Intracapsular and Extracapsular Tonsillectomy and Adenoidectomy in Pediatric Obstructive Sleep Apnea

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IMPORTANCE Limited information exists regarding clinical outcomes of children undergoing extracapsular tonsillectomy and adenoidectomy (ETA) or intracapsular tonsillectomy and adenoidectomy (ITA) for treatment of obstructive sleep apnea syndrome (OSAS).

OBJECTIVES To quantify polysomnography (PSG) and clinical outcomes of ETA and ITA in children with OSAS and to assess the contribution of comorbid conditions of asthma and obesity.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study using medical records at a tertiary pediatrics inner-city hospital. Medical records from 89 children who underwent ETA or ITA between October 1, 2008, and December 31, 2013, were analyzed. The dates of our analysis were January 6, 2014, to April 11, 2014. Inclusion criteria required no evidence of craniofacial or neurological disorders, confirmation of OSAS by PSG within the 2 years before surgery, and a second PSG within the 2 years after surgery.

INTERVENTIONS Each child underwent ETA or ITA after being evaluated by a pediatric otolaryngologist and obtaining written parental informed consent.

MAIN OUTCOMES AND MEASURES Main primary outcomes were derived from PSG. Secondary outcomes included treatment failure, defined as residual OSAS with an obstructive apnea-hypopnea index of at least 5 events per hour. Comparisons were made between and within groups. Logistic regression was used to identify factors associated with treatment failure.

RESULTS Fifty-two children underwent ETA, and 37 children underwent ITA. Children in the ETA group were older (7.5 vs 5.2 years, \( P = .001 \)) and more obese (60% [31 of 52] vs 30% [11 of 37], \( P = .004 \)). However, both groups had similar severity of OSAS, with median preoperative obstructive apnea-hypopnea indexes of 17.0 in the ETA group and 24.1 in the ITA group (\( P = .21 \)), and similar prevalences of asthma (38% [20 of 52] vs 38% [14 of 37]). After surgery, significant improvement was noted on PSG in both groups, with no differences in any clinical outcomes. There was no association between procedure type, age, or body mass index \( z \) score and treatment failure. However, in a subset of patients with asthma and obesity, ITA was associated with residual OSAS (odds ratio, 16.5; 95% CI, 1.1-250.2; \( P = .04 \)).

CONCLUSIONS AND RELEVANCE Both ETA and ITA are effective modalities to treat OSAS, with comparable surgical outcomes on short-term follow-up. However, when comorbid diagnoses of both asthma and obesity exist, OSAS is likely to be refractory to treatment with ITA compared with ETA.
Obstructive sleep apnea syndrome (OSAS) is characterized by recurrent episodes of partial or complete upper airway obstruction, with disruption in normal sleep patterns and ventilation during sleep.1 The estimated prevalence of OSAS among children is approximately 1% to 5%.2 Untreated OSAS in children leads to cardiovascular and metabolic morbidities, cognitive and learning deficits, and behavioral problems,2-9 which underscores the importance of sleep in childhood and the need for effective treatment of OSAS.

In children, anatomical factors such as adenotonsillar hypertrophy, craniofacial anomalies, or obesity and functional factors such as abnormal neuromuscular tone contribute to OSAS. However, adenotonsillar hypertrophy is considered the most common cause of childhood OSAS,10 and adenotonsillectomy is the first line of treatment.7 Despite the frequency with which this procedure is performed, there remains debate as to which surgical technique is optimal. Intracapsular tonsillectomy and adenoidectomy (ITA) is often recommended as an alternative to traditional extracapsular tonsillectomy and adenoidectomy (ETA). Most tonsillar tissue is removed in ITA, while leaving a thin rim of lymphoid tissue in the tonsillar fossae. This technique hypothetically minimizes risk of surgical damage to the underlying musculature and deeper neurovascular structures.11 Compared with ETA, ITA is associated with less postoperative pain and analgesic use, quicker return to normal activity, and reduced rates of complications.12-15

