclassification (5–8)
Repair and plastic operations on joint structures	81.4, 81.47, 81.49
Operations on muscle, tendon, fascia, and bursa	83.14
Amputation and reattachment	84.1
Other operations on musculoskeletal system	84.9,84.91

ICD-9, International Classification of Diseases, Ninth Revision, Clinical Modification.

Table 2 ICD-9 codes for pulmonary complications and predictor variable

Pulmonary complications	ICD-9 codes
Ventilator support	96.7, 96.70, 96.71, 96.72
Respiratory failure	518.81, 518.82, 518.84
Pulmonary embolism	415.1
Acute respiratory distress syndrome	518.5
Ventilator-associated pneumonia	997.31
Predictor variable	
Obstructive sleep apnea	327.2, 327.23, 327.29, 780.51, 780.53, 780.57

ICD-9, International Classification of Diseases, Ninth Revision, Clinical Modification.

Study design and study population

This is a retrospective cohort study designed to query secondary data in the NIS database. Our study period covered admissions from 2009 through 2013. Our study population constituted adults ≥18 years old admitted for traumatic injury, who underwent orthopedic operation for PLLI. The study population was identified based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnoses and procedure codes (table 1). Those included needed to have both a corresponding ICD-9-CM code for pelvic/lower limb injury and ICD-9-CM code for operation of the pelvic/lower limb. From these admissions, we excluded those which were marked as “elective admissions.” In addition, we excluded from our analyses those with concurrent moderate to severe traumatic brain injury (TBI) as most of these patients were more likely to require ventilator support for their brain injury. This was defined by any patient with a TBI with loss of consciousness greater than or equal to 1 hour.

This study was reviewed and approved by The Rutgers Institutional Review Board (Study ID Pro20170000702). A waiver of consent was granted as the study type was determined to be of Non-Human Determination with minimal risk, as such requirements for informed consent were not deemed necessary.

Study variables

Outcomes variables

Primary outcomes were pulmonary complications and length of stay (LOS). Pulmonary complications included ventilator support, respiratory failure, pulmonary embolism (PE), acute respiratory distress syndrome (ARDS), and ventilator associated pneumonia. ICD-9-CM diagnosis and procedure codes were used to identify the various pulmonary complications (table 2). Ventilator support was defined to include ICD-9 codes for continuous ventilator support for any duration of time. Respiratory failure included acute respiratory failure, acute on chronic respiratory failure and other pulmonary insufficiency not otherwise specified. Each pulmonary complication was studied separately as a dichotomous outcome (Yes/No). The LOS, a continuous measure, was directly available in the NIS database and was examined using non-parametric tests given its skewed distribution.

Predictor variable

OSA was our predictor variable, which was binary in nature and indicated whether a given a patient had or did not have OSA based on presence of ICD-9-CM diagnoses codes (table 2). We included codes specific for OSA as well as codes for unspecified sleep apnea as greater than 90% of patients with sleep apnea have OSA.[9] All codes specific for central sleep apnea were not included.

Covariates

The following covariates were included in our analyses: patients’ age (<60, ≥60), sex (male, female), race/ethnicity (white, black, other race-Hispanic, other race), discharge disposition, and presence of specific comorbidities related to pulmonary function (obesity, chronic lung disease, or pulmonary circulatory disease). All covariates were categorical in nature. Obesity used in our analysis was a chronic comorbidity measure indicator that was provided in the dataset identified based on ICD-9 codes.

Statistical analysis

Counts and proportions were used to describe categorical variables. Medians were used to describe LOS. Descriptive data were presented by OSA status. Crude associations between pulmonary outcomes and OSA status were tested using χ^2 tests. LOS, given its skewed nature, was analyzed using Wilcoxon Mann-Whitney U test. Multivariable logistic regression models were run separately for each pulmonary outcome adjusting for patients’ age, sex, race, and the specific comorbidities related to pulmonary function. Two-sided alpha of 0.01 was considered as cut-off for determining statistically significant associations given the very large sample size. To account for the stratified sample design of the NIS data, we applied survey procedures in SAS and sampling weights from HCUP to obtain weighted estimates. All statistical analysis was performed using SAS V.9.4 (SAS Institute, North Carolina, USA).

RESULTS

A total of 337 333 patients were identified in the NIS that had PLLI requiring orthopedic operation. Characteristics of the patient cohort are shown in table 3. Of patients that underwent operation for PLLI, 3.0% had a diagnosis of OSA. Of the 10 228 patients that we identified as having OSA, 8130 were identified from the code 327.23 and 2068 were identified from the code 780.57. These two codes accounted for over 99% of the cohort. A greater proportion of patients with OSA were obese (41% vs 6%), had chronic lung disease (35% vs 16%), and had pulmonary circulatory disease (8% vs 3%). In addition, patients with OSA had a longer median hospital LOS (5 days vs 4 days;

Table 3 Patient demographics and discharge dispositions

	Patients with pelvic/Lower limb injury operations, n=337333 (%)	
N (%)	Yes	No
Obstructive sleep apnea	10228 (3.0%)	327105 (97.0%)
Age		
<60	3704 (36.2%)	128142 (39.2%)
≥60	6523 (63.8%)	198646 (60.7%)
Sex		
Male	4985 (48.7%)	131568 (40.2%)
Female	5242 (51.3%)	194746 (60.0%)
Obesity	4237 (41.4%)	20569 (6.3%)
Chronic lung disease	3615 (35.3%)	52105 (15.9%)
Pulmonary circulatory disease	773 (7.6%)	9479 (2.9%)
Discharge disposition		
Routine (Home)	2155 (21.1%)	101614 (31.1%)
Home with services	1274 (12.5%)	35430 (10.8%)
Transfer to facility	6535 (63.9%)	180950 (55.3%)
Transfer to short-term hospital	136 (1.3%)	4333 (1.3%)
In-hospital death	118 (1.2%)	3821 (1.2%)

p<0.001) and were more frequently discharged to a facility (65.2% vs 56.6%; p<0.0001). In univariate analysis, pulmonary complications including ventilatory support, respiratory failure, PE, ARDS, and ventilatory associated pneumonia were more frequent in patients who had a diagnosis of OSA (table 4). When adjusting for other variables, including comorbidities related to pulmonary function and age, OSA independently predicted ventilatory support, respiratory failure, PE, and ARDS (table 5).

