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Effect of body mass index percentile on pediatric gastrointestinal surgery outcomes

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ABSTRACT

Background/purpose: Pediatric obesity is an important public health concern, yet its effect on surgical outcomes is poorly understood. The purpose of this study was to determine if age and gender-specific body mass index (BMI) percentile influences complications and hospital resource utilization following pediatric gastrointestinal surgeries.
Methods: Patients aged ≥2 to <18 years who underwent appendectomy or other gastrointestinal operations were identified in the 2012–2013 Pediatric National Surgical Quality Improvement Program datasets. Age- and gender-specific pediatric BMI percentiles were calculated. Patients who underwent appendectomy (n = 9606) and those undergoing all other intestinal operations (n = 2664) were evaluated as separate cohorts.
Results: In the appendectomy cohort, frequency of any complication increased with BMI category (normal weight 4.5%, overweight 5.3%, obese 5.7%, morbidly obese 7.3%, overall 5.0%, p = 0.014). In multivariate analysis, there was a quadratic association between BMI percentile and increased frequency of superficial incisional infection, unplanned tracheal intubation, and longer operative duration. In the intestinal surgery cohort, BMI percentile was not a predictor of any individual complication or any measure of hospital utilization.
Conclusions: Age- and gender-specific BMI percentile was associated with increased risk of complications and longer operative duration in patients undergoing appendectomy but not other intestinal operations.

1. Background

More than one third of youth are obese, and obese children are known to be at increased risk for chronic medical problems including hypertension, dyslipidemia, insulin resistance and diabetes, nonalcoholic fatty liver disease, obstructive sleep apnea, asthma, musculoskeletal complaints and psychological problems [1–4].

In adults, obesity is a well-recognized risk factor associated with chronic diseases and certain perioperative complications. From an anesthesia perspective, the obese habitus is associated with difficult airways, and difficulty visualizing anatomic landmarks makes line placements and regional anesthetics challenging [5]. Obese adults are at higher risk for aspiration owing to elevated gastric residual volumes, and drug distributions may be more difficult to predict [5]. From a surgical perspective, studies have consistently shown an increase in wound complications including infections in multiple types of nonbariatric abdominal surgeries [5–14]. Data regarding other complications are more controversial: some studies have shown obesity to be associated with wound dehiscence [15,16] and other nosocomial infections [5,17], while others have not shown obesity to be a risk factor for other major perioperative complications [7,9,10]. In fact, moderate obesity was even protective against mortality in some studies [10,13].

The literature regarding obesity in pediatric abdominal surgery is sparse in comparison to the adult literature. A single-institution study of 282 children requiring appendectomy found that obese children required longer operative times and longer hospital stays, and those with perforated appendicitis had increased risk of postoperative infections [18]. A small metaanalysis of 3 studies analyzed 220 pediatric patients undergoing laparoscopic appendectomy for perforated appendicitis, and identified that obese patients had longer operative times and increased abscess rate [19]. A study of 312 children requiring laparoscopic cholecystectomy, however, did not find any significant differences in outcomes with obesity [20]. In pediatric urologic surgery patients undergoing either genital or abdominal procedures, obese children had higher rates of overall and wound complications [21]. Recently, Michailidou studied complications following urgent or emergent laparoscopic appendectomy in 2812 pediatric patients in the Pediatric National Surgical Quality Improvement Program dataset [22]. When

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comparing obese to nonobese patients, they demonstrated no difference in complications albeit longer operative duration for obese patients.

The existing pediatric literature dichotomizes obesity, which may overlook important differences between moderately obese and morbidly obese patients. Additionally, since overall complication rates in children are low, larger studies are needed to detect any potential differences. Given that the existing literature includes mostly small studies, assesses a narrow range of operations, and has inconsistent results, further investigation is warranted. Understanding risk factors for complications is important for quality assessment and benchmarking from a health systems perspective, and is also critical for informed consent and patient counseling. Many providers anecdotally associate obesity with higher perioperative risk, but at present there is no solid quantitative data to support this. Identifying patients at high risk for specific complications allows providers to be more vigilant about other mitigating efforts, such as ensuring appropriate antibiotic prophylaxis for a patient at high risk for surgical site infections. These behaviors are important for patient care, and are also becoming increasingly relevant in the context of the shift toward value-based purchasing for health care services.

In the present study, we examined the impact of age- and gender-specific body mass index (BMI) percentile on outcomes and hospital resource utilization following pediatric gastrointestinal surgeries involving the small bowel, colon and rectum. We hypothesized that increasing age- and gender-specific BMI percentile would confer a higher rate of perioperative complications, and that care of these patients may necessitate more hospital resources.

