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Association of sleep disordered breathing symptoms with early postoperative analgesic requirement in pediatric ambulatory surgical patients

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Abstract

Introduction—Sleep disordered breathing (SDB) symptoms are associated with increased rates of opioid-induced respiratory depression as well as enhanced nociception. Consequently, practitioners often withhold or administer lower intraoperative doses of opioids out of concern for postoperative respiratory depression. Therefore, SDB may be a critical determinant of analgesic requirement in the post-anesthesia care unit (PACU). We investigated whether preoperative SDB classification was independently associated with need for PACU analgesic intervention in a cross-sectional sample of 985 children who underwent elective, painful ambulatory surgical procedures.

Methods—Using prospectively collected data, children aged 4–17yr were grouped into two categories based on whether or not they had symptoms of SDB. Perioperative variables were compared between the exposed and control groups using Chi-squared test for categorical or t-test for continuous variables. Logistic regression analysis was used to assess the association between SDB and the odds of requiring PACU IV opioids.

Results—Children with preoperative SDB symptoms (N=325) compared with the reference group of children who did not have these symptoms had higher rates of PACU analgesic intervention (47.1% vs. 37.4%; $p=0.004$) and higher mean arousal pain scores (3.7 ± 3.5 vs. 1.9 ± 2.9 ; $p<0.001$). In our primary multivariable logistic regression model adjusted for a number of variables, preoperative SDB symptoms was associated with a two-fold increased odds of receiving PACU intravenous opioid (OR = 2.01, 95% CI, 1.29–3.12; $p=0.002$).

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Conclusion—These results suggest that preoperative SDB symptoms in children undergoing ambulatory surgery, exerts a significant influence on PACU pain behavior and analgesic requirement. Mechanisms underlying this enhanced pain experience deserve further elucidation.

Keywords

Children and adolescents; postoperative pain; habitual snoring; apnea; sleep disordered breathing; ambulatory surgery

Introduction

About 3.3 million children undergo ambulatory surgery every year in the United States (1). Unfortunately, postoperative pain remains a major cause of morbidity after these procedures with an estimated incidence as high as 80%, particularly following ENT procedures (2).

Opioids have long been the cornerstone of perioperative pain therapy, but their use is often associated with significant side effects (3,4). Indeed, use of opioids for treating acute and chronic pain has increased dramatically in the last two decades (5). One of the enduring dilemmas in the care of ambulatory pediatric surgical patients is the high prevalence of obstructive sleep disordered breathing (SDB) (6) which is known to be associated with increased rates of opioid-induced respiratory depression (7,8).

Compounding this therapeutic dilemma is the observation that obstructive SDB may be associated with enhanced nociception because of chronic systemic inflammation (9,10). Thus, on the one hand these patients may have overall heightened pain sensitivity while on the other they have hypoxia-induced amplified sensitivity to the respiratory depressant effects of opioids (8). This has resulted in a pervasive culture of opiophobia in the care of children with SDB. To this end, practitioners often withhold or administer lower intraoperative doses of opioids out of concern for delayed recovery from general anesthesia and opioid-related respiratory depression (8). An unintended consequence of this practice is that patients undergoing ambulatory surgical procedures are at increased risk of postoperative pain requiring treatment upon recovery from anesthesia in the post-anesthesia care unit (PACU).

Several potential predictors of early postoperative pain following ambulatory surgical procedures have been identified (11–13). However, patient-specific predictors of clinically important PACU pain following ambulatory surgery in children have not been comprehensively determined. Exploring simple self-report measures such as symptoms of SDB (habitual snoring, witnessed apnea and history of OSA) that could help identify children who are likely to require analgesic intervention upon recovering from anesthesia in the PACU could prove critical to the provision of “personalized analgesia”. Therefore, the broad objective of this study was to identify preoperative phenotypic characteristics (such as habitual snoring, witnessed apnea and history of OSA) and to explore their association with early postoperative analgesic requirement (any, opioid and non-opioid). We tested the primary hypothesis that preoperative SDB is independently associated with early PACU analgesic requirement. We also tested the secondary hypothesis that preoperative SDB is associated with higher early mean postoperative pain scores in our subjects.