Two meta-analyses16,17 that used an apnea-hypopnea index on postoperative polysomnography (PSG) to objectively define cure reported the success rate of adenotonsillectomy to be 60% to 80% when not controlling for surgical technique. Brietzke and Gallagher16 reported a success rate of 82.9%, but the definition of treatment success varied from a postoperative apnea-hypopnea index of 0.5 to 5 events per hour. When cure was defined as an apnea-hypopnea index of less than 5 events per hour, Friedman and colleagues17 found that the estimated success rate with adenotonsillectomy was 66.2%. The latter study included nonobese and obese children, more accurately representing the population undergoing adenotonsillectomy for treatment of OSAS today. In addition to obesity, black race/ethnicity, asthma, and older age contribute to failure of adenotonsillectomy.18,19

Regarding ITA, there is concern about whether the small amount of tonsillar tissue left behind with this procedure contributes to residual OSAS.20 Studies21,22 of small cohorts of children who had documented OSAS on preoperative PSG and underwent ITA have shown resolution of OSAS after surgery. However, these studies were limited by small sample size, exclusion of patients with obesity, and absence of comparison with patients undergoing ETA.

The objective of our study was to compare the PSG outcomes before and after ETA and ITA in children with OSAS. Our hypothesis was that children with adenotonsillar hypertrophy and OSAS undergoing ETA would have a greater degree of improvement in their postoperative obstructive apnea-hypopnea index (oAHI) compared with those undergoing ITA. Our secondary aim was to compare the rate of treatment failure, defined as a postoperative oAHI of at least 5 events per hour, between groups when controlling for the common comorbidities of asthma and obesity.

Methods

This study was approved by the Institutional Review Board at Albert Einstein College of Medicine. Each child underwent ETA or ITA after being evaluated by a pediatric otolaryngologist (M.G., J.P.B., and 2 additional physicians) and obtaining written parental informed consent.

Patient Characteristics

This retrospective, cross-sectional study investigated children 2 to 18 years old who underwent ETA or ITA for treatment of OSAS at The Children’s Hospital at Montefiore between October 1, 2008, and December 31, 2013. The dates of our analysis were January 6, 2014, to April 11, 2014. To meet inclusion criteria, individuals had to have undergone baseline PSG within the 2 years before surgery and a second baseline PSG within the 2 years after surgery. All participants had normal development and intact tonsils and adenoids.

We performed a search of our institution’s computerized medical records system using an interactive software application (Clinical Looking Glass, version 3.3; CLG). Data were extracted using billing codes for adenotonsillectomy and PSG. The initial search yielded 146 patients, and a detailed medical record review was conducted to collect demographic information and medical history. Fifty-seven patients did not fulfill inclusion and exclusion criteria. The most common reasons for exclusion from the study were the presence of comorbid neurological or genetic disorders or the absence of a baseline PSG.

A data sheet template was used for data extraction, including patient demographics and surgical and PSG information. Body mass index (BMI) z score was computed using the Centers for Disease Control and Prevention 2000 growth charts for patients 2 to 18 years old.23 A BMI z score of at least 2 fulfilled obesity criteria.24,25

Adenotonsillectomy

Tonsil size was determined using the grading system by Brodsky.26 A pediatric otolaryngologist (M.G., J.P.B., and 2 additional physicians) made the decision about the need for and the type of surgery as part of routine care. The option to have ETA or ITA performed was presented to all parents, along with risks and benefits of each procedure. The otolaryngologists at The Children’s Hospital at Montefiore tend to recommend ETA when children have coexistent recurrent tonsillitis or when physical examination shows tonsil tissue situated lateral to the tonsil pillars. Likewise, they prefer to recommend ITA in younger patients who are more vulnerable to the higher rates of pain and bleeding associated with ETA. Ultimately, it was each parent’s decision to have ETA or ITA performed. There were 4 otolaryngologists (M.G., J.P.B., and 2 additional physicians) performing the procedures, often with involvement of residents, who were closely supervised to assure a consistent, high-quality procedure. The surgeons used coblation or...
monopolar electrocautery to perform extracapsular tonsillectomy. Intracapsular tonsillectomy was performed using a microdebrider.

