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REPORTS OF ORIGINAL INVESTIGATIONS

Unplanned admission after day surgery: A historical cohort study in patients with obstructive sleep apnea

Hospitalisation non prévue après chirurgie d'un jour: étude d'une cohorte historique chez des patients souffrant du syndrome d'apnée-hypopnée du sommeil

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Abstract

Purpose *Practice guidelines suggest that patients with obstructive sleep apnea (OSA) should be monitored post-operatively to reduce adverse events. This study evaluated outcomes following ambulatory surgery in patients who had previously undergone polysomnography (PSG), and compared unplanned admissions in patients diagnosed with OSA with those in patients without OSA.*

Methods *A historical cohort study (July 2003 to March 2009) was conducted using administrative data and supplemented by selective chart review. Patients undergoing ambulatory surgery at the Ottawa Hospital who had a previously documented PSG were identified. The PSG reports were reviewed, and the presence and severity of OSA was determined. Unplanned admissions to hospital within seven days of surgery were identified using administrative data. Using a nested case-control design, three charts were randomly selected for each patient admitted for a focussed health records review. Event rates in patients with OSA and treated with continuous airway pressure were compared with event rates in patients without OSA. An exploratory multivariable analysis was conducted to identify predictors of admission.*

Results *There were 77,809 ambulatory surgical procedures in the period studied. A PSG test could be analyzed in 1,547 patients, and OSA was diagnosed in 674 (44%) of those analyzed. The rate of unplanned admission was 7.0% (95% confidence interval [CI] 5.1 to 8.9) in OSA patients compared with 5.6% (95% CI 4.1 to 7.1) in patients without OSA (odds ratio 1.26; 95% CI 0.83 to 1.91; P = 0.246). Median [interquartile range; IQR] hospital length of stay was 7 hr [IQR 5, 8] with OSA and 6 hr [IQR 5, 8] without OSA (P = 0.058). Severity of OSA was not associated with unplanned admission.*

Conclusions *We did not identify a clinically important increased rate of unplanned admission associated with a prior diagnosis of OSA.*

Author contributions *Gregory L. Bryson* was the primary investigator and the primary author of the manuscript. He helped conduct the study and analyze the data, and he secured funding. *Gregory L. Bryson, Monica Taljaard,* and *Alan Forster* helped design the study. *Alan Forster* designed the administrative data linkage, and *Josée Blackburn* performed the administrative data linkage. *Claudia P. Gomez, Robert M. Jee, Josée Blackburn, Monica Taljaard,* and *Alan Forster* helped write the manuscript. *Claudia P. Gomez* and *Robert M. Jee* collected the data; *Monica Taljaard* analyzed the data, and *Claudia P. Gomez, Robert M. Jee, Josée Blackburn,* and *Alan Forster* reviewed the analysis of the data.

This work should be attributed to the Department of Anesthesiology, The Ottawa Hospital.

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Résumé

Objectif *Les directives professionnelles suggèrent que les patients souffrant du syndrome d'apnée-hypopnée du sommeil (SAHS) soient suivis en postopératoire afin de réduire les événements indésirables. Cette étude a évalué les résultats après chirurgie ambulatoire chez des patients qui avaient précédemment subi une polysomnographie (PSG) et a comparé les hospitalisations non prévues chez les patients ayant un diagnostic d'AOS et chez les patients n'ayant pas d'AOS.*

Méthodes *Une étude de cohorte historique (juillet 2003 à mars 2009) a été menée en utilisant les données administratives issues d'une analyse sélective des dossiers. Les patients subissant une chirurgie ambulatoire à l'hôpital d'Ottawa et qui avaient eu une PSG documentée antérieurement ont été identifiés. Les comptes rendus de PSG ont été examinés et la présence ainsi que la sévérité de SAHS ont été déterminées. Les hospitalisations non prévues survenant dans les sept jours suivant la chirurgie ont été identifiées grâce aux données administratives. Utilisant un schéma d'étude de cas-témoins emboîtés, trois dossiers ont été sélectionnés au hasard pour chaque patient hospitalisé dans le but de faire une analyse fouillée des dossiers médicaux. Les taux d'événement chez les patients présentant un SAHS et traités par pression positive continue des voies aériennes ont été comparés aux taux d'événements chez les patients sans SAHS. Une analyse multifactorielle exploratrice a été effectuée pour identifier les éléments prédictifs d'hospitalisation.*

Résultats *Il y a eu 77 809 interventions de chirurgie ambulatoire au cours de la période étudiée. Une PSG a pu être analysée chez 1547 patients : un SAHS a été diagnostiqué chez 674 patients (44 %). Le taux d'hospitalisations non prévues a été de 7,0 % (intervalle de confiance [IC] à 95 % : 5,1 à 8,9 %) dans le groupe de patients avec SAHS et de 5,6 % (intervalle de confiance [IC] à 95 % : 4,1 à 7,1 %) chez les patients sans SAHS (rapport de cotes : 1,26; IC à 95 % : 0,83 à 1,91; P = 0,246). La durée médiane de séjour a été de sept heures (écart interquartile [IQR] : 5,8) avec AOS et six heures (IQR 5,8) sans SAHS (P = 0,058). Les SAHS sévères n'ont pas été associés à des hospitalisations non planifiées.*

