Success of Adenotonsillectomy with Concurrent Supraglottoplasty in Children with Down Syndrome.

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Abstract

OBJECTIVE: To examine surgical outcomes of adenotonsillectomy with concurrent supraglottoplasty for obstructive sleep apnea in children with Down syndrome.

METHODS: A retrospective case control study was conducted at a tertiary care children's hospital for children with Down syndrome and obstructive sleep apnea who underwent adenotonsillectomy with concurrent supraglottoplasty compared to adenotonsillectomy alone. All children had preoperative and postoperative polysomnogram within 18 months of surgery. The polysomnogram outcomes were compared via Wilcoxon Rank-Sum and Fisher's Exact tests for the two groups . Between group polysomnogram differences were tested using linear regressions, adjusting for BMI percentile, sex, and age.

RESULTS: The study population comprised 93 children who underwent adenotonsillectomy with concurrent supraglottoplasty and 439 control patients who underwent adenotonsillectomy alone. The majority of patients were male (56.2% overall) and over the age of 2 years old (84.1%). Patients with a concurrent or prior SGP were significantly younger (median age 2.4 years [IQR : 1.8, 4.3]) than patients with T+A only (median age 4.2 years [IQR : 2.7, 7.3]; $p < 0.001$). There was a significant improvement in OSA severity in both groups, with no statistically significant difference in improvement between groups. A significantly higher proportion of patients in the T+A with Concurrent or Prior SGP group had Moderate – Severe OSA during the pre-op PSG compared to the T+A Only group ($p = 0.003$), but rate of conversion from moderate-severe OSA to cured/no OSA was not different between the groups.

CONCLUSION: Our preliminary data had suggested that T&A+ SGP trended towards improved outcomes compared to T&A alone, however upon expansion of our cohort, this difference was tempered. Clinically, this suggests that in patient with Down syndrome who

continue to struggle with OSA following a T&A, additional consideration should be taken prior to proceeding with an SGP, given lack of statistical significance in outcomes when an SGP was perfomed in addition to T&A. Drug Induced Sleep Endoscopy (DISE) is an option in this population in order to more specifically qualify the upper airway anatomy, and futher investigation evaluating DISE in this population is warranted.

Keywords: Down syndrome, obstructive sleep apnea, laryngomalacia, supraglottoplasty, adenotonsillectomy

Introduction

The overall prevalence of pediatric obstructive sleep apnea (OSA) is 1-4% in the general population. For children with Down syndrome (DS), the estimated prevalence is substantially higher at 30 – 66%.[1,2] The higher OSA prevalence is multifactorial and related to hypotonia and anatomical abnormalities including a narrow nasopharynx, midfacial hypoplasia and macroglossia.[3]

The American Academy of Pediatrics (AAP) recommends an adenotonsillectomy (T&A) as first-line treatment for pediatric OSA.[4] In the childhood adenotonsillectomy study (CHAT), the overall cure rate for OSA following T&A was 79%. The CHAT study excluded children with DS, hypoxemia, severe obesity and markedly severe OSA (AHI> 30 events/hour).[5]

Unfortunately, the success rate of T&A in the DS population is markedly lower than for non-syndromic children. Approximately half of children with DS still have moderate to severe (OAHI > 5 events/hour) residual OSA after a T&A.[6-8] In one investigation, only 12% of children had a postoperative obstructive apnea/hypopnea index (OAHI) of less than one event an hour.[7]

For children with DS and persistent OSA, management options include positive pressure ventilation (PPV), medications, supraglottoplasty, lingual tonsillectomy, tongue base reduction, and upper airway stimulation.[9-14]

