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ORIGINAL ARTICLE

Pilot study comparing post-anesthesia care unit length of stay in moderately and severely obese children

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Abstract

Objective Obesity is a risk factor for surgical complications in adults and children. Differences in postsurgical outcomes according to severity of obesity [moderate: 95–98th age-gender-specific body mass index (BMI) percentile versus severe: ≥99th percentile] in children remain unclear. This study compared post-anesthesia care unit (PACU) stay and hospital admission between severely obese children and moderately obese children undergoing surgery.
Methods In a retrospective review over a 6-month period, obese children, 2–18 years of age undergoing surgery were identified. Multivariate mixed-effects regression was used to compare PACU length of stay (LOS) need for opioid analgesia, and hospital admission between moderately and severely obese patients.
Results There were 1324 records selected for inclusion. PACU LOS did not significantly differ between moderately obese (50 ± 36 min) and severely obese patients (55 ± 38 min). There were no differences between moderately and severely obese patients in use of opioids in the PACU. Yet, severely obese patients were more likely to require inpatient admission than moderately obese patients.
Conclusions The duration of PACU stay still averaged less than 1 h in our cohort, suggesting that the majority of these

patients can be cared for safely in the outpatient setting. Future studies should focus on identifying the co-morbid conditions that may prolong postoperative PACU stay or result in unplanned hospital admission in moderately and severely obese patients. Our preliminary data suggest that these factors may include a younger age and the complexity or duration of the surgical procedure.

Keywords Safety · Obesity · Discharge time · Perioperative complications

Introduction

Childhood obesity remains an important public health concern in the United States. The prevalence of obesity among children is increasing and has tripled over the last 20 years. In 2011–2012, 32.2% of children in the United States, aged 2–18 years, were overweight and 17.3% were obese. Additionally, 5.9% of children met the criteria for severe obesity [body mass index (BMI) for age >99th percentile] [1–3]. Obesity is recognized as a risk factor for perioperative complications following surgery in both the adult and pediatric population, being associated with both an increased incidence of respiratory complications and length of hospital stay [4, 5]. Compared to normal weight children, severely obese pediatric patients also have higher rates of planned and unplanned admissions [6]. Obesity has been shown to increase the risk of intraoperative complications including a higher incidence of difficult mask ventilation and airway obstruction during anesthetic induction [7].

Given these concerns, there is a hesitancy to perform surgical procedures in the outpatient setting in obese pediatric patients. Nevertheless, cost constraints mandate an increased use of outpatient facilities for pediatric surgical

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procedures [8–12]. This necessitates appropriate risk strati- fication of obese children scheduled for surgery, to ensure patients with a significantly higher risk of complications are cared for in the inpatient setting. The primary aim of this retrospective study was to determine whether the degree of obesity (moderate compared to severe) was associated with a need for a prolonged stay in the post-anesthesia care unit (PACU) among children undergoing surgery with general anesthesia. Secondary aims included testing whether severe obesity was associated with a greater likelihood of opioid use in the PACU and a greater need for inpatient admission.

Methods

Following Institutional Review Board approval with a waiver of individual consent, a retrospective chart review was performed to identify obese patients from 12,981 procedures during the first 6 months of 2012. All patients meeting inclusion criteria (described below) were selected for inclusion in the analysis, and no a priori sample size estimation was performed. Patients defined as moderately obese (95–98th BMI-for-age percentile) or severely obese (≥99th BMI-for-age) were selected if they had undergone surgery under general anesthesia. In patients undergoing multiple surgeries over the course of the study period, the earliest surgery was selected for analysis. Exclusion criteria were age <2 or >18 years, patients undergoing cardiac sur- gical procedures, non-invasive imaging studies performed as the sole procedure, combined procedures or procedures not classifiable as described below, and surgical procedures requiring immediate admission to the pediatric intensive care unit (PICU). Additionally, patients were excluded if there were missing data on LOS in the PACU.