DISCUSSION

Using a large national database, our study demonstrates that OSA is an independent predictor of pulmonary complications in orthopedic trauma patients with PLLI undergoing operation. Although sleep apnea has been extensively reported on in surgical patients, to our knowledge, this study is the first one to look at clinical manifestations of OSA specifically in the orthopedic trauma patient population. Our findings in patients undergoing operation for PLLI are consistent with previous literature that shows an increase in respiratory complications in patients undergoing elective lower extremity orthopedic procedures.[6 10 11] The literature has also previously shown higher non-pulmonary complications in patients with sleep apnea undergoing lower extremity orthopedic procedures,[12] yet in this study we chose to focus just on pulmonary complications.

OSA is a disease that is highly underdiagnosed and underreported in the general population.[13] In our study, we found the rates of sleep apnea to be 3% in patients with PLLI undergoing operation. Although only 1% to 9% of patients that present to elective operation have a known diagnosis of sleep apnea,[1] studies have shown that when using screening tools for sleep apnea prior to operation, there is a high prevalence of undiagnosed sleep apnea in surgical patients.[14] We suspect that the prevalence of OSA was also underreported in the NIS database and that sleep apnea would have had an even larger effect if it were accurately reported.

Table 4 Percentage of patients with pulmonary complications stratified by obstructive sleep apnea status in patients undergoing operation for pelvic/lower limb injury

	(–) Obstructive sleep apnea (%)	(+) Obstructive sleep apnea (%)	P value
Ventilatory support	3.1	5.3	<0.001
Respiratory failure	2.6	7.7	<0.001
Pulmonary embolism	0.7	1.2	<0.001
Acute respiratory distress syndrome	2.4	4.2	<0.001
Ventilator-associated pneumonia	0.8	1.0	0.007

Table 5 Multivariable logistic regression analysis with obstructive sleep apnea as the predictor for pulmonary complications in pelvic/lower limb injuries operations

Outcomes	Adjusted OR	95% CI	P value
Ventilatory support	1.37*	1.24 to 1.51	<0.0001
Respiratory failure	1.90*	1.74 to 2.06	<0.0001
Pulmonary embolism	1.40*	1.15 to 1.70	0.0008
Acute respiratory distress syndrome	1.36*	1.23 to 1.52	<0.0001
Ventilator-associated pneumonia	1.05	0.85 to 1.30	0.6276

Adjusted for age, sex, race, pulmonary circulatory disease, chronic lung disease, and obesity.
*Denote statistically significant numbers (p<0.01).

With underdiagnoses of OSA and the known risks of increased complications, the Society of Anesthesia and Sleep Medicine recommend the use of screening tools[15] to identify patients who have OSA or are at high risk prior to operation.[16 17] A formal sleep study is needed for an official diagnosis of sleep apnea, but several quick and easy screening tools, such as Berlin Questionnaire, STOP-BANG, or the American Society of Anesthesiologist checklist, have been shown to preoperatively identify patients at risk for OSA in the elective operation population.[18 19] The use of these screening tools could be expanded to trauma patients, as they can be quickly administered, even in route to the operating room in patients that are not in extremis. Identifying these patients with OSA preoperatively will allow the healthcare providers to have a heightened level of awareness preoperatively, intraoperatively, and postoperatively. Although it is not always possible in a trauma setting, the anesthesia plan can be altered to optimize the patients' OSA if their status is known. Postoperatively, extubation criteria can be reassessed in patients with OSA, and a continuous positive airway pressure machines (CPAP) can be made readily available. If we are able to identify these patients prior to operation, we could possibly mitigate or prevent some of these respiratory complications.

There are several limitations to our study. First, this was a retrospective study using a national databank based on ICD-9 codes. Although this study design allowed us to review data on tens of thousands of patients, there were many data points that were unavailable including but not excluded to the severity of the patients' sleep apnea, ventilator days, injury severity score, information about the use of CPAP prior to hospitalization, and information about adherence to CPAP machine in hospital. Positive pressure ventilation has been shown to decrease the long-term complications of sleep apnea; yet, CPAP usage in hospital is low.[20] In this study, we were unable to investigate the usage of CPAP machine and its possible effect on pulmonary complications. In addition, using the NIS database, we were dependent on the appropriate diagnosis coding. We chose to include a broader definition of OSA, including six distinct codes. As OSA is the most prevalent form of sleep apnea accounting for over 90% of patients,[9] we made the assumption that these additional codes were also representative of patients with OSA.

In conclusion, OSA is an independent predictor of pulmonary complications in trauma patients with PLLI undergoing orthopedic operation. It is important to identify these patients and make the entire healthcare team aware of the potential complications. Future prospective studies should focus on identifying patients with sleep apnea and strategies to mitigate these known pulmonary complications in the orthopedic trauma population.

Contributors MF, FH, and ACM participated in the literature search. FH, SRP, DHL, and ACM participated in study design. FH participated in data collection. MF, FH, SRP, DHL, and ACM participated in data analysis. MF, FH, SRP, DHL, and ACM participated in data interpretation. MF, FH, and SRP participated in writing. MF, FH, SRP, DHL, and ACM participated in critical revision.

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