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Association of BMI and pediatric urologic postoperative events: results from pediatric NSQIP

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Summary

Background—Elevated body mass index (BMI) is a well-known risk factor for perioperative complications in adults, but has not been investigated in children undergoing urologic procedures. Given the low rate of complications associated with urologic surgery, a large sample is required for their characterization, but BMI is frequently not available in administrative databases. Here we report results from the first nationally based, prospectively assembled cohort analyzed with respect to the association of BMI with 30-day postoperative events for pediatric urologic procedures.

Objective—To determine the association of elevated BMI with overall 30-day postoperative events and wound complications in a large national sample of children undergoing urologic procedures.

Study design—We queried the 2012 Pediatric National Surgical Quality Improvement Program database (NSQIP), defining obesity as a BMI above the 95th percentile and overweight above the 85th percentile, per CDC definitions. We used BMI <85th percentile as a referent group. Complications were collected within 30 days of the procedure. Comorbidity was classified on a linear scale using a validated pediatric-specific comorbidity score, and procedures were classified as genital, abdominal without bowel involvement, or abdominal with bowel involvement. Univariate and multivariate logistic models were used to test significance of associations.

Results—2,871 patients aged 2–18 years were analyzed. Of these, 420 (14.6%) were overweight and 440 (15.3%) were obese. A summary of 30-day events and complications is shown in the structured abstract table. On multivariate analysis adjusting for age, gender, class of procedure, and comorbidity, BMI remained a significant risk factor for 30-day events when comparing

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Conflict of interest
None.

BMI 85th percentile to BMI <85th percentile (OR 1.36, 95% CI 1.03–1.8, $p=0.035$). An exploratory subgroup analysis examining the rate of wound complications demonstrated an odds ratio of 2.36 (95% CI 1.28–4.35, $p=0.006$) for BMI>85th percentile on multivariate analysis.

Discussion—Overweight/obese status increased the odds of overall complications by 36%, and of wound complications by 140%. In adults there is a known profound effect of body composition on wound complications, but in children this association is less clear, and has not been studied in the pediatric urologic literature on a large scale. The mechanisms linking BMI to pediatric postoperative complications are unclear, but cytokine mechanisms or changes in the response to inflammation have been postulated. Limitations of this study include restriction to those urologic procedures included in ACS-NSQIPP and sorted into broad general categories. We did not control for secondary procedures. BMI/BMI percentile may not be appropriate measures of body composition in patients with atypical body habitus or proportions (e.g. myelomeningocele).

Conclusion—BMI in the pediatric NSQIP urologic population was found to be associated with overall complication after adjustment for case type and preoperative comorbidity in a large national sample assembled for assessment of perioperative outcomes. An exploratory analysis uncovered more than two-fold increase in odds of wound complication in obese/overweight patients compared with a normal weight referent population. These results may be useful in preoperative counseling patients regarding perioperative risk.

Keywords

BMI; Obesity; Pediatric; Surgery

Introduction

Obesity is increasingly prevalent among children in the United States; 16.9% of 2- to 19-year-olds were obese in 2011–2012 [1]. This is more than double the prevalence of pediatric obesity 30 years ago [2]. Surgical complications have been shown to be linked with measures of body composition, including body mass index (BMI), although this relationship is complex [3,4]. Knowledge of the impact of such factors in children would be useful in counseling patients and families perioperatively, but this requires a large sample from which the data are captured; and most administrative datasets large enough to capture significant numbers of complications after urological procedures do not include BMI among their covariates

We sought to analyze a prospectively collected national database with respect to 30-day events after surgery stratified by categories of BMI. Our aim was to determine adjusted and unadjusted 30-day overall events and wound-specific complication rates in obese or overweight children. We hypothesized that overweight and obese children would have higher overall 30-day postoperative event rates and higher wound complication rates in both unadjusted and adjusted analyses, when compared with non-overweight/non-obese control patients.

Methods

Study design and data source

We queried the 2012 American College of Surgeons National Surgical Quality Improvement Program-Pediatric database (ACS-NSQIPP). This comprises 50 participating sites nationally. Pre-, intra-, and postoperative events (within 30 days) are collected prospectively by on-site reviewers [5]. We included patients between the ages of 2 and 17 years, as BMI percentiles are not defined by the CDC below 2 years of age [6].

