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Risk of Failure of Adenotonsillectomy for Obstructive Sleep Apnea in Obese Pediatric Patients

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Abstract
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).
Methods: *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 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.*
Keywords: *Obstructive Sleep Apnea, Obese, Patients.*

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 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.

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 [9e14].

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.

Materials and Methods

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. 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.

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 adenotonsille-ctomy 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 postoperative 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 O2 saturation, and baseline O2 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.

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 O2 saturation, change in nadir O2 saturation). All statistical tests were two-sided and performed to 95% confidence (a ¼ 0.05).

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 supraglotto-plasty), 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 ¼ 0.51) or gender (p ¼ 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.

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 postoperative 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 ¼ 0.02) and lower nadir O2 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/self report at a post-operative visit within 3 months of surgery. Among non-obese patients, 43 of 47 (91.4%) reported subjective improvement. There was no significant difference between the rate of caregiver/self reported improvement in the two groups (p ¼ 0.70).

Table 1
Patient characteristics.

	Obese	Non-obese	p-value
Number of patients	26	47	
Mean age ± SD (years)	11.4 (7.73, 13.62)	11.0 (6.92, 12.85)	0.32
Males	16 (61.5%)	24 (51.1%)	0.49
BMI	36.9 (30.25, 39.7)	18.3 (15.55, 21.35)	<0.001
BMI z-score	2.6 (2.54, 2.84)	0.5 (−0.18, 0.95)	<0.001
Time from pre-op PSG to post-op PSG (months)	8.52 (5.57, 19.17)	N/A*	N/A*
Time from surgery to post-op PSG (months)	4.69 (3.02, 5.81)	N/A*	N/A*

Only 4/47 patients in the non-obese group had postoperative PSG, making comparison between obese and non-obese groups less meaningful.
Presented: Median values with Interquartile ranges.

Table 2
Pre-operative AHI and nadir O_2 saturation.

	Obese	Non-obese	P Value
N	26	36	
Total AHI	9.4 (4.38, 26.03)	5.2 (2.9, 6.95)	0.02
Nadir O_2	80 (72, 86.75)	90 (88, 91)	<0.001

Presented: Median values with Interquartile ranges.

Effect of obesity on post-operative PSG metrics

Pre- and post-operative PSG data for patients in the obese group are summarized in Table 3. Following surgery, obese patients had significant reductions in median total AHI [IQR] (3.7 [-1.2, 18.93], p ¼ 0.03), NREM AHI (2.55 [-0.3, 14.08], p ¼ 0.01) and significant increase in O2 nadir (3 [-11, 0], p ¼ 0.01) and obstructive AHI (3.37 [-3.3, 15.23], p ¼ 0.05). Only 3 of 26 patients (11.5%) had a postoperative total AHI of 1 event/hour. 13 of the 26 patients (39.5%) had a post-operative total AHI of 5 events/hour.

There was a statistically significant difference between BMI z-score and the change in total AHI (p ¼ 0.05). On regression, there was an inverse linear relationship between perioperative BMI z-score and the difference between pre- and post-operative AHI, shown in Fig. 1. This regression indicates that for every increase of 0.1 in BMI z-score beyond 1.65, the amount of improvement in total AHI decreases by 1.63 events/hour. The x-intercept was at perioperative BMI z-score ¼ 3.10. There was not a significant relationship between BMI z-score and total AHI post-operatively (p ¼ 0.17), change in nadir O2 saturation (p ¼ 0.32), or post-operative nadir O2 saturation (p ¼ 0.45).

Table 3
Polysomnography Characteristics among Obese patient group.

	Pre-operative	Post-operative	Δ (pre-post)	p- value
Total AHI	9.4 (4.38, 26.03)	5.75 (3.25, 12.63)	3.7 (−1.2, 18.93)	0.03
Obstructive AHI	9.4 (4.38, 21.23)	5.5 (2.1, 12.5)	3.37 (−3.3, 15.23)	0.05
NREM AHI	4.85 (2.33, 21.2)	3.05 (1, 5.88)	2.55 (−0.3, 14.08)	0.01
REM AHI	21.2 (9.28, 39.88)	19.8 (5.4, 31.5)	−3.1 (−12.3, 22.2)	0.51
Central AHI	0.13 (0, 0.28)	0 (0, 1)	0 (−0.45, 0.13)	0.22
Nadir $\%O_2$	80 (72, 86.75)	85 (78, 88)	−3 (−11, 0)	0.01
Mean $\%O_2$	96 (94, 98)	95 (94, 96.5)	0 (−1.75, 3)	0.45

Presented: Median values with Interquartile ranges.