Supraglottoplasty has become an increasingly common surgical procedure to treat OSA for all children.[15] A supraglottoplasty improves the OAHI by either releasing the short aryepiglottic folds and/or removing redundant tissue over the arytenoids.[16-18] It converts a “tight” larynx into one that is more patent. The surgery improves not only breathing and sleep, but also feeding.[19] It is the primary procedure to manage children with occult laryngomalacia. Occult laryngomalacia differs from classic infantile laryngomalacia in that it affects older children and is manifested by

snoring rather than stridor. Multiple investigations have reported the surgical outcomes of an isolated supraglottoplasty or supraglottoplasty following T&A; however, there is a lack of research examining T&A with concurrent supraglottoplasty.[17-20] At our institution, otolaryngologists have been performing T&A with concurrent supraglottoplasty (T&A+S) for children with DS, OSA, inspiratory stridor and overt laryngomalacia. More recently, if the larynx has anatomical changes consistent with laryngomalacia (i.e. short aryepiglottic folds and an omega shaped epiglottis) along with OSA, a T&A+S is offered to the family.

The objective of this investigation was to assess whether the addition of a supraglottoplasty to a T&A for children with DS and OSA would improve PSG outcomes better than T&A alone.

Methods

Participants

The Colorado Multiple Institutional Review Board (COMIRB) reviewed and approved this research study (COMIRB #: 19-2031). Clinical charts were identified through a retrospective search of the electronic medical record by diagnostic and procedural codes and confirmed by chart review. The investigational group included children who had a diagnosis of Down syndrome and underwent T&A with concurrent supraglottoplasty (T&A+S) between January 2012 – May 2020. The control group were children with Down syndrome who underwent T&A alone, between 2009 – 2015. The T&A+S cohort were matched 1:2 to individuals with T&A alone via nearest neighbor propensity score based on age at surgery, pre-PSG weight status, OSA severity, presence of congenital heart anomalies, pulmonary hypertension, history of pneumonia, and hypothyroidism. Children were included if they had both preoperative and postoperative

PSGs within 12 months of the date of surgery and did not have any other sleep surgery within the two PSG dates.

Measures

Demographic information collected for each participant included age, sex, ethnicity, prematurity, medical comorbidities and dates associated with PSG and surgery. Height and weight were collected at each time-point. Weight status was determined via weight for age percentile for children 24 months or younger at preoperative PSG, and via BMI for age/sex percentile for those older than 24 months at initial PSG. Obesity was defined as weight for age percentile or BMI for age percentile greater than the 95th percentile. The polysomnographic measures collected included: obstructive apnea-hypopnea index (OAHI), total sleep time (TST), mean heart rate for TST, mean awake SpO2, mean asleep SpO2, SpO2 nadir, hypoxemia i.e. ≥2% percent of TST with SpO2 <90%, and mean end-tidal carbon dioxide (EtCO2) for TST. The data was collected from PSG reports and recorded in a secure REDCap database.[21] OSA severity was defined by OAHI: mild = OAHI 1 - 4.9 events/hr, moderate = OAHI 5 - 9.9 events/hr, severe = OAHI ≥10 events/hr.

Statistical Methods

Demographic and clinical characteristics were compared using two-sample t-tests, Wilcoxon Rank-Sum tests, or chi-squared tests for continuous, non-normally distributed continuous, and categorical variables respectively. Shapiro-Wilks test was used to test for normality of continuous variables. Percent change in relevant PSG results prior to and following surgery were modeled via linear regression on surgery type, adjusting for age and weight status at initial PSG. As the percent change in variables was not normally distributed, a cubic root transformation was used prior to modeling. All values were back transformed prior to reporting estimates.

Significance for all testing was set at alpha 0.05. R version 3.4.1 software (R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/) was utilized.

Results

Between 2009 and 2015, 278 children with DS underwent T&A at our institution. Of those, 88 (32%) met inclusion criteria for matching to the group who underwent T&A+S. A total of 66 (N = 22 T&A+S, N = 44 T&A alone) individuals were included in the analysis. Two patients in the TA=S group had upper respiratory symptoms at their initial postoperative PSG, and thus had repeat PSGs that were used in analysis. The mean age was 4.3 years (SD 4.1) and the median (IQR) age at surgery was 2.5 (1.9, 5.2) years. There were 31 (47%) female subjects. **Table 1** describes the demographics and comorbidities of each group. A larger proportion of children in the T&A+S cohort were under 2 years old at time of preoperative PSG (n=15, 68%) than in the T&A alone group (n=13, 30%), even after matching (p = 0.006). Similarly, even after matching on weight category, children in the T&A+S group tended to be smaller than those who had T&A only, with the median weight category percentiles at surgery of 10.4 (4.1, 35.7) and 37.8 (9.1, 75.8) respectively (p = 0.07).