Patient selection

Patients were identified by primary procedure CPT code and procedure description; all urologic procedures included are shown in Table 1. We divided the procedures into genital procedures (hypospadias repair, clitoroplasty), abdominal procedures without bowel involvement (e.g., renal and ureteral surgery, orchidopexy), and abdominal procedures with bowel involvement (appendicovesicostomy, augmentation cystoplasty).

Variables

BMI category was calculated using z-scores to account for age, weight and height according to CDC categories [6]. We excluded those with BMI >5 z-scores from the standardized mean, per CDC guidelines, and also excluded patients with BMI >65, as these were thought to represent inaccurately recorded data. The categories were non-overweight, non-obese (<85th percentile), overweight (85th-95th percentile) and obese (>95th percentile). For the purposes of our primary analysis, we compared patients with BMI <85th percentile to those with BMI ≥85th percentile. The operative characteristics included operative time in hours, type of procedure, American Society of Anesthesiologists (ASA) classification, and wound classification (clean, clean/contaminated, contaminated, dirty/infected). Using a pediatric surgical risk score developed by Rhee *et al.*, we assigned a risk score to each patient based on several preoperative patient characteristics and comorbidities. This has been shown to be superior to the Charlson Comorbidity Index in predicting perioperative mortality in children [7].

Complications and outcomes

ACS-NSQIP-Pediatric collects data on 21 defined postoperative complications within 30 days of surgery. A table of all complications collected is provided (Table 2). A composite measure of 30-day adverse events was constructed, which included any ACS-NSQIP-defined 30-day complication, readmission within 30 days and/or reoperation within 30 days. Wound complications were defined as a composite of superficial surgical site infection (SSI), deep SSI/organ space infection and/or wound dehiscence.

Statistical analysis

Descriptive statistics were used to characterize the cohort (Table 3). The associations between 30-day adverse events and the potentially relevant patient- and procedure-level factors detailed above were evaluated via logistic regression. For those complication types with very few events, comparisons were performed using Fisher's exact test. Variables that

had significant univariate associations and/or clinical relevance were included in the final multivariate model: age (years), gender, type of procedure, BMI category, comorbidity score and operative time (for overall complications and for wound complications). Wound classification and ASA classification were removed from the multivariate model to avoid multicollinearity while leaving comorbidity score in the model.

Functional forms of continuous covariates were examined, and diagnostic checks and sensitivity to outliers of the fitted models were performed. Data processing and statistical analysis was conducted using SAS v9.3 (SAS Institute Inc., Cary, NC, USA). A p value of <0.05 was considered to be statistically significant.

Results

3,395 patients aged 2–18 years undergoing urologic procedures were present in the dataset; 495 patients were excluded because of incalculability of BMI (all because of lack of recorded height) and 29 patients were excluded because of BMI range constraints described above. As shown in Table 1, a total of 2,871 patients was analyzed; 876 had undergone genital procedures, 1,799 underwent abdominal procedures without bowel involvement, and 196 underwent abdominal procedures with bowel involvement. 61% of the cohort was male, and the median age was 6.1 years (IQR: 3.8–9.9) as shown in Table 2. Most of the cohort had no pre-existing comorbidity (80% with a comorbidity score of 0), and most wounds (76%) were “clean-contaminated”. Of the 2,871 patients, 2,011 were non-overweight, 420 were overweight non-obese and 440 were obese. This was anticipated given the genitourinary nature of the procedures within the cohort.

Overall, events of any kind occurred in 242 patients (8.4%), which corresponds to 92 (10.7%) events in of obese/overweight patients and 150 (7.5%) events in non-overweight patients. The most common complications were urinary tract infection, wound complications, and bleeding. A total of 124 (4.3%) patients were readmitted within 30 days and 44 (1.5%) patients had a reoperation within 30 days. The types of complications occurring in each of the BMI categories are presented in Table 3.