Chi-square tests and unpaired t tests were used to com- pare demographic and clinical characteristics between moderately and severely obese patients, including the pri- mary outcome of PACU LOS (minutes), opioid analgesia (morphine, hydromorphone, or fentanyl) use in the PACU, and inpatient admission from the PACU. As postopera- tive outcomes varied by type of procedure, multivariable mixed-effects regression was used to estimate the differ- ence in PACU LOS between moderately and severely obese patients (according to BMI-for-age), accounting for vari- ation in each outcome across the following surgery types: ear, nose, and throat (ENT); laparoscopic; gastrointestinal (GI); orthopedic; eye or dental; urological; interventional radiology; plastic surgery; or general pediatric surgery.

Covariates in the analysis included gender, age, Ameri- can Society of Anesthesiologists (ASA) physical status, sur- gery duration, intraoperative opioid dosing, and intraopera- tive use of acetaminophen or ketorolac. Opioid dosing was expressed in mg of morphine equivalent, with conversions

from hydromorphone and fentanyl to morphine equiva- lent determined as 1–0.2 and 0.01 mg, respectively. Vari- ation across procedure types was empirically estimated as a standard deviation (SD) of the procedure type random effect, such that SD = 0 implied that all procedure types shared the same intercept, and SD ≠ 0 implied that the intercept significantly varied from procedure to procedure. The statistical significance of this SD was determined using a likelihood-ratio test against a model that did not include a random effect. Similarly, multivariable mixed effects logis- tic regression was used to predict PACU opioid use and inpatient admission. Multivariable models included cases with complete data on surgery duration; all other covariates in the analysis had no missing data. Statistical analyses were performed in Stata/IC 13.1 (StataCorp, College Station, TX, USA). $p < 0.05$ was considered statistically significant.

Results

Moderate or severe obesity was identified in 1324 patients, who were subsequently evaluated for inclusion in the study. Among the 1324 records that were evaluated, 985 met inclusion criteria and were selected for analysis. Twenty- four of the patients evaluated for inclusion were scheduled for PICU admission following the surgical procedure and were excluded from subsequent analysis, leaving a final analytic sample of 418 boys and 543 girls at or above the 95th percentile for BMI, with a mean age of 9.8 ± 4.5 years and a mean BMI-for-age percentile of 98.0 ± 1.4%. Among these patients, 309 (32%) were severely obese (BMI ≥ 99th percentile; mean weight 65.7 ± 40.0 kg; mean BMI 30.7 ± 8.4 kg/m^2) and the remainder were moderately obese (mean weight 57.3 ± 27.3 kg; mean BMI 25.6 ± 5.1 kg/ m^2). The most common surgical procedures were ENT surgery (311, 32%), orthopedic surgery (156, 16%), eye or dental (118, 12%), and GI surgery (114, 12%). The demo- graphic characteristics of moderately and severely obese groups are compared in Table 1. Severely obese patients were younger than moderately obese patients (9.08 ± 4.86 vs. 10.19 ± 4.30 years, $p < 0.001$), more likely to be male gender (63 vs. 53%, $p = 0.004$), more likely to be ASA sta- tus 3–5, and more likely to undergo eye or dental surgery.

There were no differences in mean PACU LOS between moderately and severely obese patients (50.3 ± 35.6 ver- sus 54.6 ± 37.7 min, $p = 0.089$). By contrast, our depart- ment estimated an average PACU LOS of 31 min during the study period for all children. PACU LOS in excess of 1, 2, and 3 h were observed among 182, 37, and eight moderately obese patients, respectively. The correspond- ing numbers of severely obese patients staying in the PACU in excess of 1, 2, and 3 h were 102, 18, and five patients, respectively. Differences in PACU LOS >1, >2, or

Table 1 Demographic and clinical characteristics by patient degree of obesity ($N = 961$)