Conclusions *Nous n'avons pas identifié d'augmentation cliniquement importante du taux d'hospitalisation non prévue en association avec un diagnostic antérieur de SAHS.*

Obstructive sleep apnea (OSA) may be found in 9% of adult women and up to 24% of adult men in North America.[1] It is estimated that 93% of women and 82% of men with moderate to severe OSA remain clinically undiagnosed.[2] If untreated, OSA has significant implications for population health.[3,4] A recent systematic review[5] suggests an association between OSA and perioperative hypertension, arrhythmias, and respiratory complications.

Approximately 6% of patients presenting for elective surgery may have been previously diagnosed with obstructive sleep apnea (OSA).[6] The America Society of Anesthesiologists Practice Guideline[7] states "there is insufficient literature to evaluate the effects of continuous positive airway pressure (CPAP) or noninvasive positive-pressure ventilation on the postoperative respiratory status of patients with OSA" and suggests that patients with OSA "should not be discharged from the recovery area to an unmonitored setting (i.e., home or unmonitored hospital bed) until they are no longer at risk for postoperative respiratory depression." Prolonging the stay of one in twenty surgical patients in monitored high-dependency units has obvious implications on resource utilization; however, defining the role of positive airway pressure (PAP) ventilation and the time at which a patient with OSA is "no longer at risk" is not an obvious task.

In June 2003, The Ottawa Hospital introduced a policy guiding the perioperative care of the patient with OSA (Appendix). Under this policy, patients with OSA who are chronically treated with PAP (which for the purpose of this paper refers to both CPAP and bi-level positive airway pressure techniques) and undergo ambulatory surgery are discharged home following a four-hour observation period. Patients diagnosed with OSA and not treated with PAP are ineligible for outpatient care. This policy is innovative as it creates explicit guidelines for providers with respect to when they can safely discharge a patient with OSA. However, as the policy is not based on scientific evidence but rather on clinical common sense, there was a need to evaluate its impact. The primary objective of this observational cohort study was to document the outcomes of our policy, specifically, to estimate the rates of unplanned admission to hospital following ambulatory surgery both in patients diagnosed with OSA and treated with PAP and in those without OSA. A secondary objective was to characterize the influence of OSA on outcome by a limited exploration of other factors associated with unplanned admission. Thus, this evaluation would serve as a basis to reconsider our strategy, if necessary, and also to help other organizations decide if it would be appropriate to emulate our approach.

Methods

This observational cohort study complies with the STrengthening the Reporting of OBservational studies in

Epidemiology (STROBE) initiative.[8] The Ottawa Hospital is a 900-bed tertiary care university-affiliated hospital spanning three geographically distinct campuses. The Civic and General Campuses are inpatient facilities, and the Riverside Campus is a freestanding ambulatory surgical centre. Approximately 15,000 ambulatory surgical procedures are performed annually at all three campuses of the Ottawa Hospital. Following Ottawa Hospital Research Ethics Board approval (OHREB Protocol Number 2008835-OH1), analysts identified all patients undergoing polysomnography (PSG) using the Ottawa Hospital Data Warehouse (OHDW). The OHDW is a peer-reviewed research database that integrates clinical data from laboratory, pharmacy, and radiology information systems with administrative data from patient registration and health records. Polysomnography reports were available in OHDW from as early as 1996. All patients who underwent ambulatory surgery at any of the three campuses of the Ottawa Hospital from July 1, 2003 to March 30, 2009 were identified. Patients undergoing airway surgery (tonsillectomy, uvulopalatopharyngoplasty, etc.) could not wear PAP following surgery and were thus ineligible for ambulatory care and excluded from this report. Procedures performed exclusively with monitored anesthesia care, such as ophthalmological surgery and gastrointestinal endoscopy, were also excluded. All other ambulatory surgeries, including orthopedic surgery, laparoscopic surgery, and surgery of the upper abdomen, were included. Patients who had previously undergone a PSG at the Ottawa Hospital at any time prior to their surgery were assembled as our population of interest. Anesthetic technique was not controlled by the OSA policy and perioperative use of opioids was permitted. Patient characteristics, hospital length of stay, mortality, and unanticipated admission and readmission to hospital within seven days of discharge were abstracted from admission-discharge records. The linking of data tables and recoding of the variables of interest were performed by an experienced programmer (J.B.) and overseen by the health services researcher (A.J.F.) who supervises the OHDW.