The unadjusted odds of any 30-day event were substantially higher in those with BMI 85th percentile (OR 1.5; 95% CI 1.1–2.0, $p=0.004$) compared with the reference group. This effect remained in the multivariate model (OR 1.36, 95% CI 1.03–1.8, $p=0.034$), adjusted for age, gender, procedure type and comorbidity. When examining wound complications alone, the unadjusted (OR 2.6, 95% CI 1.4–4.7, $p=0.002$) and adjusted (OR 2.4, 95% CI 1.3–4.3, $p=0.006$) odds were substantially higher in those with BMI 85th percentile. In an exploratory analysis examining odds of wound complications among obese patients (BMI 95th percentile) compared with those with a BMI<95th percentile, the adjusted odds ratio was 4.0 (95% CI 2.1–7.5, $p<0.0001$). This effect was not seen in those with BMI between the 85th and 95th percentiles compared with those with a BMI<85th percentile (OR 1.1, 95% CI 0.4–3.0, $p=0.79$). This implies that the excess burden of wound complications fell primarily on the obese subset (>95th percentile) of the population.

Discussion

We examined the effect of BMI on 30-day postoperative events and wound complications in a prospective-assembled, nationally based cohort of children undergoing urologic surgery. We found that overweight/obese status increased the adjusted odds of overall 30-day event by 36%, and increased the adjusted odds of wound complication by 140%.

In adults there is a profound effect of body composition on wound complications; in some series the odds of a wound infection in those with higher body fat were 400% higher than those with the lowest percentage of body fat with a roughly linear effect [8]. Importantly, the effect of BMI is not universally observed in adult series, even with several different types of procedures included in a large series [3]. In children, the effect of extreme weight percentile is also uncertain. Stey *et al.* analyzed a pediatric ACS-NSQIPP sample examining the effect of extreme weight percentile. They found that there was no impact of weight >95th percentile on overall complication rate. However, it was suggested that children with weight >95th percentile had a 1.35-fold higher odds of surgical site infection (95% CI 1.16–1.57) compared with those with weight between 5th and 95th percentile. Of note, this study population included infants (overall range 29 days–18years), and therefore is not strictly a study of BMI [4].

There is precedent in analyzing the impact of weight and BMI in pediatric urologic complications. Donovan *et al.* analyzed a single-institution database of patients with myelodysplasia undergoing reconstruction [9]. They reported unadjusted complication rates of 40% in both the referent group (BMI <85th percentile) and in overweight patients (85th–95th percentile), but found complication rates of 75% in those with a BMI >95th percentile. Specifically, there was a higher burden of stomal stenosis in obese patients, and multiple complications occurred more frequently in obese patients. Most patients in this study were children or adolescents (median age 14 years), although the ages ranged from 6 to 29 years, and follow-up was over a median of 39 months. Our study is confined to complications within 30-days, and therefore the demonstration of greater risk of short-term complications in the overweight/obese population is novel.

Although most of the literature regarding weight and complications among pediatric urological patients has focused on overweight, there is some evidence that underweight may also increase complication risk; weight <5th percentile was shown to triple the odds of perioperative complications in a pilot study [10]. We investigated the possibility that underweight status (<5th percentile) might affect complications in an exploratory analysis, but we did not find a difference in complications between the underweight group and patients in the 5th–85th weight percentile. We therefore elected to combine the underweight patients ($n=159$) with the non-overweight reference group ($n=1852$).

It is possible that indices of adiposity other than BMI may more precisely stratify patients with respect to surgical risk [8]. Nonetheless, BMI is an important surrogate, as this information is readily extracted from commonly available clinical data (height and weight). This requires neither the expense nor invasiveness of additional testing (impedance testing, dual-energy X-ray absorptiometry, or caliper application). This is also important for

retrospective clinical data in which only limited anthropometric data are available but risk stratification is desired.