Variable	Cases missing data	Moderately obese ($N = 652$)	Severely obese ($N = 309$)	p^a
		Mean (SD) or N (%)	Mean (SD) or N (%)	
Age (years)	0	10.19 (4.30)	9.08 (4.86)	<0.001
BMI-for-age percentile	0	97.35 (1.15)	99.49 (0.28)	<0.001
Female	0	304 (47%)	114 (37%)	0.004
ASA classification status	0			<0.001
1		117 (18%)	40 (13%)	
2		473 (73%)	196 (63%)	
3–5		62 (10%)	73 (24%)	
Procedure	0			<0.001
ENT surgery		221 (34%)	90 (29%)	
Laparoscopic surgery		42 (6%)	26 (8%)	
GI surgery		79 (12%)	35 (11%)	
Orthopedic surgery		105 (16%)	51 (17%)	
Eye or dental surgery		63 (10%)	55 (18%)	
Urological surgery		37 (6%)	16 (5%)	
Plastic surgery		14 (2%)	15 (5%)	
General pediatric surgery		31 (5%)	11 (4%)	
Surgery duration (minutes)	54	42.31 (48.95)	39.57 (36.46)	0.398
Intraoperative opioid dosing (morphine equivalents mg/kg)	0	0.11 (0.08)	0.09 (0.07)	<0.001
Acetaminophen used intraoperatively	0	134 (21%)	66 (21%)	0.773
Ketorolac used intraoperatively	0	79 (12%)	44 (14%)	0.358
PACU time (minutes)	0	50.33 (35.59)	54.65 (37.69)	0.086
Opioids used in PACU	0	109 (17%)	58 (19%)	0.433
Inpatient admission	0	214 (33%)	122 (39%)	0.043

SD standard deviation, *BMI* body mass index, *PACU* post-anesthesia care unit, *ENT* ear, nose, and throat, *GI* gastrointestinal, *ASA* American Society of Anesthesiologists

[a] *p* values by Chi-square test for categorical variables and independent *t* test for continuous variables

>3 h between the moderately and severely obese patients were not statistically significant ($p = 0.106$, $p = 0.925$, $p = 0.624$, respectively). Multivariable mixed-effects regression analysis confirmed that among patients undergoing the same procedure, there was no difference in PACU LOS by degree of obesity (Table 2). Prolonged PACU LOS was associated with ASA status ≥2, longer surgical time, higher intraoperative opioid dosing, and the intraoperative administration of acetaminophen.

A total of 336 (35%) patients required inpatient admission after surgery, with admission (planned or unplanned) being more common among severely compared to moderately obese patients (39%, 122 of 309 patients versus 33%, 214 of 652 patients, $p = 0.043$). Unanticipated admission was recorded for seven moderately obese patients and three severely obese patients ($p = 0.883$), and occurred after ENT ($n = 6$), orthopedic ($n = 3$), and eye ($n = 1$) procedures. In multivariable analysis, severe obesity was associated with a more likely need for admission (planned or unplanned) among children undergoing the same procedure

(Table 3: OR 1.71; 95% CI 1.18, 2.48; $p = 0.005$). Intravenous acetaminophen administration was associated with greater odds of postoperative admission (OR 2.97; 95% CI 1.99, 4.44; $p < 0.001$), while the intraoperative use of ketorolac was associated with lower odds of postoperative admission (OR 0.53; 95% CI 0.30, 0.93; $p = 0.026$). Younger age, female gender, prolonged surgery time, and higher opioid dosing during surgery were also associated with higher odds of inpatient admission (Table 3).

There were 167 (17%) cases requiring opioid analgesia in the PACU, with similar proportions among moderately (17%) and severely (19%) obese patients. Older age, but not degree of obesity, was associated with opioid use in the PACU among patients undergoing the same procedure (Table 3). There were 30 moderately obese and nine severely obese patients who received a regional block during the procedure, most commonly during orthopedic ($n = 26$) and laparoscopic ($n = 6$) procedures. Among these procedures, use of a regional block was not associated with differences in PACU