2. Methods

2.1. Patient selection and body mass index assessment

After the Seattle Children's Hospital Institutional Review Board approved this study as exempt, we obtained and queried the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) Pediatric Participant Use Data Files from 2012 and 2013. This database includes patients less than 18 years of age who underwent major inpatient or outpatient surgical procedures. Trauma and transplant cases are excluded. For high-volume contributing hospitals, the first 35 consecutive cases meeting inclusion criteria within 8-day cycles were included. Regular audits are performed to ensure data quality. The 2012 dataset contains 51,008 cases submitted from 50 sites, and the 2013 dataset contains 63,387 cases submitted from 56 sites. Hospital types eligible for inclusion in NSQIP Pediatric include freestanding general and specialty children's hospitals, children's hospitals within larger hospitals, and general hospitals with pediatric wings.

Current Procedural Terminology (CPT) codes were chosen to include only patients undergoing operations on the small bowel, colon or rectum. Bariatric and feeding tube operations were excluded, as well as other cases such as adhesiolysis not involving resection, enterectomy, or anastomosis. Laparoscopic operations were determined based on procedure codes. For patients in the intestinal surgery cohort with multiple concurrent procedures, cases were coded as laparoscopic if at least one of the procedures was a laparoscopic abdominal procedure.

NSQIP Pediatric includes binary variables for complications occurring within 30 days of surgery, which were assessed individually and in composite. Table 3 shows key complications assessed (the complete list is found in the tables in the supplemental material); the term “any complication” refers to the presence of at least one of these identified complications. The dataset also includes 30-day measures of hospital resource utilization including anesthesia time, operative duration, ventilator days, length of stay, readmission and reoperative data, and work Relative Value Units (RVUs), which were also assessed.

We included patients aged ≥2 to <18 years in this study. This range was chosen because the Center for Disease Control's (CDC) age and gender-specific BMIs begin at age 2 years. Other norms such as length for age and weight for age are available for younger children, but these are less appropriate for assessing obesity. The CDC's 2000 gender-specific growth chart tables and publically available SAS program [23] were used to calculate age- and gender-specific pediatric BMI percentiles. We excluded cases with missing height and weight values rather than imputing them, given that there were limited variables available for imputation calculations and that these parameters were of primary interest. Weight data was missing for <0.5% of patients and height data was missing for 27% of patients; however, analysis comparing patients with full BMI data to those with weight data only demonstrated minimal, <5% differences. The CDC algorithm flags biologically implausible BMI percentiles; these patients were excluded from further analysis under the assumption that they were either very significant outliers or represented inaccuracies in the dataset. Given that our intent was to evaluate implications of obesity, we excluded patients <5th percentile for BMI.

12,270 patients met our inclusion criteria; of them, 9606 (78%) underwent either laparoscopic or open appendectomy and 2664 underwent other intestinal operations. Given the large proportion of patients undergoing a single operation, we sought to determine whether the appendectomy and other intestinal surgery subsets should be pooled or separated for analysis of outcomes by comparing patient characteristics and preexisting conditions (Tables 1 and 2). Given that the populations had different BMI distributions and extensive, statistically significant differences in most parameters assessed (Tables 1 and 2), we therefore analyzed outcomes for appendectomy patients separately from other intestinal surgery patients.

2.2. Univariate analysis

Descriptive statistics were performed to assess demographic characteristics and comorbidities for the overall population as well as the appendectomy and other intestinal surgery subgroups. The NSQIP Pediatric dataset includes binary data on presence of conditions present preoperatively. These were divided into acute and chronic conditions by our research team for conceptualization, although the specific time course of diagnosis for individual patients is not available. For appendectomy patients, a marker for severe appendicitis was created based on both diagnosis and procedure codes, and included patients with documented perforation or diagnosis of appendicitis with intraabdominal abscess.

For categorical analysis, the CDC's established age- and gender-specific pediatric categories were adapted: normal weight for BMI 5th to less than the 85th percentile, overweight if 85th to less than the 95th percentile, and obese if 95th percentile or greater. An additional category of morbid obesity was applied to patients with BMIs greater than the 99th percentile (the obese category was adjusted to include ≥95th to ≤99th percentiles). Rates of complications within each BMI category were calculated, and significance assessed using either Pearson's Chi Square tests or Fisher's Exact test depending on observation count. The association of BMI category with temporal measures such as operative time and hospital length of stay were assessed using ANOVA.

2.3. Multivariable analysis

Multivariable logistic and linear regression analyses were constructed individually for each cohort to account for the effect of demographic factors and comorbidities on the association between BMI percentile and outcomes. Only variables with more than 20 observations were considered in the models. Variables were included if they caused at least a 10% change in the models or if clinically important. BMI percentile was used as a continuous variable.

For the appendectomy cohort, a quadratic association between BMI percentile and resulting complications was most predictive of the true relationship after evaluating multiple models. The final model to predict complications included the square of age and gender-specific BMI