Methods

Study Design

The present report is a component of a larger on-going study to determine the incidence and risk factors for postoperative pain requiring treatment in the PACU among children aged 4–17 years undergoing elective, ambulatory surgical procedures at the Mott Children's Hospital (Ann Arbor, MI). The Institutional Review Board of the University of Michigan approved this prospective, observational, cross-sectional study (*HUM00077285*). Present analyses included patients recruited from January 24, 2015 to May 31, 2016 who underwent painful ambulatory surgical procedures.

Study Population and Data Source

Patients were enrolled on randomly selected weekdays during the preoperative interview. All patients scheduled for outpatient surgery on selected days were approached for possible inclusion in the study. Perioperative caregivers (anesthesiologists and nurses) did not know subject recruitment days in advance nor were they aware of the study's hypotheses. Consistent with routine clinical care, all perioperative interventions were at the discretion of the anesthesia care givers. Trained research assistants (RAs) collected baseline clinical and anthropometric data on study enrollees. Patients with chronic pain disorders or those on preoperative analgesia were excluded from the study. Patients were also excluded if they did not speak English or were unable to self-report their pain after surgery (significant cognitive impairment). For the purposes of the present analyses, we only included painful surgical procedures identified by the intraoperative administration of intravenous analgesia (opioid or non-opioid), use of local anesthetic infiltration or nerve block.

Outcome measures

Our primary outcome measure was the administration of PACU IV opioid analgesia. As a sub-aim, we also examined overall PACU analgesia use (any, opioid – intravenous or oral, and non-opioid) by SDB group. We considered PACU analgesia consumption as the primary outcome, rather than patient reported pain intensity, because PACU analgesic administration is associated with a more accurate and consistent nursing documentation. If a child was sleeping during the first 15 min of PACU admission, the nurses recorded a pain score of zero. This is consistent with routine clinical practice and has been previously reported (13). Furthermore, the primary objective of this report was PACU rescue analgesic requirement, hence cross-sectional (first or arousal and the highest recorded pain scores) were noted for all patients.

PACU analgesic administration was recorded as categorical (yes/no) as well as by type (opioid or non-opioid). Total dose of PACU analgesic used for each patient was also recorded. PACU opioids were converted to morphine equivalents per kilogram body weight. Typically, the PACU nurses administer analgesics prescribed by anesthesia caregivers for clinically significant postoperative pain (numeric pain score ≥ 4).

Our secondary outcome measures included pain intensity upon recovery from anesthesia as well as PACU length of stay, defined as the time in minutes from PACU admission to PACU

discharge. During the pre-operative assessment, study patients were provided with the following information regarding PACU pain monitoring: “when you get to the wake up room after your operation, you will be asked to rate your pain by choosing a face or a number that best show how you are hurting. You should choose the face or provide the number that best describes how you are feeling.” The RAs noted the numeric pain scores recorded upon recovery from anesthesia or within 15min of PACU admission (first arousal pain score) as well as the highest PACU pain score for each patient.

Potential confounding variables

These were selected on the basis of statistical significance and clinical and/or biological plausibility. Variables previously shown to be associated with postoperative pain such as age, race and surgical specialty () were automatically included as exploratory variables.

Primary exposure variable was SDB symptoms defined as the presence of one or more of the following: habitual snoring (HS), witnessed apnea and history of OSA. HS was investigated with the question: “Does your child snore very loudly on at least 3 or more nights per week?” Based on this criterion, study subjects were classified into habitual snorers and non-habitual snorers (14). For witnessed apnea, parents were asked “have you ever seen your child stop breathing when he/she was asleep?” (No or yes). Finally, parents or caregivers were asked the direct question “has your child ever been formally diagnosed with obstructive sleep apnea (OSA)?” Subjects who were habitual snorers or gave a positive history of witnessed apnea or OSA were then classified as having SDB and patients without these two symptoms as controls.

The following variables were also recorded: age (yr.), sex, surgical specialty, height (cm), weight (Kg), body mass index (BMI in kg/m^2), as well as type and duration of surgery and anesthesia. Type of intraoperative opioid used was noted as was the use of intraoperative multimodal analgesia. Multimodal analgesia was defined as the administration of two or more different classes of analgesics (e.g. opioids + intravenous acetaminophen or non-steroidal analgesia). Intraoperative opioids were converted to morphine equivalents per kilogram body weight. Morphine equivalents were calculated using equivalents formulae (15).