Investigators (G.L.B., C.P.G., and R.M.J.) then manually abstracted the following variables from the diagnostic PSG report (i.e., before prescription of PAP): Epworth sleepiness score; apnea hypopnea index (AHI); respiratory disturbance index (RDI); lowest saturation recorded on pulse oximetry (nadir SpO_2); and severity of OSA. Grading of OSA severity was defined by the sleep specialist reporting the test. If the reporting physician failed to grade the severity of OSA, the American Society of Sleep Medicine criteria[9] were applied to the AHI (AHI 0 – 4 = no OSA; AHI 5 – 14 = mild OSA; AHI 15-29 = moderate OSA; and AHI 30 or more = severe OSA).

The primary outcome variable was the rate of unplanned admissions within seven days of surgery. Unplanned admissions were identified using OHDW's admission-discharge-transfer database and defined as either (a) a patient not discharged home on the day of surgery as planned or (b) a patient readmitted to hospital within seven days of discharge. The paper health records of all unplanned admissions were manually reviewed to confirm admission-discharge status and to characterize the patient, anesthetic, and surgical characteristics associated with the unplanned admission. Indications for unplanned admission were broadly categorized into surgical (change in surgical procedure, surgical complication), anesthetic (postoperative nausea or vomiting, inadequate analgesia), cardiac (hypertension and major adverse cardiac events, including non-fatal cardiac arrest, myocardial infarction, arrhythmia, and congestive heart failure), and respiratory (bronchospasm, laryngospasm / post obstructive pulmonary edema, witnessed apnea, requirement for supplemental oxygen). The location of events prompting the unplanned admission (operating room, recovery room, and ambulatory surgery unit) were noted.

The validity of the admission-discharge coding was assessed using a nested case-control design in which three "control" records for each unplanned admission underwent a manual review. Control records were drawn at random from those among the population of interest (eligible ambulatory surgery with a previous PSG) who had not been identified as an unplanned admission. No attempt was made to match for demographic characteristics other than inclusion/exclusion criteria. Data collected for the nested case-control study were used to further characterize postoperative adverse events.

Sample size

Our sample was a census of all patients with a prior PSG undergoing ambulatory surgery over the five-year period following implementation of the protocol. Our total sample size of 1,500 patients was sufficient to yield 95% power to detect a 5% absolute difference in unplanned admission rates between OSA negative (5%) and OSA positive cases (10%) using a two-sided test at the 5% level of significance. An absolute difference of 5% was considered clinically relevant.

For the secondary objective of characterizing complications in our population, a total sample size of 400 patients would be sufficient to yield acceptable precision (margin of error of $< 2\%$) around an anticipated proportion of 5%, using a 95% two-sided confidence interval and a finite population correction factor. For this reason, we sampled three non-admitted patients (selected using a random numbers table) for each admitted patient to yield an overall sample size of approximately 400 patients.

Statistical analysis

All data from the OHDW was downloaded in SAS® 9.1 (SAS, Cary, NC, USA) and assigned a unique identifier. Information from the health record and PSG data were recorded on an Excel 2003 (Microsoft, Redmond, WA, USA) spreadsheet hosted on a password-protected secure network drive. All data were merged using the unique identifier and analyzed in SAS 9.1.

Data were assessed for normality of distribution using visual inspection of histograms and normal probability plots. Categorical variables were described using frequencies and percentages. Continuous variables were described using medians and 25th and 75th percentiles [interquartile range; IQR] and presented using box plots. Accuracy of the admission-readmission data in the OHDW was assessed using the kappa statistic with 95% confidence intervals (CI). Characteristics of the study population (all patients undergoing eligible ambulatory surgery who had previously undergone a PSG) were compared according to OSA status (none, mild, moderate, severe) using Cochran-Armitage or log-rank tests for trend. Characteristics of patients included in the manual chart review were compared according to OSA status (none, any OSA) using Chi square and Wilcoxon two-sample tests. Estimated rates of complication for each class (surgical, anesthetic, cardio-respiratory, and protocol), together with 95% CIs, were calculated using appropriate weights to account for the oversampling of patients admitted or readmitted to hospital. Rao-Scott Chi square tests were used to compare weighted complication rates between patients with and without OSA. Severity of OSA and presence of complications were entered into two separate logistic regression models to estimate the associations with pooled admission and readmission within seven days of surgery. Age, sex, body mass index, type of anesthesia, and AHI were subsequently entered into a multivariable logistic regression model to estimate adjusted associations and to identify multivariable predictors of unplanned admission within seven days of surgery. Results from the logistic regression models were described with odds ratios (OR) and 95% CI.