Table 2 Mixed-effects linear regression of PACU length of stay in minutes

Variable	Unstandardized coefficient	CI	p
BMI ≥99th percentile	4.01	(−0.87, 8.89)	0.107
Age (years)	−0.14	(−0.67, 0.39)	0.602
Female	0.87	(−3.53, 5.28)	0.697
ASA status			
1	Ref.		
2	7.68	(1.59, 13.77)	0.013
3–5	15.04	(6.59, 23.49)	<0.001
Surgery duration (minutes)	0.09	(0.04, 0.15)	0.001
Intraoperative opioid dosing (morphine equivalent mg/kg)	48.18	(15.63, 80.74)	0.004
Acetaminophen used intraoperatively	19.13	(13.53, 24.74)	<0.001
Ketorolac used intraoperatively	−2.93	(−9.64, 3.77)	0.391
Standard deviation of random effect[a]	7.84	(4.32, 14.23)	<0.001

CI confidence interval, *BMI* body mass index, *PACU* post-anesthesia care unit, *ASA* American Society of Anesthesiologists

[a] Random effect of procedure type. Statistical significance assessed by likelihood-ratio test against a model without the random effect, and $p < 0.05$ implies significant residual variation in PACU length of stay across procedure types, after accounting for observed covariates

Table 3 Mixed-effects logistic regressions of PACU opioid use and inpatient admission by procedure type

Variable	Model 1: PACU opioid use			Model 2: inpatient admission		
	OR	CI	p	OR	CI	p
BMI ≥99th percentile	1.18	(0.79, 1.76)	0.431	1.71	(1.18, 2.48)	0.005
Age (years)	1.06	(1.01, 1.10)	0.016	0.96	(0.92, 1.00)	0.040
Female	1.27	(0.89, 1.83)	0.192	1.75	(1.25, 2.46)	0.001
ASA status						
1	Ref.			Ref.		
2	0.85	(0.52, 1.41)	0.537	0.81	(0.51, 1.29)	0.367
3–5	1.14	(0.59, 2.20)	0.696	1.70	(0.91, 3.17)	0.096
Surgery duration (minutes)	1.00	(1.00, 1.01)	0.629	1.01	(1.01, 1.02)	<0.001
Intraoperative opioid dosing (morphine equivalent mg/kg)	0.29	(0.02, 4.47)	0.377	24.75	(2.10, 291.46)	0.011
Acetaminophen used intraoperatively	1.54	(1.01, 2.37)	0.047	2.97	(1.99, 4.44)	<0.001
Ketorolac used intraoperatively	0.64	(0.35, 1.15)	0.135	0.53	(0.30, 0.93)	0.026
Standard deviation of random effect[a]	0.73	(0.36, 1.45)	<0.001	1.17	(0.68, 2.02)	<0.001

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *PACU* post-anesthesia care unit, *ASA* American Society of Anesthesiologists

[a] Random effect of procedure type. Statistical significance is assessed by likelihood-ratio test against a model without the random effect, and $p < 0.05$ implies significant residual variation in the odds of a given outcome across procedure types, after accounting for observed covariates. This estimate and its CI are not exponentiated, meaning the CI may include 1 but would not include 0 when $p < 0.05$

LOS or opioid. However, in moderately and severely obese patients, inpatient admission was less common in patients who received a regional block (ten of 32 patients, 31%) compared to patients that did not receive a regional block (119 of 192 patients, 62%; $p = 0.001$).

Discussion

Obesity is a known risk factor for adverse perioperative events with children undergoing surgery. Obesity has been shown to be associated with an increased perioperative risk for adverse respiratory events [12–14]. The consequences of obesity during the perioperative period in adults are well recognized, but there are limited data on the impact of the severity of obesity on postoperative outcomes. In a meta-analysis from the adult population, there was no difference in PACU discharge times when comparing obese with non-obese adult patients [15]. It was noted that non-medical factors, such as absence of a nurse to transfer the patient to the ward or waiting for an anesthesiologist to sign the patient out before leaving the PACU, were responsible for

the variability of PACU discharge. However, they did note that postoperative recovery was influenced by the choice of anesthetic with recovery being faster after desflurane than after sevoflurane, isoflurane, or propofol anesthesia in obese patients.