Statistical Analysis

Data analyses were performed with PASW Statistics v.22.0 program for Windows (SPSS Inc. Chicago, IL). Basic descriptive statistics, including means, standard deviations and percentages were calculated for demographic, anthropometric and clinical variables. Number of cases per surgical specialties were presented as simple proportions and displayed with simple bar graphs.

Univariate factors associated with PACU pain treatment were assessed with Chi-squared or t-test as necessary. We conducted bivariate analyses to explore the relationship between several categorical and continuous variables and having an SDB diagnosis. To explore our primary aim, relationships between SDB diagnosis and receipt of PACU analgesia (any, IV or oral opioids, and non-opioids) were explored graphically (using column plots) and differences in the proportional distribution of these variables across SDB groups were

compared with χ^2 test. Severe first arousal pain score was defined as pain score ≥ 7 . Proportions of patients reporting severe first arousal pain were compared across SDB categories and bivariable unadjusted odds ratios were calculated.

Multivariable Regression Analysis—In order to examine the relationship between SDB symptoms and PACU analgesic intervention (IV opioid) we conducted a multivariable logistic regression analysis. To fit our logistic regression models, we estimated the $Pr(Y=1/X)$, with Y being the binary dependent variables (receipt of PACU IV opioid yes/no) and X is the vector of the covariates. We chose receipt of PACU IV opioid as the Y variable because of its relevance in the context of clinical care and potential for patient risk exposure. The adjusted probability of receipt of PACU IV opioid was thus modeled with age, gender, SDB, first recorded PACU pain score, and intra-operative opioid use dose included as predictors. The results from the logistic regression analyses are presented as adjusted odds ratios (ORs) with 95% confidence intervals (CI). Goodness of fit of our regression model was assessed with the Hosmer-Lemeshow test (16). Furthermore, the model's prediction strength was assessed using Receiver operating characteristic (ROC) analyses and area under the curve (AUC). All reported P values were two-sided and a P value of <0.05 was considered to be statistically significant.

An a priori sample size calculation was not performed for this study, as the sample size was drawn as a subset of a larger study population. A post-hoc power analysis showed that group sizes of 325 and 660, respectively, have 85% power to detect a difference between the group proportions for the primary aim of 0.100. Additionally, these group sample sizes produce a two-sided 95% confidence interval for the difference in population proportions with a width that is equal to 0.131 (0.03, 0.16). All post-hoc sample size calculations were computed using PASS 14 (PASS 14 Power Analysis and Sample Size Software (2015). NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/pass).

Results

Characteristics of the study participants

Among the 985 children, just over half (56.5 %) were boys. The mean age of the subjects was 9.64 ± 4.04 years and about one third (33%) had a preoperative history consistent with SDB. About one third of the patients underwent otolaryngological procedures. Figure 1 displays the distribution of cases according to surgical specialties. The anthropometric and perioperative characteristics of the study subjects are summarized in Table 1. The cases (SDB-yes) and controls (SDB-no) were not statistically different from each other with respect to certain key variables including gender, weight, use of midazolam premedication, duration of surgery, and intraoperative morphine equivalents/kg. Nevertheless, certain important characteristic statistical differences were observed between the groups. Notably, cases were more likely to be younger, overweight/obese, and were more likely to have received intraoperative multimodal analgesia than controls. Intraoperative multimodal analgesia was used in 69.8% of patients. Children with SDB symptoms were more likely than controls to have received intraoperative multimodal analgesia (75.7% vs. 67.0%; OR = 1.54, 95% CI = 1.14–2.07; $p = 0.005$).

Is preoperative SDB diagnosis associated with PACU pain and analgesic intervention?

The primary aim of this study was to determine the association of SDB symptoms with PACU analgesic requirement. Overall, 400 patients (40.6%) received *any* analgesia in the PACU. Expectedly, children who received PACU analgesics had higher mean first PACU pain score and mean highest recorded PACU pain scores than those who did not receive any analgesics (first PACU pain score 4.9 ± 3.4 vs. 1.1 ± 2.2 ; $p < 0.001$ and highest PACU pain score 6.3 ± 2.9 vs. 1.7 ± 2.4 ; $p < 0.001$). Furthermore, 29.4% received IV opioid, 32.3% received some form of opioid (IV or oral) while 15.6% of subjects received a non-opioid in the PACU. As hypothesized, there was a statistically significant difference between cases (SDB-yes) and controls (SDB-no) in the proportions of patients requiring any PACU analgesia, PACU IV opioids, and any PACU opioids (IV or oral) (Fig 2). Conversely, subjects with SDB were more likely than controls to receive PACU non-opioid (Fig 2). When PACU pain was examined as a dichotomous variable, children with SDB symptoms had higher odds of reporting severe pain compared with their peers without SDB (16.5% vs. 6.6%; OR = 2.8, 95%CI = 1.8–4.3; $p < 0.001$).