Results

We identified 77,809 ambulatory surgical procedures from July 1, 2003 to March 30, 2009 – 26,330 from the Civic Campus, 13,486 from the General Campus, and 37,993 from the Riverside Campus. There were 1,593 unplanned admissions (2.1%; 95% CI 1.9 to 2.2). The rate of unplanned admissions varied among campuses: 1,121 (4.3%; 95% CI 4.0 to 4.5) at the Civic Campus; 464 (3.4%; 95% CI 3.1 to 3.8) at the General Campus; and 8 (0.02%; 95% CI 0.01 to 0.04) at the freestanding ambulatory operating rooms at the Riverside Campus.

From these 77,809 procedures, 1,589 unique patients were identified who had a previously documented PSG on file. Data were screened to ensure that each individual patient participated only once. The PSG results could not be identified or characterized in 42 files leaving 1,547 cases for analysis. Selection of eligible records is summarized in Fig. 1. The AHI from 1,547 PSG reports is summarized graphically in Fig. 2. There were 674 patients (44%)

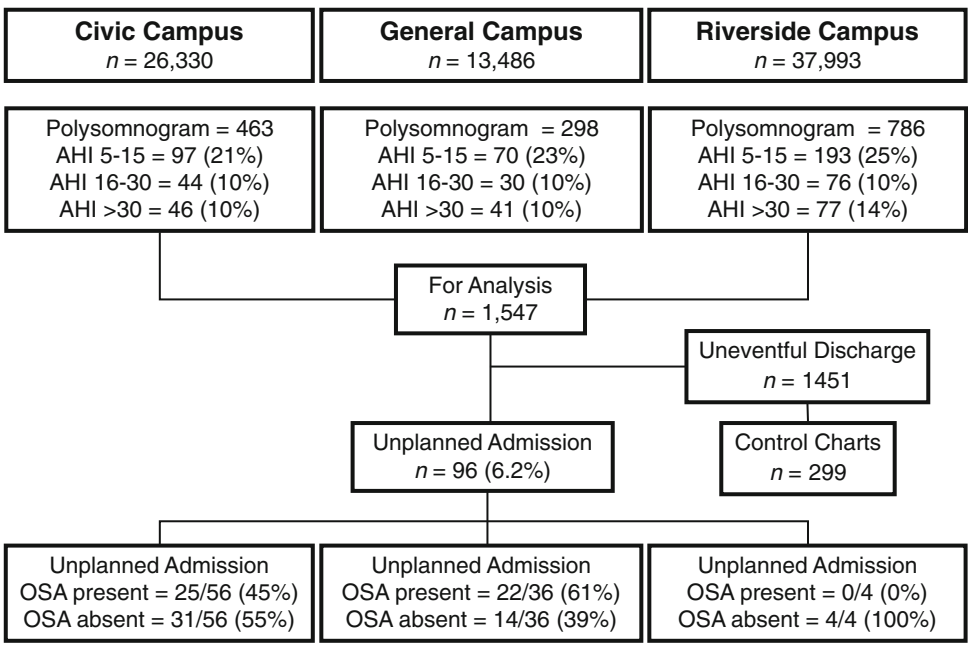

Fig. 1 Identification of the study population

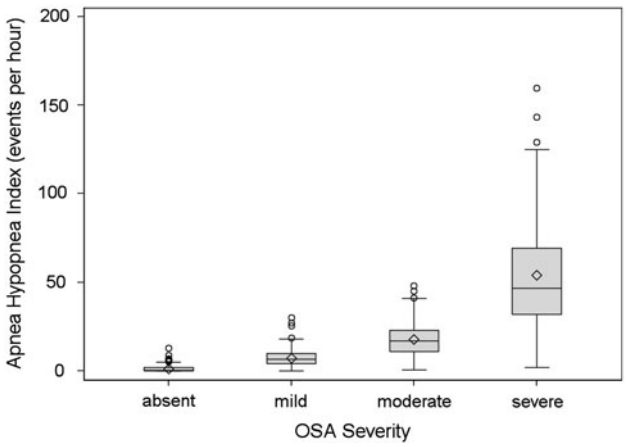

Fig. 2 Polysomnogram results: apnea hypopnea index (AHI) *vs* severity of obstructive sleep apnea (OSA)

identified with some degree of OSA in this cohort of patients who had previously undergone a PSG. There were 360 (23%) patients with mild OSA, 150 (10%) with moderate OSA, and 164 (11%) with severe OSA. Table 1 shows the basic demographic and admission-discharge data from the OHDW for all 1,547 eligible patients, subdivided by OSA status. As anticipated, increasingly severe OSA was associated with increased AHI (Fig. 2) and RDI and lower nadir oxygen saturation during PSG (results not shown). Interestingly, no association was noted between the severity of OSA and perceived daytime somnolence, as assessed by the Epworth sleepiness scale.

