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Risk of failure of adenotonsillectomy for obstructive sleep apnea in obese pediatric patients

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ABSTRACT

Introduction: Pediatric obesity is a leading risk factor for obstructive sleep apnea (OSA), a condition commonly treated with adenotonsillectomy (T&A). It has been hypothesized that obesity increases a child's risk of failing T&A for OSA, however this relationship has not yet been quantified. The primary objective of this study was to investigate the relationship between obesity as measured by perioperative Body Mass Index (BMI) and persistent OSA following T&A as measured by polysomnography (PSG).
Study design: Retrospective chart review.
Methods: Pediatric patients who underwent T&A between Jan. 2004 and Jan. 2016 were included. We recruited both obese and non-obese patients to compare caregiver/self reported improvement. Obese patients were recruited from a weight management clinic and included if they had a BMI z-score >1.65 and had pre- and post-operative polysomnograms (PSGs). Control patients included those undergoing T&A for OSA at our institution with BMI <1.65. These patients were age matched to the obese patient population. Age, gender, perioperative BMI z-score, caregiver/self reported improvement, total Apnea-Hypopnea Index (AHI), and O_2 saturation nadir were collected where available. Univariate linear regressions were calculated between perioperative BMI z-score and PSG data.
Results: 26 obese study and 47 control subjects were identified for analysis. T&A resulted in statistically significant improvements in total AHI ($p = 0.030$) and nadir O_2 saturation ($p = 0.013$) in obese subjects. There was no significant difference between the rate of caregiver/self reported improvement in the two groups. There was a statistically significant correlation between perioperative BMI z-score and the change in total AHI ($p = 0.049$). Within our population, for every increase by 0.1 in perioperative BMI z-score, the improvement in total AHI post-operatively decreased by 1.63 events/hr. Further, patients with BMI more than 3 standard deviations away from the age-derived normative mean received essentially no benefit from T&A alone.
Conclusions: Our study established an inverse linear relationship between perioperative BMI z-score and improvement in total AHI with essentially no improvement in patients with BMI z-scores >3. Further studies are required to further elucidate this relationship and investigate the role of additional procedures in the initial management of OSA in obese children.
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1. Introduction

The childhood obesity epidemic has become a prominent focus of public health awareness. Prevalence among children has doubled and has quadrupled among adolescents in the past 30 years [1,2]. Ogden et al. found that 8.1% of infants and toddlers age <2 and 16.9% of children age 2–19 were obese (defined as BMI > 95 percentile on the weight-for-age CDC growth chart from 2000) [3]. Childhood obesity is associated with a number of comorbidities including hyperlipidemia, hypertension, and impaired glucose tolerance as well as an increased risk of cardiovascular and gastrointestinal disease as adults [4]. Notably, obesity is a major risk factor for obstructive sleep apnea syndrome (OSAS) and sleep-disordered breathing in both adults and children [3,5,6].

While adenotonsillar hypertrophy is widely accepted as the

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primary driver in the pathogenesis of pediatric OSAS, obesity may contribute to the pathophysiology of OSAS by increasing pharyngeal fat, altering chest wall motion, and causing dysfunction in neuromotor control of ventilatory drive [5]. Overweight and obese patients not only have an increased risk of developing OSAS but also appear to derive less benefit from adenotonsillectomy, which is recommended by the American Academy of Pediatrics as the first line-treatment for most children with adenotonsillar hypertrophy causing OSAS [7,8]. These patients also have higher complication rates from this therapy [9–14].

Guidelines on performing adenotonsillectomy as first line OSAS surgery in obese children have not been put forward. We investigated the relationship between the severity of a patient's obesity and their post-operative outcomes, focusing primarily on the change in Apnea-Hypopnea Index (AHI) as a measure of improvement in disease severity. Here, we propose strategies for risk-stratifying obese patients based on pre-operative AHI and perioperative BMI z-score.

2. Materials and methods

The Vanderbilt University Institutional Review Board approved this retrospective review. Retrospective review of patients from the pediatric weight management clinic who had T&A or tonsillectomy alone was performed at Vanderbilt Children's Hospital between January 2004 and January 2016. Patients were included in the study group if they were age 18 or below at the time of surgery, underwent a tonsillectomy ± adenoidectomy, were obese, and had pre- and post-operative polysomnograms (PSGs).