Cases were significantly more likely than controls to have received intraoperative dexamethasone and they had longer PACU length of stay. Compared to their peers without SDB, children with SDB diagnosis were also assigned statistically significantly higher mean first arousal PACU pain score ($p < 0.001$ – Table 1).

Given that SDB symptoms are often more prevalent in children undergoing ENT procedures than among those undergoing other surgical procedures (), we performed separate sub-group analysis of the association of SDB symptoms with PACU pain experience among children who underwent non-ENT procedures. Patients undergoing nonENT procedures who have SDB symptoms were more likely than their peers without SDB to have documented moderately severe PACU pain (32.0 vs. 19.3%; OR = 1.9; 95%CI = 1.05–3.68; $p = 0.032$). Interestingly, the odds of PACU IV opioid administration was not significantly different between cases and controls (cases 21.8% vs. controls 20.0%; OR = 1.02, 95%CI = 0.67–1.53; $p = 0.938$).

The relationship between preoperative SDB symptoms and PACU IV opioid use using multivariable logistic regression model to adjust for confounding

The degree to which preoperative SDB diagnosis was independently associated with PACU IV opioid administration was examined in a multivariable logistic regression model adjusted for age (as a continuous variable), gender (categorical), race (white as reference category), duration of surgery (minutes), intraoperative morphine equivalents, as well as first recorded arousal pain score. Model diagnostic parameters as well as the adjusted odds ratios are included in Table 2. The ROC curve analysis of the logistic regression model showed an AUC of 0.82; 95% CI = 0.79–0.86; $p = 0.001$.

Preoperative SDB was significantly associated with PACU IV opioid administration in the adjusted model. Specifically, holding all the other variables in the model constant, SDB was associated with a two-fold higher odds of PACU IV opioid requirement (OR = 2.01; 95% CI = 1.29 – 3.12, $p < 0.002$). Furthermore, the probability of PACU IV opioid administration

was associated with increasing first arousal pain score such that, every unit increase in first arousal pain score was associated with a 38% higher odds of PACU IV opioid administration. Other factors significantly associated with PACU IV opioid use in the adjusted model are displayed in Table 2. Of interest, no significant associations were found between age or ASA status and the dichotomous outcome of PACU IV opioid administration.

Finally, children with SDB symptoms had significantly longer PACU length of stay compared to their peers without these symptoms (113.6 ± 55.2 vs. 99.6 ± 51.4 ; $p < 0.001$).

Discussion

In this prospective, observational study of children and adolescents who underwent elective ambulatory surgery, the central question we asked was whether preoperative SDB was associated with PACU analgesic requirement. We found that PACU pain requiring analgesic intervention was very common and that about a third of children required some IV opioid during their PACU stay. We also report for the first time in a pediatric surgical population, that preoperative SDB diagnosis was independently associated with PACU pain requiring IV opioid administration. We also found that compared to those without these symptoms, children with SDB symptoms were more likely to report severe postoperative pain.

Postoperative pain remains an important clinical problem and it causes unnecessary suffering in children. Early postoperative pain (occurring upon emergence from anesthesia) can be quite distressing and blemish the entire perioperative experience for children and their parents (17). For example, whereas preoperative anxiolytics may blunt memories of the induction of anesthesia and the surgical procedure, pain occurring in the PACU is often remembered, may delay PACU discharge and is a principal cause of overall increase in cost of care (18,19).