Among the 1,547 patients with a PSG record, 96 patients required an unplanned admission after surgery; 94 could not be discharged and two were readmitted following discharge. The rate of unplanned admission to hospital among patients with a PSG on file before surgery was 6.2% (95% CI 5.0 to 7.4). The rate of unplanned admission in patients with OSA (7.0%; 95% CI 5.1 to 8.9) was similar to that in patients without OSA (5.6%; 95% CI 4.1 to 7.1) (Table 1). The diagnosis of OSA did not significantly increase the odds of unplanned admission (OR = 1.26; 95% CI 0.83 to 1.91). However, the rate of unplanned admission in patients with a preoperative PSG was higher (6.2%) than that in our base cohort of 77,809 patients (2.1%). A breakdown of unplanned admission by hospital campus is shown in Fig. 1. No deaths were recorded within seven days of surgery.

To evaluate the accuracy of our health records query we manually reviewed a subset of our analysis population to identify unplanned admissions. A manual review was performed on all 96 charts that OHDW identified as requiring unplanned admission as well as the 299 charts from surgeries identified as having an uneventful discharge. There was excellent overall agreement between the OHDW records and the manual chart review for the primary outcome of unplanned admission (kappa = 0.97; 95% CI 0.94 to 0.99).

The data from the 395 charts that were manually reviewed were used to explore factors associated with unplanned admission. The results of this nested case-control analysis are presented in Table 2. The chart review identified that patients with OSA were less likely to receive a general anesthetic, but when general anesthesia was chosen, these patients had similar Cormack-Lehane

Table 1 Admission Discharge Data by Severity of Obstructive Sleep Apnea

	No OSA $n = 873$	Mild OSA $n = 360$	Moderate OSA $n = 150$	Severe OSA $n = 164$	*P* value
Male	308 (35%)	211 (59%)	101 (64%)	116 (71%)	
General anesthesia	620 (78%)	232 (70%)	88 (67%)	82 (55%)	
Type of surgery					
Head and neck	172 (20%)	66 (18%)	24 (16%)	23 (14%)	
Abdominal	50 (6%)	34 (10%)	16 (11%)	13 (8%)	
Extremities, spine	151 (17%)	73 (20%)	35 (24%)	37 (23%)	
Cutaneous, breast	100 (12%)	35 (10%)	7 (5%)	14 (9%)	
Minimally invasive	320 (37%)	118 (33%)	52 (35%)	61 (37%)	
Other	71 (8%)	32 (9%)	13 (9%)	15 (9%)	
Interval between PSG and surgery (months)	37 [16, 73]	36 [14, 73]	37 [9, 52]	32 [15, 55]	
Length of stay (hours)	6 [5,8]	7 [5, 8]	7 [6, 8]	7 [5, 8]	0.058
Unanticipated admission	49 (5.6%)	21 (5.8%)	12 (8.0%)	12 (7.3%)	0.246
Readmission within 7 days	0	2 (0.6%)	0	0	0.721

Data presented were abstracted from administrative databases and electronic health records on all 1,547 eligible patients and are expressed as count (percent). Time intervals described with median [interquartile range]. Head and neck surgery includes surgery involving the airway. Minimally invasive surgery includes laparoscopic, arthroscopic, and endoscopic procedures. PSG = polysomnogram; OSA = obstructive sleep apnea

Table 2 The perioperative management in 395 patients whose records were reviewed manually

	No OSA n = 204	Any OSA n = 191	P value
Male	67 (32.8%)	127 (66.5%)	
Body Mass Index ($m.kg^{-2}$), Median [IQR]	28.2 [24.6, 32.8]	32.6 [27.1, 38.6]	
Type of Surgery			
Head and neck	31 (15.2%)	44 (23.0%)	
Abdominal	17 (8.3%)	22 (11.5%)	
Extremities, spine	40 (19.6%)	39 (20.4%)	
Cutaneous, breast	22 (10.8%)	14 (7.3%)	
Minimally invasive	75 (36.8%)	57 (29.8%)	
Other	19 (9.3%)	15 (7.9%)	
General Anesthesia	157 (77.0%)	120 (62.8%)	
With indirect laryngoscopy	10 (6.4%)	7 (5.8%)	
With direct laryngoscopy	59 (37.6%)	59 (49.2%)	
Cormack-Lehane grade			
1	32 (54.2%)	33 (55.9%)	
2	19 (32.2%)	18 (30.5%)	
3	5 (8.5%)	7 (11.9%)	
4	1 (1.7%)	0 (0%)	
Duration of surgery (min)	70 [60, 114]	70 [50, 100]	0.272
Nadir SpO_2 (%)			
In surgery	98 [96, 99]	97 [95, 98]	0.003
In Phase 1 recovery	94 [91, 96]	94 [90, 95]	0.168
In Phase 2 recovery	96 [95, 98]	96 [95, 97]	0.784
Duration Recovery (minutes)			
Phase I	60 [50, 90]	85 [45, 155]	0.001
Phase II	105 [80, 180]	102 [65, 145]	0.170

P values were not reported for descriptive data. Statistical comparisons were reserved for outcomes, such as duration of stay and nadir SpO_2. Of importance, these data refer to outcomes in the manual review of all 96 unanticipated admission/readmissions and all 299 controls (patients not admitted/readmitted). OSA = obstructive sleep apnea; SpO_2 = oxygen saturation on pulse oximetry. Data presented as number (%) or median [interquartile range]

laryngoscopy grades and use of indirect laryngoscopy as those without OSA. The median nadir oxygen saturation during surgery was lower and length of stay in the phase 1 postanesthesia care unit was greater in patients with OSA. Oxygen saturation and length of stay at other intervals were similar in patients with and without OSA.