The mechanisms of the increased risk of complication as a function of BMI are elusive. There is known to be a higher risk of non-surgical infection in obese children. Yang *et al.* demonstrated in a non-surgical population of children under age 3, in a model adjusting for age and gender, the odds of UTI was higher in obese compared with non-obese children (OR 1.84, 95% CI 1.11–3.05) as was pyelonephritis (OR 2.43, 95% CI 1.3–4.7). The authors cite several possible causes, including the known production of pro-inflammatory cytokines by adipose tissue, or the association of obesity and enhanced renal inflammation in response to infection [11]. Regarding wound infection, the association between elevated BMI ($>30\text{kg/m}^2$) and infection in pediatric spine surgery has been shown [12]. Unfortunately, even in children, obesity is known to be associated with cardiovascular risk factors such as diastolic pre-hypertension, systolic pre-hypertension, and low high-density lipoprotein in 2–9 year olds [13], which is echoed in other large population-based cohorts [14].

The results of this study should be interpreted in light of its limitations. We only captured the portion of urologic procedures who are included in ACS-NSQIPP; this large database includes selected procedures from a range of specialties, but is not comprehensive. We broadly controlled for type of urologic procedure in our model, based on general categories (e.g. involvement of bowel), but were not able to control for the specific procedures themselves as these data were not available. We also did not control for secondary procedures. When analyzing readmission, we included all readmissions for any cause, which may not be linked to the procedure itself. Furthermore, BMI (and specifically BMI percentile) may not be an appropriate measure of body composition in all circumstances; this is especially true in patients with atypical body proportions (e.g. non-ambulatory myelomeningocele patients). In adults, it has been shown that adiposity is underestimated in those with spinal cord injuries (particularly tetraplegia) [15]. Those authors proposed a lower BMI cutoff to define obesity in this population. As we were not able to incorporate this as a factor in our analysis, this type of misclassification by use of BMI may have caused an underestimation of the true effect of adiposity on 30-day event in our analysis. Importantly, although BMI was associated with 30-day events and wound complications, overall events were rare in this pediatric urologic sample; the overall odds of 30-day event increased by 3.3% and odds of wound infection increased by 1.6%.

Conclusion

Obese/overweight status was associated with higher risk of 30-day postoperative events in the pediatric NSQIP population after urologic surgery. This effect remained after adjustment for type of procedure and preoperative comorbidity in a large national sample assembled for assessment of perioperative outcomes. Subgroup analysis revealed more than two-fold odds of wound complication in obese/overweight patients compared with a normal weight referent population. These results may be useful in preoperative counseling of patients regarding perioperative risk.

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Table 1

Procedures included in analysis

Procedures, Categorized	#
Genital procedures	
Hypospadias repair	875
Clitoroplasty	1
Category total:	876
Abdominal procedure, non-bowel	
Extirpative renal ^a	233
Pyeloplasty	132
Open ureteral cases	820
Open bladder procedures	147
Abdominal orchidopexy	357
Abdominal gynecologic	110
Category total:	1799
Abdominal procedure, bowel	
Appendicovesicostomy	104
Augmentation cystoplasty	66
Other	26
Category total:	196
Total	2871

^aRenal surgery includes partial or radical nephrectomy performed laparoscopically or open with or without ureterectomy, and open renal biopsy.

Table 2

Cohort characteristics

Gender		Comorbidity score	
Male	1738 (61%)	0	2310 (80%)
		1	419 (14%)
Age, years		2	77 (3%)
Median (IQR)	6.1 (3.8, 9.9)	3	54 (2%)
		4	11 (1%)
BMI			
Normal weight (Ref)	2011 (70%)	Operative time, hours	
Overweight	420 (15%)	Median (IQR)	1.7 (0.8, 2.7)
Obese	440 (15%)		
ASA Class		Wound classification	
Class 1	1037 (36%)	Clean	623 (21%)
Class 2	1417 (49%)	Clean/contaminated	2181 (76%)
Class 3	406 (14%)	Contaminated	45 (2%)
Class 4	11 (1%)	Dirty/infected	22 (1%)