SDB is highly prevalent in children (20). The increasing prevalence of SDB (either formally diagnosed as OSA or as is typical in many children, undiagnosed) in the general population increases the likelihood that a child presenting for surgery and anesthesia would have one or more symptoms suggestive of SDB (21). Concurrent with the rising prevalence of SDB is a pervasive culture of “opio-phobia” (relating to the care of patients with SDB) among pediatric anesthesia caregivers (22). Clinicians are routinely faced with the dilemma of how best to treat pain in children with SDB because previous reports indicated that, on the one hand, these patients are more sensitive to the respiratory depressant effects of opioids (8) while on the other, they appear to have enhanced nociception (10,23). The seemingly contrasting phenotype of enhanced nociception and increased opioid potency in patients with OSA makes it difficult to adequately treat their pain. One unintended consequence of this conflicting phenotypic presentation is that patients with symptoms of SDB or formally diagnosed OSA undergoing painful surgical procedures may be given lower (sub-optimal) doses of opioids during surgery resulting in these patients requiring higher or more frequent pain interventions in the PACU.

We found that SDB symptoms was indeed associated with a two-fold higher adjusted odds of requiring PACU IV opioids. These patients also had higher mean first arousal pain scores than their peers without SDB symptoms. Notably, intraoperative opioid use (measured in morphine equivalents/kg) was similar between children with SDB symptoms and their peers without these symptoms.

Explanatory Hypotheses

Previous investigators have shown that adult patients with SDB or OSA appear to show enhanced nociception to clinical pain (23). That patients with SDB symptoms received comparable intraoperative doses of opioids to those without these symptoms and yet had poorer PACU pain experiences would appear to be in consonant with this notion of enhanced nociception. Putative mechanisms suggested for enhanced nociception in SDB patients include hypoxia-induced systemic inflammation as well as the negative effect of sleep fragmentation on pain perception (24,25). Experimental sleep disruption was associated with hyperalgesic systemic inflammation and increased pain complaints in volunteers (26). These inflammatory and hyperalgesic mechanisms may partly explain some of the findings observed in our study. Clearly, alternative explanations of our results may be plausible, but the most parsimonious would appear to be related to baseline differences in systemic inflammation. Future studies exploring the association of baseline systemic inflammation with postoperative analgesic requirements in children with SDB symptoms may provide clearer explanations for our findings.

The confounding effect of obesity on our results should also be considered because obesity is strongly associated with SDB/OSA (27) and OSA appears to amplify the underlying systemic inflammation that is present in obesity (28). As in previous studies (27), we found that children with SDB symptoms were more likely to be overweight or obese. We (29) and others (30) have also shown that obesity is an independent predictor of acute postoperative pain. Interestingly, when we included an interaction term of high BMI by SDB category in a regression model, the model performance worsened (Hosmer-Lemeshow p value = 0.016; other results not shown). This is likely due to the strong association between SDB and obesity. Isolating the joint or separate contributions of obesity and SDB to enhanced postoperative pain behavior is likely going to be very difficult given the similarities in the inflammatory profiles of the two disorders. However, future studies comparing perioperative analgesic consumption between obese SDB patients with systemic inflammation and obese SDB patients without systemic inflammation may provide some answers.

The association of SDB symptoms with longer PACU stay is not wholly unexpected. Given that these patients were more likely to require analgesic intervention during their PACU admission; this may be contributory to the longer PACU stay. Furthermore, children with SDB or diagnosed OSA are more likely to have postoperative respiratory complications (31) which may also be a factor in our patients. Unfortunately, the present study did not collect data on PACU respiratory adverse events as a possible contributor to increased PACU length of stay.

The contribution of race to postoperative pain experience is noteworthy. Previous investigators have reported that racial/ethnic minority children compared to their white peers

experienced significantly more pain and more frequent analgesic interventions (32). Our findings agree with this earlier report. Putative mechanism responsible for the observed difference in pain experience may be related to the previously described genetic variability which indicates that African American children have faster rates of morphine clearance than their Caucasian peers (32). There are also reports of ethnic variability in response to systematic, controlled laboratory pain which suggests that African American patients are more sensitive to noxious stimuli (33). Unfortunately, we do not have genetic data on the present cohort of children and the surgical procedures were not standardized. Future studies exploring the role of genetic variability in pain experience among children after standardized surgical procedures are necessary.