Table 3 shows the weighted rates of unplanned admission and their indications as identified in the manual review of 395 charts. Nine (4.7%) of 191 patients with OSA were admitted to hospital for failing to meet the inclusion criteria for our protocol; eight were unwilling or unable to wear PAP, and one was inappropriately booked for airway surgery on an outpatient basis. The most frequent complication leading to unanticipated admission was the requirement for supplemental oxygen. This complication occurred as often in patients with OSA (7.8%) as it occurred in those without OSA (4.9%). The next most common category was surgery-related complications, such as bleeding (n = 8), infection (n = 3), conversion from laparoscopic to open surgery (n = 3), or surgical injury (n = 3). As all events identified in OHDW were purposely sampled, increasing the prevalence in samples chosen for chart review, summary complication rates have been adjusted to reflect all 1,547 eligible patients (Table 3).

Results from the exploratory analysis to identify potential predictors of unplanned admission are shown in Table 4. The presence of complications was strongly associated with the likelihood of an unplanned admission, while the severity of OSA bore no influence. A final multivariable model that includes complications, severity of OSA, patient demographic characteristics, and type of anesthesia is presented as adjusted odds ratios (aOR). This final model indicates that patient demographic characteristics, general anesthesia, and severity of sleep apnea were not independently associated with unplanned admission. Following adjustment, only the occurrence of a complication (aOR 54.5; 95% CI 20.9 to 142.3) was associated with an unplanned admission to hospital.

Discussion

The findings of this study suggest that patients previously diagnosed with OSA and managed with a protocol directing a four-hour observation period followed by the use of previously prescribed PAP did not have significantly higher rates of unplanned admissions after ambulatory anesthesia compared with patients who also underwent PSG without being diagnosed with OSA. Adverse cardiorespiratory events were distributed evenly among those with and without OSA. Multivariable predictors indicated that unplanned admission was associated with the occurrence of complications but was not associated with the diagnosis and severity of OSA.

The results of our study contrast the findings of several recent publications. A large observational study from 1998 to 2007 using administrative data from inpatient orthopedic and general surgeries identified an association between OSA and pulmonary complications.[10] In a cohort of 55,538 orthopedic patients, OSA was associated with increased risks of aspiration pneumonia (OR 1.41; 95% CI 1.35 to 1.47); adult respiratory distress syndrome (OR 2.39; 95%

Table 3 Observed and estimated rates of complications in the 395 records reviewed manually

Complication	No OSA $n = 204$	Any OSA $n = 191$	Estimated rate no OSA	Estimated rate any OSA	*P* value
Change in procedure	1	2			
Surgical complication	20	5			
Any surgical complication	21	7	2.6% (1.8 to 3.5)	0.9% (0.3 to 1.6)	0.013
PONV	3	3			
Inadequate analgesia	3	5			
Any anesthetic complication	6	8	1.7% (0.0 to 3.5)	3.7% (0.9 to 6.4)	0.186
MACE	3	0			
Hypertension	2	4			
Bronchospasm	5	1			
Laryngospasm/POPE	0	2			
Witnessed apnea/obstruction	3	2			
Supplemental oxygen	10	15			
Any cardiorespiratory	23	24	7.2% (3.8 to 10.6)	9.4% (5.3 to 13.6)	0.386
Miscellaneous	9	15	1.6% (0.3 to 2.9)	2.0% (1.2 to 2.9)	0.632
Any of the above	59	54	13.1% (9.3 to 16.9)	16.0% (11.2 to 20.8)	0.346

OSA = obstructive sleep apnea; PONV = potoperative nausea and vomiting; MACE = major adverse cardiac event, including non-fatal cardiac arrest, myocardial infarction, arrhythmia, and congestive heart failure. POPE = postobstructive pulmonary edema; CPAP = continuous positive airway pressure and includes bilevel positive airway pressure. Data for each complication presented as counts. Data for pooled surgery, anesthesia, cardiorespiratory, and protocol-related complications presented as estimated percentages (weighted by sampling fraction) with 95% confidence intervals. *P* values refer only to the pooled estimated values

Table 4 Multivariable predictors of unplanned admission to hospital in 395 subjects whose records were manually reviewed