There is an association between increasing BMI and adverse perioperative events [4, 16]. Preoperatively, difficult laryngoscopy and difficult mask airway are more common in obese children compared to overweight or normal weight children [4]. However, the difference in perioperative outcomes by severity of obesity in pediatrics is not well understood. With ongoing focus on cost-constraints in medical care, risk stratification is necessary to identify patients who have a significantly higher incidence of perioperative complications or those that require inpatient hospital admission as they would not be ideal candidates for outpatient surgery. On the other hand, given its incidence, it is not feasible to admit all patients or avoid the use outpatient operating rooms merely based on body weight or BMI. At younger ages, the BMI may be under appreciated since it is the percentile and not the actual number that is used for stratification. These patients may present at ambulatory sites for operative dentistry, inguinal hernia, or ENT procedures. Weight may be obtained initially from primary care office and BMI may not be calculated as height may not be universally obtained during the preoperative visit. Changes in weight from the time of the preoperative visit to the day of surgery may significantly impact the BMI as a difference of a kilogram in a month can tip a child from moderately to severely obese.

In the current study, we noted that although PACU LOS was prolonged in both moderately and severely obese children undergoing surgery with GA when compared to non-obese children, there was no difference in LOS according to the degree of obesity. The severity of obesity was associated with a greater need for postoperative admission (planned and unplanned) although no difference was noted in the need for unplanned admission. In obese patients, the need for admission may be the result of various co-morbid conditions associated with childhood obesity include hypertension, type II diabetes, asthma, gastroesophageal reflux disease, and fatty liver disease, which may lead to a greater risk of postoperative complications [17–19]. However, in our cohort, there was no difference in unplanned admission, likely due to the small number of unplanned admissions recorded during the study period. Therefore, the increased need for postoperative admission was related to physician preference or hospital-related policies when caring for moderately and severely obese patients. Our institutional practice is that children over 99% BMI are not considered as candidates to have their procedure at our ambulatory surgery sites, due to possible inpatient admission. During the preoperative process, if obese patients are

found to have significant co-morbidities or additional concerns regarding the perioperative course, they are requested to be booked with an in-patient bed. Furthermore, in patients undergoing adenotonsillectomy, we have admission guidelines in place based on BMI percentile [20]. Although we have some specific institutional guidelines regarding BMI, these are broad enough to be translated to other hospitals. As mentioned earlier, not all patients' weight/height are known or accurate prior to arrival, which may account for some unanticipated admissions.

Obesity may also impact intraoperative care and medication administration. Inadequate analgesia and the need for opioid administration in the PACU may further delay PACU discharge times. PACU discharge criteria are based on the Association of periOperative Registered Nurses (AORN) discharge criteria from PACU [21]. Pain medication is given based on moderate and severe pain based on Face, Legs, Activity, Cry, and Consolability (FLACC) or FACES visual analog scale scoring for moderate/severe pain. Additionally, uncontrolled pain may result in unplanned hospital admission. A number of pharmacokinetic changes have been reported in obese adults, including increased volume of distribution for lipophilic drugs and an increased rate of elimination for some medications [22, 23]. To date, there are limited data in the younger, pre-adolescent obese pediatric population. Although these patients may require a larger loading dose at the initiation of therapy, obese patients may require decreased maintenance dosing due to a longer elimination half-life that results from a larger volume of distribution in this population [23]. Children who receive inappropriate doses based on weight may be at greater risk for adverse events due to the accumulation of opioid. There also may be concern for underdosing, resulting in reduced efficacy. Although the number of patients who required additional opioid analgesia in the PACU was the same in moderately and severely obese patients, intraoperative opioid dosing (morphine equivalents/kg) was less in severely obese patients. Pain regimen dosing was not standardized in this study, which poses a limitation and should be looked at prospectively. As actual body weight increases, pharmacokinetic mass increases logarithmically, suggesting there may be an upper limit to the weight by which opioids should be dosed [24]. Thus, if opioids are dosed merely based on actual body weight in severely obese patients, there is a greater risk for excessive dosing, over-sedation, and possibly development of withdrawal upon rapid discontinuation. The Academy of Pediatrics recommends that pediatric weight-based dose should not exceed recommended adult maximum doses [25].