Study Strengths and limitations

To our knowledge, this is the first study to document an association between SDB symptoms and clinically important PACU pain in children. Despite being a single institution, cross-sectional study, the large sample size had sufficient statistical power to detect associations at both bivariable and multivariable levels. Despite these strengths, we must acknowledge some limitations with our study design and data analyses. First, we did not report data on the type of, or severity of surgery in our patients. Given that surgical procedures such as adenotonsillectomy or other airway mucosal procedures are usually associated with greater early postoperative pain (34) and patients undergoing these procedures also tend to have a higher prevalence of SDB symptoms (34), we cannot completely exclude the confounding effect of surgical procedure type on our findings. Although as expected, more patients undergoing ENT procedures were categorized as having SDB, this was not an exclusive group. Subgroup analyses of children undergoing non-ENT procedures indicated that although children in the SDB category were more likely to be categorized as having PACU moderately severe pain, there was no significant difference in the rates of PACU IV opioid between cases and controls. This may be because our study was not specifically powered for this sub-group analyses. It is possible that with larger sample size, significant differences between the groups will be demonstrable. Future studies exploring the association of SDB symptoms in non-ENT procedures are warranted.

Second, this study was conducted in one center, limiting the generalization of our findings to all children. Third, the cross-sectional nature of the study disallows any conclusion about causality to be drawn. The cross-sectional, non-experimental design also introduces heterogeneity into the data, which increases the possibility of unmeasured covariates that may be influential to the primary outcome variable, chief among which is a PACU nurse's decision to treat a child's pain with IV opioids. Nevertheless, we have no reason to believe that any bias in PACU analgesic intervention would systematically differ by SDB symptoms especially given that perioperative care givers (including PACU nurses) were unaware of the study's hypothesis nor were they aware of which of the symptoms of SDB would be used for group allocations.

Additionally, we did not record pain scores before or after analgesic intervention in these patients. Finally, diagnosis of SDB was entirely clinical (crude parent- and child report) and because symptoms were combined, possibility of misclassification bias exists. This may

partly explain why population reports of SDB prevalence (35) is lower than what we observed in our sample of children. Previous investigators using preoperative data have reported SDB rates similar to ours (34). Unfortunately, cost implications of overnight polysomnography makes it impractical to insist that children undergo this test preoperatively. To this end, our data actually mirrors “real-life” clinical practice as most institutions do not insist on preoperative polysomnography in children. Lastly, other unmeasured confounders of PACU pain requiring intervention such as race, quality of sleep the night before surgery, pain coping skills as well as history of depression were not examined in the present cohort.

Perspectives and Conclusions

The findings of the present report have several implications for research and perioperative care of children particularly regarding measures designed to ameliorate postoperative pain among children with SDB. First, our results provide exciting preliminary evidence that when describing early postoperative pain in children, SDB should be considered. Second, designing future studies and experiments to determine the mechanistic bases of our findings is a worthwhile endeavor. Future studies may also examine genetic and pharmacologic differences between children with or without SDB symptoms to assess differences in the perioperative handling of opioids and other analgesics between children with and without SDB symptoms. Finally, replication of our study and duplication of our findings across other health care institutions will be needed to confirm the widespread applicability of the effect of SDB symptoms on early postoperative pain requiring PACU opioid intervention. This could ultimately lead to the development of personalized analgesia for children with SDB symptoms.

Lastly, pediatric postoperative pain is a complex process that may be determined by clinical phenotype (such as SDB), systemic inflammation and other as yet undetermined variables. Here we identified another candidate predictor of acute PACU pain in children and since no one factor has been shown to predict pain heterogeneity, individual differences in SDB status, inflammation, surgical technique and other variables may play significant roles.

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Fig. 1.
Showing patient distribution by surgical specialties
Abbreviations: GI= gastrointestinal

Fig. 2.

Proportion of patients receiving post-anesthesia care unit analgesia (any, IV or oral opioid and any non-opioid) by SDB category.

Abbreviations: PACU = Post anesthesia care unit; IV= intravenous; SDB = sleep disordered breathing

Fig. 3.