There was no significant difference in length of stay between the two groups; overall median (IQR) length of stay was 1.0 (1.0, 2.0) days. There were no respiratory complications in the T&A+S group.

Figure 1 highlights the preoperative and postoperative PSG findings. On preoperative PSG for both groups, no child had mild OSA and 82% had severe OSA. Postoperatively, sixteen children (73%) in the T&A+S group had an OAHI < 5 events/hour. The median decrease in OAHI for

this group was 86.6% (IQR -92.6%, -63.6%). The postoperative OAHI improved to < 5 events/hour for 24 (55%) of the T&A alone group. There was a median decrease of 68.2% (IQR -89.5%, -38.4%) in OAHI from preoperative to postoperative PSG in this group. **Table 2** compares preoperative and postoperative PSG measures for both groups. There was no statistical difference for T&A+S compared to T&A alone for the following comparisons: percent of children with postoperative OAHI < 5 events/hour ($p = 0.25$) or median percent change in OAHI pre-op to post-op ($p = 0.14$) There was also no effect of group on OAHI percent change after adjusting for age and size differences in a regression analysis ($p = 0.69$). Furthermore, an analysis of the additional PSG measurements from table 2 did not show any significant change postoperatively between groups ($p > 0.05$).

Discussion

OSA is estimated to affect 30-66% of children with DS.[1,2] Unfortunately, the success of T&A alone is suboptimal. Predisposing anatomical risk factors within this population, as well as other comorbidities including thyroid dysfunction and obesity, all contribute to the higher rate of OSA.[3] Occult laryngomalacia may be playing a role as well. In a retrospective case series by Chan et al of 22 children who underwent supraglottoplasty for OSA and occult laryngomalacia, both with and without prior T&A, 91% had an improvement in AHI following supraglottoplasty.[18] The senior author of the current study elected to start performing supraglottoplasty concurrently with T&A for children with DS and OSA who were found to have a larynx consistent with laryngomalacia since the cure rate for T&A alone is low.

More recently, drug induced sleep endoscopy (DISE) is being performed in children with persistent OSA after T&A to evaluate for other sites of upper airway obstruction that cannot be

visualized on a routine physical exam.[11,22] DISE-directed surgery, such as lingual tonsillectomy, tongue base reduction and supraglottoplasty may then be performed as indicated. Especially for younger children, the surgical options to alleviate persistent OSA are more limited. The mean age for both lingual tonsillectomy (9.3 – 14.2 years) and posterior tongue base reductions (5 – 13.1 years) are higher .[9,10,23, 24] Most of the children in our cohort at the time of surgery were younger than 5 years of age and subsequently only a candidate for a supraglottoplasty. Although positive pressure ventilation (PPV) is effective for those children who can tolerate it, PPV has the potential risk of affecting craniofacial development.[25] Since children with DS already have maxillary hypoplasia, one needs to be cognizant that PAP may exacerbate the hypoplasia. Furthermore, adherence to PAP among pediatric patients is suboptimal and thus other treatment options must be explored.[26,27]

Although our cohort showed no statistically significant difference between the T&A+S and T&A alone groups, the T&A+S group was trending towards more successful outcomes with approximately 75% of these children either being cured or only having mild OSA. Of note, the interquartile range for the T&A+S cohort was narrower which suggests that surgical outcomes were more consistent. Children with DS who undergo T&A alone have approximately 50% mean reduction in OAHI from preoperative to postoperative PSG;[6] children in our cohort who underwent T&A and supraglottoplasty had a median 87% reduction in OAHI.