	Odds ratio	Adjusted odds ratio	*P* value
Any complication	39.2 (17.2 to 89.5)	54.5 (20.9 to 142.3)	< 0.001
OSA			0.321
Mild *vs* None	0.82 (0.45 to 1.49)	0.87 (0.29 to 2.67)	0.814
Moderate *vs* None	1.08 (0.50 to 2.33)	0.40 (0.11 to 1.40)	0.150
Severe *vs* None	1.07 (0.46 to 2.50)	1.76 (0.24 to 13.09)	0.583
Age		0.99 (0.96 to 1.01)	0.377
Male		0.78 (0.34 to 1.77)	0.893
BMI		0.99 (0.93 to 1.05)	0.631
General anesthesia		0.86 (0.33 to 2.28)	0.767

All data presented as odds ratios with 95% confidence limits. C statistic for goodness of fit of the multivariable model = 0.889. *P* values refer only to adjusted odds ratios in final multivariable model. Of importance, $P = 0.321$ refers to the omnibus test comparing any OSA *vs* no OSA on the outcome of unplanned admission. To prevent "oversampling" this association, only the shown contrasts of severity were entered into the final model. OSA = obstructive sleep apnea; BMI = body mass index

CI 2.28 to 2.51); pulmonary embolism (OR 1.22; 95% CI 1.15 to 1.29); and mechanical ventilation (OR 5.20; 95% CI 5.05 to 5.37). Comparable risks of these complications were noted among 45,457 general surgery inpatients. An observational cohort study of 282 inpatients with OSA and 189 propensity-matched controls identified an association between postoperative hypoxemia (OR 6.9) and intensive care unit (ICU) transfer (OR 4.4).[11] An earlier systematic review also suggested an association between OSA and adverse events in the perioperative period.[5] What could be responsible for the disparate findings in our population?

The majority of the studies mentioned above involved inpatient populations undergoing major surgery. Less morbid surgeries in an ambulatory setting may not present the same risk of postoperative complications. Among a cohort of 234 patients with OSA who underwent ambulatory surgery and a similar number of matched control subjects, the odds of adverse events (OR 1.67; 95% CI 0.40 to 6.97) and unplanned admission to hospital (OR 1.36; 95% CI 0.77 to 2.46) did not differ significantly between OSA and control subjects.[12] In a more recent observational cohort study in over 3,500 patients undergoing ambulatory surgery, a questionnaire and propensity modelling were used to identify patients with known and suspected OSA (4.4% and 4.8%, respectively). This study identified positive associations between OSA and the number of intubation attempts, Cormack-Lehane laryngoscopy grade, and probability of vasoactive drug use,[13] but no relationship was found with major cardiorespiratory events or unplanned admission to hospital. The continued use of PAP following surgery may also be responsible, in part, for the successful outcome of patients reported in our study. Surprisingly, the effects of

PAP in the perioperative period have been little studied. Rennotte *et al*. reported no in-hospital postoperative cardiopulmonary complications in a group of sixteen patients treated with PAP three weeks before surgery.[14] Gupta *et al*. found that patients with OSA who received PAP following surgery experienced outcomes similar to those experienced by healthy controls.[15] Lastly, Liao *et al.* reported that 94 patients, who had used PAP preoperatively and continued use of PAP following surgery, experienced rates of unplanned ICU admission, oxygen saturations of $< 90\%$, or prolonged oxygen therapy that were comparable with those experienced by 240 patients without OSA.[16] Neither of the two large observational cohort studies described earlier addressed the use of PAP in the perioperative period. Our protocol limited access to day surgery to those who were treated with PAP and willing to continue its use following surgery. Within the constraints of our protocol, rates of both cardiorespiratory complications in the postanesthesia care unit as well as unplanned admissions were similar in patients with and without OSA. These findings suggest that patients diagnosed with OSA and treated with PAP may be considered eligible for same-day discharge following ambulatory surgery.