Receiver operator characteristic (ROC) curve for model predicting need for PACU IV opioid. Area under the curve (AUC) for the predictors was 0.82; 95% CI = 0.79–0.77; $p=0.001$. AUC for the ROC indicates the usefulness of a test (our model) in predicting a binomial outcome (receipt of PACU IV opioid yes/no). A value of 0.82 shows ‘good’ predictive ability for our model

Table 1

Patient characteristics according to SDB status

Variables	SDB-yes (N=325)	No SDB (660)	Total (985)	p-value
<i>Continuous variables (Mean $\pm$ SD)</i>				
Age (years)	8.8 $\pm$ 3.9	10.0 $\pm$ 4.1	9.6 $\pm$ 4.0	<0.001
Weight (Kg)	37.5 $\pm$ 23.8	39.2 $\pm$ 20.0	38.6 $\pm$ 21.3	0.213
BMI (kg/m ²)	19.4 $\pm$ 6.2	18.7 $\pm$ 4.6	18.9 $\pm$ 5.2	0.048
OR MS equiv./kg	0.09 $\pm$ 0.06	0.08 $\pm$ 0.07	0.08 $\pm$ 0.07	0.095
Arousal pain score	3.7 $\pm$ 3.5	1.9 $\pm$ 2.9	2.8 $\pm$ 3.1	<0.001
PACU MS equiv./kg	0.02 $\pm$ 0.03	0.01 $\pm$ 0.02	0.01 $\pm$ 0.02	0.027
Surgery time (min)	37.4 $\pm$ 44.3	41.0 $\pm$ 43.1	39.8 $\pm$ 44.5	0.230
PACU time (min)	113.6 $\pm$ 55.2	99.6 $\pm$ 51.4	104.0 $\pm$ 53.0	<0.001
<i>Categorical variables (%)</i>				
Sex (male)	56.7	56.3	56.5	0.915
Overweight/Obese	39.0	28.5	31.6	0.001
<i>Racial category</i>				0.030
Whites	81.4	74.5	79.1	
Blacks	10.6	6.6	7.9	
Others	15.0	12.0	13.0	
Oral Tylenol preop.	27.1	37.7	34.2	0.001
OR Non-opioid	80.9	73.0	75.6	0.007
OR multimodal anal.	75.7	67.0	69.8	0.005
<i>Surgical Specialties</i>				<0.001
ENT	56.7	18.8	31.3	
Ophthalmology	8.1	15.8	13.3	
General Surgery	9.0	12.6	11.4	
Orthopedics	5.0	12.2	9.8	
Dental	3.4	3.5	3.5	
Plastics	4.4	12.3	9.7	
Urology	4.4	9.4	7.7	
GI	5.9	11.4	9.6	
Others**	3.1	4.0	3.7	
OR Morphine	51.4	25.6	34.1	<0.001
OR Fentanyl	68.3	84.1	78.9	<0.001
OR LA used	28.9	35.0	33.1	0.060
OR Nitrous oxide	83.7	75.5	78.2	0.003
Dexmedetomidine	4.0	1.8	2.5	0.041
Dexamethasone	77.5	67.1	70.6	0.001
PACU nausea	9.8	8.5	8.9	0.481
PACU vomiting	7.7	4.1	5.3	0.017

Abbreviations: BMI = body mass index; OR = operating room; MS = morphine sulfate; PACU = post anesthesia care unit; IV= intravenous; **LA= local anesthetic**; SDB = sleep disordered breathing; ENT = Ear Nose and Throat; GI= gastrointestinal endoscopies; Others** includes, gynecology, hematology/oncology and neurology

Table 2

Multivariable logistic regression model to assess the association between SDB symptoms present and PACU IV opioid requirement.

Parameter	AOR	95%CI	p-value
SDB symptoms present	2.01	1.29–3.12	0.002*
Age (yr.)	1.01	0.96–1.06	0.73
ASA status	0.85	0.59–1.23	0.39
Gender (female)	0.52	0.37–0.79	0.002*
Surgery duration (min)	1.006	1.002–1.011	0.002*
OR MS equivalents/kg	19.37	1.48–25.37	0.024*
First arousal pain score	1.38	1.31–1.48	<0.001*
<i>Race or Ethnicity</i>			
White	<i>Reference</i>		
Black	2.26	1.05 – 4.88	0.038
Other ethnic minority	1.84	1.007 – 3.39	0.048

Model $\chi^2 = 7.91$, df=8; Pseudo $R^2 = 0.33$; Hosmer-Lemeshow test p value =0.443; N = 985.

Abbreviations: ASA -American Society of Anesthesiologists; SDB – sleep disordered breathing; OR- operating room; AOR – adjusted odds ratio; CI – confidence interval * represents significant predictors of PACU opioid requirement