Table 3

Types of events and specific 30-day events

	BMI <85th percentile	BMI 85th percentile	Full cohort	<i>p</i> ^a
Any complication ^b	82 (4.1%)	58 (6.7%)	140 (4.9%)	0.003
Urinary tract infection	38 (1.9%)	25 (2.9%)	63 (2.2%)	0.09
Sepsis	2 (0.1%)	4 (0.5%)	6 (0.2%)	0.07 ^c
Pneumonia	1 (0.05%)	1 (0.12%)	2 (0.07%)	0.5 ^c
Unplanned intubation	3 (0.2%)	3 (0.4%)	6 (0.2%)	0.37 ^c
Postoperative bleeding	26 (1.3%)	15 (1.7%)	41 (1.4%)	0.35
Any wound complication	21 (1.0%)	23 (2.7%)	44 (1.5%)	0.002
Superficial surgical site infection	9 (0.5%)	13 (1.5%)	22 (0.8%)	0.005
Deep surgical site infection	3 (0.2%)	4 (0.5%)	7 (0.2%)	0.21 ^c
Organ space infection	2 (0.1%)	5 (0.6%)	7 (0.2%)	0.02 ^c
Dehiscence	9 (0.5%)	3 (0.4%)	12 (0.4%)	0.71
Reoperation within 30 days	27 (1.3%)	17 (2.0%)	44 (1.5%)	0.21
Readmission within 30 days	78 (3.9%)	46 (5.3%)	124 (4.3%)	0.08
Any 30-day event	150 (7.5%)	92 (10.7%)	242 (8.4%)	0.004

^a Obtained using logistic regression.^b In addition to complications shown, there were no cases of acute kidney injury, embolic events, or neurologic events.^c Obtained using two-tailed Fisher's exact test because of small cell count.

Table 4

Rates of 30-day postoperative events in pediatric urologic procedures

Any 30-day event	Reference (<i>n</i> =2011) BMI <85th percentile	Overweight or obese (<i>n</i> =860) BMI 85th percentile		
	30-day event, <i>n</i> (%)	30-day event, <i>n</i> (%)	OR (95% CI)	<i>p</i>
Univariate	150 (7.4)	92 (10.7)	1.49 (1.13–1.95)	0.004
Multivariate	-	-	1.36 (1.03–1.82)	0.034

Wound complications	Reference (<i>n</i> =2011) BMI <85th percentile	Overweight or obese (<i>n</i> =860) BMI 85th percentile		
	30-day event, <i>n</i> (%)	30-day event, <i>n</i> (%)	OR (95% CI)	<i>p</i>
Univariate	21 (1.04)	23 (2.7)	2.60 (1.43–4.73)	0.002
Multivariate	-	-	2.36 (1.28–4.35)	0.006

Multivariate model: adjusted for age, gender, procedure type, comorbidity.

Table

Association of BMI with 30-day postoperative events in children after urologic procedures

	BMI <85th percentile	BMI 85th percentile	Full cohort	<i>p</i> ^a
Any complication ^b	82 (4.1%)	58 (6.7%)	140 (4.9%)	0.003
Urinary tract infection	38 (1.9%)	25 (2.9%)	63 (2.2%)	0.10
Postoperative bleeding	26 (1.3%)	15 (1.7%)	41 (1.4%)	0.35
Any wound complication	21 (1.0%)	23 (2.7%)	44 (1.5%)	0.002
Superficial surgical site infection	9 (0.5%)	13 (1.5%)	22 (0.8%)	0.005
Deep surgical site infection	3 (0.2%)	4 (0.5%)	7 (0.2%)	0.21 ^c
Organ space infection	2 (0.1%)	5 (0.6%)	7 (0.2%)	0.02 ^c
Dehiscence	9 (0.5%)	3 (0.4%)	12 (0.4%)	0.71
Reoperation within 30 days	27 (1.3%)	17 (2.0%)	44 (1.5%)	0.21
Readmission within 30 days	78 (3.9%)	46 (5.3%)	124 (4.3%)	0.08
Any 30-day event	150 (7.5%)	92 (10.7%)	242 (8.4%)	0.004
Odds of any 30-day event (unadjusted)	-	1.49 (1.13–1.95)	-	0.004
Odds of any 30-day event (multivariable)	-	1.36 (1.03–1.82)	-	0.034
Odds of wound complication (unadjusted)	-	2.60 (1.34–4.73)	-	0.002
Odds of wound complication (multivariable)	-	2.36 (1.28–4.35)	-	0.006

^aObtained using logistic regression.^bIn addition to complications shown, there were no cases of acute kidney injury, embolic events, or neurologic events.^cObtained using two-tailed Fisher's exact test because of small cell count.