In the risk/benefit analysis one needs to factor in the morbidity associated with the procedure. Fortunately, supraglottoplasty's complication rate is low.[28,29] None of the patients in the T&A+S group had any respiratory complications and there was no significant difference in length of hospitalization between the T&A+S and T&A alone groups. In summary, there was no additional morbidity associated with performing a concurrent supraglottoplasty.

The primary limitations of this study are the small size of T&A+S cohort and that the T&A+S children were younger. Additionally, the anatomical characteristics of the larynx for children in the control group were not collected. It is unknown if all the children in the control group would have been candidates for a concurrent supraglottoplasty. We recognize that the outcomes of T&A for OSA in children with DS are often suboptimal. A lower threshold to perform an endoscopic examination of the upper airway either in clinic and/or DISE at the time of a T&A will identify children who may benefit from adjuvant surgery in addition to a T&A. Potentially, a lower threshold to perform concurrent surgery may minimize the needs for additional anesthetics, surgical procedures or medical management for these children. Specific strengths of this study include PSG testing within 12 months of surgery and 2:1 matching with the control group. Since the age of the children and OAHI was not normally distributed, the median rather than mean values were reported.

In conclusion, a concurrent supraglottoplasty for those children who have a “tight” larynx may optimize airway patency. More research is necessary to assess long-term outcomes following concurrent T&A+S; however, given the minimal risks and the potential benefits one should discuss performing a concurrent supraglottoplasty in addition to T&A for these children.

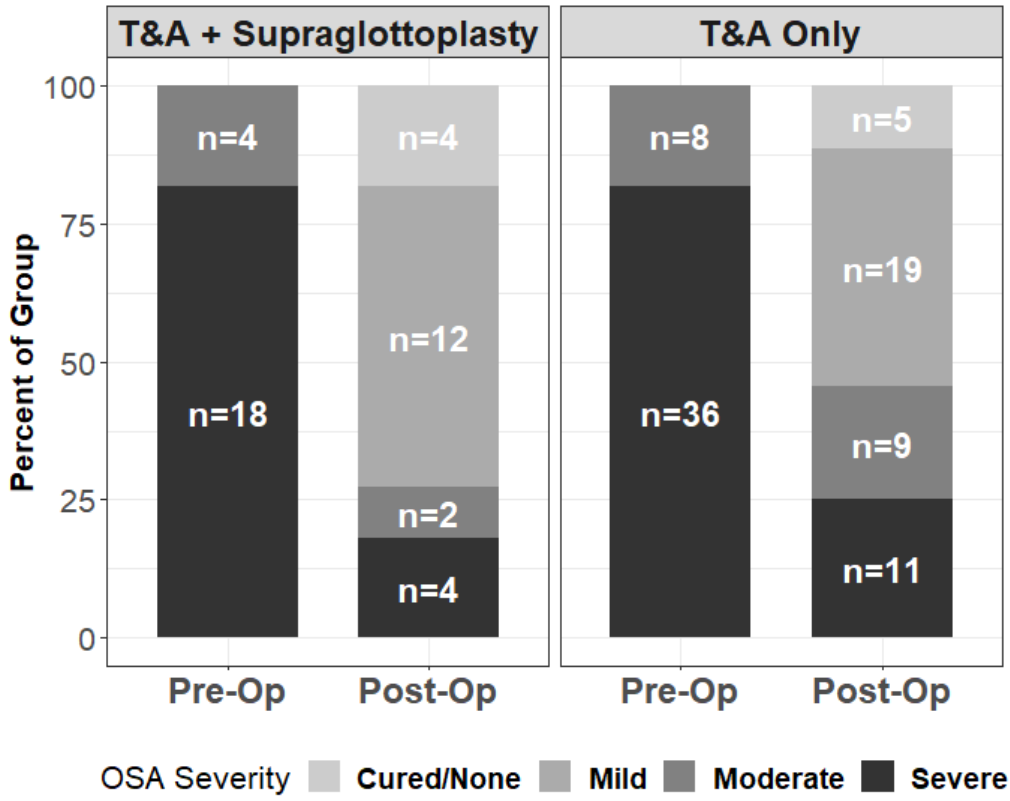

Figure 1. Differences in Pre-Operative and Post-Operative OSA severity by surgery type.