Perioperative BMI z-scores were calculated using the measured height and weight at the time of surgery from patient charts and the Centers for Disease Control and Prevention 2000 growth standards. This measure was used to characterize obesity status of patients due to inevitable variability in growth (and thus mean BMI) between ages of children. The z-score is the deviation of the BMI for an individual from the mean BMI of a reference population divided by the standard deviation for the reference population. An online calculator created through Baylor College of Medicine was used (https://www.bcm.edu/cnrc-apps/bodycomp/bmiz2.html). A perioperative BMI z-score > 1.65 (>95th percentile) qualified a patient as obese.

For demographic and pre-operative PSG data comparison, a non-obese comparison group was collected among patients who underwent surgical management for either PSG proven OSA or a clinical diagnosis of sleep apnea by a pediatric otolaryngologist at Vanderbilt after January 1st, 2004. Patients were included in the non-obese comparison group if they had perioperative BMI z-score < 1.65 and had tonsillectomy ± adenoidectomy as the only surgical management for OSA. As the patients in the obese group were relatively older than the average adenotonsillectomy patient, non–obese patients were selected through age matching to minimize age related bias. Because sleep studies are not routinely ordered for all patients being evaluated for initial surgical management of OSA, selecting only patients with pre- and post-operative PSGs would bias toward those with severe and/or refractory disease, thus this was not performed. Exclusion criteria included the presence of neuromuscular or craniofacial disease that affected breathing, other concurrent surgical interventions for OSA, and incomplete data.

The following data were collected from patient charts: gender, age at time of surgery, perioperative BMI (within 30 days of surgery), date of pre- and post-operative PSGs, and presence of medical (neurologic, cardiac, respiratory, genetic, or aerodigestive) comorbidities. From PSG reports, we recorded the AHI, obstructive AHI, central AHI, nadir O_2 saturation, and baseline O_2 saturation. All PSG reports, including those from outside sleep centers, were included if they contained all of these data. We also assessed if there was clinical improvement based on the post-operative visit. Clinic notes from within 3 months of surgery were examined to assess if patients or their parents noted improvement in sleep quality, energy during the day, snoring or loud breathing, and choking during sleep.

We examined the data for differences in subjective reporting of symptoms between obese and non-obese patient populations and objective changes in pre- and post-operative PSG data in the obese group as modified by BMI z-score.

2.1. Statistical analysis

Statistical analysis was completed using STATA (2016, StataCorp LP). Descriptive statistics (mean, median, standard deviation and range) were calculated to summarize continuous variables where appropriate. The Wilcoxon sign-rank test was used for comparison of paired, non-parametric studies, Mann-Whitney rank-sum test was used for comparison of unpaired, non-parametric studies, Student's T-test was used for comparison of parametric studies, and Fisher's exact test was used for analysis of categorical variables. Univariate linear regressions were used to examine the relationship between perioperative BMI z-score and the primary endpoints (final AHI, change in AHI, final nadir O_2 saturation, change in nadir O_2 saturation). All statistical tests were two-sided and performed to 95% confidence ($\alpha = 0.05$).

3. Results

In the initial review of patients from the weight management clinic who had T&A or tonsillectomy for obstructive sleep apnea alone, 33 obese patients were found. Of these, 7 were excluded, leaving 26 total patients in the study group. Patients were excluded for the following reasons: two patients were excluded because of underlying Trisomy 21, one patient was excluded because other upper airway interventions were performed (sleep endoscopy and supraglottoplasty), two patients were excluded for having perioperative BMI z-score < 1.65, and two patients were excluded due to missing PSG data. 47 patients were found on chart review for the non-obese comparison group.

A summary of the demographic information for the study and comparison groups in shown in Table 1. There were no significant differences between the obese and non-obese groups with regard to age ($p = 0.51$) or gender ($p = 0.49$). The perioperative BMI z-scores of obese patients ranged from 1.73 to 3.27, and 20 of the 26 patients (77%) had a perioperative BMI z-score between 2.5 and 3.0. There was no statistically significant correlation between perioperative BMI z-score and age. Additionally, there was no significant difference between perioperative BMI z-scores for male and female patients in either group.

3.1. Obese versus non-obese patient disease severity

Initial preoperative PSG data for obese and non-obese patient groups is summarized in Table 2. All patients in the obese group had pre- and post-operative PSG; 36 of the 47 (77%) of patients in the non-obese group had pre-operative PSG data. Because only four patients in the non-obese control group had pre- and post-operative PSG data, comparison of post-operative PSG data and time to postoperative PSG was not meaningful.

Patients in the obese group had significantly higher total AHI ($p = 0.02$) and lower nadir O_2 saturation ($p < 0.001$) than patients in the non-obese group pre-operatively. Of obese patients, 22 of 26 (84.6%) were noted to have subjective improvement by caregiver/

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