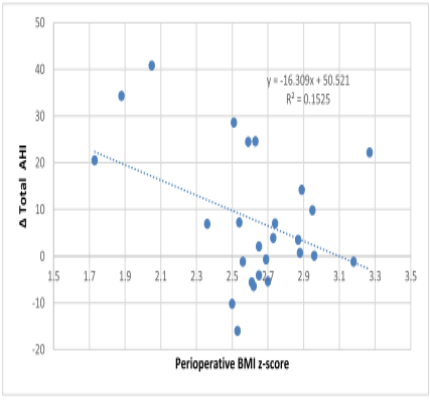

Fig. 1. Change in Total AHI versus Perioperative BMI z-score. Negative linear relationship between perioperative BMI z-score and the difference between pre- and post-operat AHI. AHI: Apnea-Hypopnea Index; BMI: Body Mass Index.

Discussion

Our retrospective study established a quantitative relationship between perioperative BMI z-score and post-operative PSG measures. We found an inverse linear relationship between perioperative BMI z-score and the difference between pre- and postoperative AHI, demonstrating that children with higher perioperative BMI z-scores derive less benefit from T&A for OSAS. In our study, patients with perioperative BMI z-score >3 would be, on average, expected to derive little improvement in AHI from T&A alone for OSAS. Beyond a z-score of 1.65, we demonstrate that for every increase in perioperative BMI z-score of 0.1 the postoperative improvement in AHI decreases by 1.63 events/hour, representing a clinically significant decrease in efficacy of T&A alone as BMI increases. Studies evaluating postoperative outcomes have demonstrated limitations of T&A alone in treating OSAS in obese children. Two meta-analyses of studies examining treatment of OSAS using T&A in children with pre- and post-operative PSG data demonstrated T&A significantly reduces the severity of OSAS but is more rarely curative in obese children [10,13].

In 2010, Bhattacharjee et al. performed a multicenter retrospective study of 578 children of otherwise healthy children undergoing T&A for OSAS, of which 50% were obese. Their study demonstrated a significant correlation between BMI z-score and post-T&A AHI and that most children who exhibited residual OSAS after T&A alone (i.e post-T&A AHI >5 events/hour) also fulfilled obesity criteria [9]. Our data suggest pre-operative AHI has a positive correlation with reduction in AHI post-operatively, consistent with previous studies [11,15e17]. However, Tauman et al. found the absolute decrease in AHI after surgery was greater with increasing relative BMI.

The relative BMI was based on growth curves published in 1991, which may account for the discrepancy in our results. Taken together, these studies suggest obese children with OSAS comprise a group of patients who may require a more complex approach to treatment than those of normal weight. However, no study to date has proposed clinical criteria for surgical decision-making. We suggest incorporating perioperative BMI z-score in surgical planning and counseling for patients with OSAS. In our study, we found that patients with a BMI z-score 3.10 would likely derive little to no improvement in AHI following T&A alone.

Furthermore, based on our data, providers could project that a patient with a BMI z-score 2.5 may only expect to have an AHI reduced by up to 10 events/hour on average. Thus, this suggests a limited role for T&A alone and that such patients may require multiple interventions. Furthermore, our study supports previous literature[15] demonstrating post-operative PSG data does not always correlate well with caregiver reported outcomes. This underscores the need for objective data in tracking sleep outcomes among children, particularly those who are medically complex.

This information should also allow physicians to better plan timing of post-operative PSG, in that may best be performed only after all stages of surgical intervention for OSAS are complete. The authors recognize limitations to this study. Given its retrospective nature, this study falls short of providing evidence for formal clinical recommendations. Further studies, potentially including prospective randomized trials of various strategies of surgical intervention, are needed in order to formally guide clinical practice.

Additionally, this study recruited patients from an obesity clinic who were being treated for OSAS and is likely not fully representative of the general population. Further studies are required to further investigate the role of additional procedures in the initial management of OSAS in obese children and determine proper treatment algorithms for these patients.

Conclusion

Our study demonstrated T&A alone may have a limited role in treating OSAS in children with higher perioperative BMI z-scores, quantifying suggestions from previous literature that suggested obese children with OSAS to derive less benefit from T&A alone than children of normal weight. A patient with perioperative BMI z-score 3 would likely derive no reduction in AHI following T&A alone. Perioperative BMI z-score is a useful clinical tool that could be incorporated into surgical planning and counseling for obese children, however further studies are required in order to determine clinical recommendations.

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