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Table 1. Patient Demographics and Comorbidities

	T&A+S (N=22)	T&A Alone (N=44)	Total (N=66)	p value
Age Category at Pre-Op PSG				0.006
Under 2 years	15 (68.2%)	13 (29.5%)	28 (42.4%)	
Sex				0.337
Male	14 (63.6%)	21 (47.7%)	35 (53.0%)	
Female	8 (36.4%)	23 (52.3%)	31 (47.0%)	
Race/Ethnicity				
White	11 (50.0%)	18 (40.9%)	29 (43.9%)	
Hispanic or Latino	7 (31.8%)	19 (43.2%)	26 (39.4%)	
Black/African American	1 (4.5%)	1 (2.3%)	2 (3.0%)	
Asian	0 (0.0%)	1 (2.3%)	1 (1.5%)	
More than One Race	3 (13.6%)	4 (9.1%)	7 (10.6%)	
Other	0 (0.0%)	1 (2.3%)	1 (1.5%)	
Premature?				0.587
No	15 (68.2%)	33 (75.0%)	48 (72.7%)	
Yes	7 (31.8%)	10 (22.7%)	17 (25.8%)	
Unknown	0 (0.0%)	1 (2.3%)	1 (1.5%)	
Comorbidities				

Congenital Cardiac Anomalies	13 (59.1%)	27 (61.4%)	40 (60.6%)
Pulmonary Hypertension	5 (22.7%)	6 (13.6%)	11 (16.7%)
History of Pneumonia	5 (22.7%)	8 (18.2%)	13 (19.7%)
Hypothyroidism	6 (27.3%)	3 (6.8%)	9 (13.6%)

Table 2. Changes in polysomnographic measures (Median (IQR)).

	T&A+S (N=22)	T&A Alone (N=44)	p value
Mean SpO2% Wake			
Pre-op	94.6 (93.4, 95.1)	93.9 (92.6, 95.8)*	0.84
Post-op	95.0 (93.8, 96.1)	94.3 (93.3, 95.4)	0.15
Mean SpO2% TST			
Pre-op	93.5 (91.7, 94.1)	92.3 (91.0, 93.8)	0.30
Post-op	94.5 (92.4, 95.8)	93.3 (92.1, 94.7)	0.18
Min SpO2% TST			
Pre-op	77.0 (74.5, 82.0)	80.0 (72.8, 83.3)	0.49
Post-op	83.5 (78.3, 88.0)	82.0 (79.0, 85.0)	0.39
>2% sleep time <90% SpO2			
Pre-op	17 (77.3%)	35 (79.5%)	1.000
Post-op	8 (36.4%)	20 (45.5%)	0.660
OAHI			
Pre-op	19.7 (12.1, 31.7)	16.2 (10.7, 28.9)	0.53
Post-op	3.4 (2.0, 6.7)	4.0 (2.3, 9.4)	0.25

Mean EtCO2 TST			
Pre-op	42.0 (40.3, 44.0)	43.1 (40.3, 46.0)**	0.25
Post-op	41.0 (40.0, 44.0)	44.0 (41.8, 45.0)	0.05
Mean Heart Rate TST			
Pre-op	102.5 (96.4, 107.5)	94.7 (83.5, 104.6)	0.05
Post-op	95.4 (89.4, 98.9)	88.0 (82.9, 98.8)	0.06
Total Sleep Time TST			
Pre-op	335.4 (267.8, 389.0)	339.4 (279.9, 378.0)	0.90
Post-op	443.0 (376.5, 477.0)	374.5 (333.8, 457.6)	0.15

***** N=44, data not available for 2 subjects

** N=41, data not available for 3 subjects