Our study has several important limitations. First, we have selected only those patients who underwent both PSG and surgery at the Ottawa Hospital. Only 674 (0.8%) patients in our overall cohort of 77,809 patients undergoing ambulatory surgery were identified with OSA. Given recent estimates of the prevalence of diagnosed OSA in surgical patients (1.49 - 2.51%),[10] it is likely our results underreport the true rate of OSA in our population. Information concerning patients diagnosed with OSA at other institutions was not available to OHDW analysts and could be a potential cause of this lower than expected rate of OSA. Our findings are further limited by the inability of administrative data systems to document PAP compliance before or after surgery. If non-compliance was present and associated with adverse outcomes, an association between OSA and unplanned admission would have been expected; this was not the case. Our reported rate of unplanned admission in patients with a PSG (6.2%; 95% CI 5.0 to 7.4) was higher than in our general ambulatory population (2.1%; 95% CI 1.9 to 2.2) and higher than rates published from other ambulatory care centres.[17-19] It is unclear why patients who had previously undergone a PSG would be admitted more frequently than those who had not been tested. A review of Table 3 suggests that indications for unplanned admission were predominantly surgical or related to oxygen saturation. A hypothesis could be made that the PSG acted as a surrogate for obesity or other unmeasured confounding variables associated with unplanned admission. Obesity has been associated with oxygen desaturation in those with and without OSA[20]; however, obesity has not been associated with increased admissions following ambulatory surgery.[11,21] Higher rates of unplanned admission at the inpatient centres could reflect a population at higher medical and / or surgical risk. It is equally likely that access to 23-hr stay units at the Civic and General Campuses offered a lower threshold for admission. The OHDW was unable to capture adverse events that prompted admission to hospitals other than the Ottawa Hospital. The Ottawa Hospital is the largest single care facility in the Ottawa-Gatineau metropolitan area, and patients discharged from our ambulatory surgical program are instructed to return to our hospital in the event of complications. In our view, this loss of events would similarly affect those with and without OSA and therefore would not bias our comparisons. Data for the nested case-control study were assembled retrospectively and were dependent on the completeness of clinical recordkeeping at the time. As a result, the definition and incidence of a number of potential complications may be inaccurate. A review of all 1,547 records in search of complications would not have changed our conclusion as unplanned admissions were reliably identified by the OHDW. We are confident that major adverse events leading to significant patient harm were accurately characterized and free of bias.

Our study has a number of strengths. This is a novel study describing the outcomes of patients with diagnosed OSA undergoing ambulatory surgery. The use of the electronic health records permitted us to identify a cohort of 674 subjects in whom the diagnosis of OSA was clearly established, quantified, and known to the perioperative care team before surgery. As all included patients had symptoms or physical characteristics warranting a PSG, our selection criteria provided some measure of control for unmeasured variables associated with OSA and a control population in which the diagnosis of OSA had been definitively ruled out. Use of administrative data provided accurate length of stay and admission data on a large cohort of patients over a five-year period.

In summary, patients with OSA previously diagnosed with PSG reported rates of unplanned admission to hospital and lengths of stay following ambulatory surgery that were comparable with those of patients in whom the diagnosis of OSA had been excluded. These data apply only to those patients diagnosed with OSA. Given the prevalence and likelihood of underdiagnosis of OSA in North America, there is likely a large population of "at risk" individuals to whom our results would not apply. Validated clinical screening tools, such as the STOP[22] and P-SAP[23] questionnaires, and ongoing research into the physiology of untreated OSA will inform the perioperative management of this challenging population. However, our results indicate that rates of complications experienced by patients diagnosed and treated for OSA in the outpatient setting are no greater

than those experienced by patients without OSA. This knowledge permits greater access to care for those known to have OSA; it frees resources for those at risk and facilitates a multicentre prospective evaluation of this treatment strategy. Future research should prospectively validate outpatient care of the patient with diagnosed OSA and explore management of the patient identified at risk of OSA but not yet diagnosed with OSA on preoperative screening.

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Appendix: The Ottawa Hospital sleep apnea policy for outpatients

Preoperative evaluation

1 Preoperative screening evaluations will seek the presence of obstructive sleep apnea (OSA).

2 Patients with OSA must be seen in consultation by an anesthesiologist preoperatively.

3 Sleep study reports should be obtained and appended to the patient record.

Day of surgery

4 Patients treated with nasal continuous positive airway pressure (CPAP) or bi-level positive airway pressure (BiPAP) will bring their machines to hospital on the day of surgery.

5 Sedative premedication is to be avoided.

6 Short-acting anesthetic drugs should be considered.

Postanesthesia or monitored care unit(s)

7 All patients with OSA will be observed in a monitored environment for a minimum of four hours postoperatively.

8 All patients with CPAP appliances will wear their devices while resting/sleeping.

9 A patient may be discharged to community after four hours observation if:

- 9.1 The patient meets day surgery unit discharge criteria.
- 9.2 The patient possesses and has been instructed to use their CPAP appliance.
- 9.3 The patient experienced no episodes where oxygen saturation was less than 90%.
- 9.4 The patient experienced no apnea or airway obstruction.
- 9.5 The patient is assessed by anesthesia.
- 9.6 The patient has adequate analgesia with non-opioids or weak opioid analgesia (60 mg codeine *po* Q4H or equivalent).

10 A patient must remain in a monitored environment for the first postoperative night if:

- 10.1 The patient is unwilling or unable to wear their CPAP appliance.
- 10.2 The patient has undergone a procedure associated with postoperative airway edema and obstruction (e.g., uvulopalatopharyngoplasty, radical neck dissection, carotid endarterectomy).
- 10.3 The patient experiences apnea or desaturation during the four-hour observation period.
- 10.4 The patient has inadequate analgesia with increasing and unpredictable use of parenteral opioids.

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