In the current cohort of patients, a higher rate of postoperative admission (planned and unplanned) was noted both with higher intraoperative doses of opioids and a longer length of surgery in moderately and severely obese patients.

While this could be attributed to altered pharmokinetics in obesity, a cofounding factor is the increased surgical time which could reflect more complex procedures and therefore the need for postoperative admission. Intravenous acetaminophen administration was associated with an increased incidence of postoperative admission whereas the use of ketorolac was not. Given the retrospective nature of the study and the lack of controlled indications for the use of these medications, it is difficult to identify if there is a true causal relationship between these two medications and the need for inpatient admission. This difference may merely reflect our practice variations in that the more expensive and newer medication (acetaminophen) may have been reserved for higher risk patients. Furthermore, intravenous acetaminophen is commonly used in our adenotonsillectomy whereas ketorolac is not given the perceived risks of bleeding. This population is frequently scheduled for postoperative admission given the comorbid conditions of obstructive sleep apnea and sleep disordered breathing. Prospective studies would be needed to clearly define these relationships. Although the numbers were limited, the use of a peripheral nerve blockade in association with general anesthesia decreased the need for inpatient admission among severe and moderately obese children. Peripheral nerve blockade provides excellent analgesia with a low rate of adverse events [26, 28]. Peripheral nerve blockade has been shown to facilitate hospital discharge following ambulatory orthopedic even in non-obese adolescents following outpatient orthopedic surgical procedures [27, 28].

Limitations of our study are its retrospective nature and potential case selection bias. While a prospective study would assure greater consistency of data collection and allow for a more detailed assessment of surgical outcomes in obese children, the rarity of severe obesity [e.g., 309 patients (2%) out of the 12,981 surgeries initially examined] may complicate efforts to recruit severely obese children for a confirmatory prospective study. Whereas our primary finding of no difference in PACU LOS between moderately and severely obese children may have been due to a limited sample size, a post hoc power analysis for a two-tailed independent t test, according to PACU LOS means and standard deviations shown in Table 1, suggests that our sample size had 49% power to reject the null hypothesis given this difference in PACU LOS between the two groups. Assuming that moderately obese children outnumber severely obese children 2:1, further power analysis found that 1974 patients—more than double the current sample—would have had to be enrolled to attain a conventional power of 80%.

We also did not take into account the choice of anesthetic (volatile agent, opioids, and adjuncts including acetaminophen and ketorolac). Although we noted a longer PACU stay in obese patients, the exact reasons for this are difficult to determine retrospectively. As this is a single-center retrospective review, it may be biased by incomplete data and under-reporting. There was a low incidence of unplanned admission and therefore, it is difficult to identify factors that are responsible for this outcome. Unplanned admissions are a key factor in determining which patients may be safely anesthetized in outpatient surgical settings as such issues significantly impact patient flow and operating room efficiency. A larger cohort would be necessary to identify these variables.

With the prevalence of obesity continuing to increase in the pediatric population, there is a need for clear stratification of the perioperative risks factors in obese children. In this study, severe obesity was not associated with prolonged PACU stay as compared to moderate obesity in children undergoing a variety of surgical procedures. Yet, this conclusion was potentially biased by confounding and the small number of severely obese patients out of the total population of children undergoing surgery. The duration of PACU stay averaged less than 1 h in our cohort, suggesting that the majority of obese children can be cared for safely in the outpatient setting. Future studies should focus on identifying the co-morbid conditions, which may prolong postoperative PACU stay or result in unplanned hospital admission in moderately and severely obese patients. Our preliminary data suggest that these factors may include a younger age and the complexity or duration of the surgical procedure.

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