**Overnight PSG**

Initial referral for overnight PSG was made by a pediatric pulmonologist (K.N., R.A., and 4 additional physicians), pediatric otolaryngologist (M.G., J.P.B., and 2 additional physicians), or primary care physician for patients in whom there was concern about sleep-related breathing disorder. The decision to refer a patient for PSG before consideration of adenotonsillectomy was based on the individual health care professional’s discretion. Recommendations for follow-up PSG after adenotonsillectomy are generally made by a pediatric sleep physician interpreting the initial PSG.

Overnight PSG (Natus SleepWorks 7.1.1.; Xltek) was performed at the Sleep Disorders Center at The Children’s Hospital at Montefiore. Sleep staging and scoring of arousals and respiratory events were performed per standard criteria. Obstructive sleep apnea syndrome and the severity of OSAS were defined using standard criteria of an obstructive apnea index of at least 1 event per hour or an oAHI of at least 2 events per hour. Patients were classified as having a normal study result with an oAHI of less than 2 events per hour, mild OSAS with an oAHI of at least 2 but less than 5 events per hour, moderate OSAS with an oAHI of at least 5 but less than 10 events per hour, and severe OSAS with an oAHI of at least 10 events per hour. We defined treatment failure as a postoperative oAHI of at least 5 events per hour.

**Statistical Analysis**

Statistical analysis was conducted using software programs (MATLAB; The MathWorks, Inc and SPSS, version 21; SPSS Inc). Medians and interquartile ranges were used to summarize non-normally distributed, continuous variables. For comparisons of medians within groups, Wilcoxon paired signed rank test and Fisher exact test were used, as appropriate. For comparisons of medians between groups, Mann-Whitney test, Pearson χ² test, and Fisher exact test were used, as appropriate. Logistic regression was used to estimate odds ratios and 95% CIs of treatment failure for operative procedure while adjusting for preoperative oAHI, age, and BMI z score. An unadjusted model was constructed for the small subset of children with both asthma and obesity. P < .05 was considered statistically significant.

**Results**

**Patient Characteristics**

Of the 89 patients who met inclusion criteria, 52 had undergone ETA, and 37 had undergone ITA. The patient characteristics are summarized in Table 1. There were no significant differences between groups by sex, race/ethnicity, or comorbid diagnosis of asthma. Compared with the ITA group, the ETA group was significantly older (7.5 vs 5.2 years, P = .001), contained more patients with obesity (60% [31 of 52] vs 30% [11 of 37], P = .004), and had a higher median BMI z score (2.22 vs 1.66, P = .01).

**Clinical Outcomes**

There were no significant differences between the ETA and ITA groups in clinical outcomes. These included the time taken to perform the procedure, estimated blood loss, complication rate, admission rate, emergency department visits, and length of stay.

**Overnight PSG**

For baseline and preoperative PSG, there was no significant difference between the ETA and ITA groups when comparing PSG variables, except for a slightly higher peak end-tidal carbon dioxide in the ITA group (Table 2). Although both groups had more patients with severe OSAS, there was no significant difference between groups in regard to the distribution of mild, moderate, and severe disease (P = .14).

After surgery, follow-up PSG was performed at medians of 149 days (interquartile range, 90.8-258.8 days) and 136 days (interquartile range, 92.0-236.5 days) in the ETA and ITA groups, respectively (P = .80). There was no difference between the ETA and ITA groups when comparing PSG variables and no difference between groups in the distribution of the severity of disease (P = .63). In both the ETA and ITA groups, there was a significant reduction in the oAHI after surgery compared with preoperative values (P < .001 for both) (Figure).

### Table I. Patient Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>ETA (n = 52)</th>
<th>ITA (n = 37)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex, No. (%)</td>
<td>33 (64)</td>
<td>19 (51)</td>
<td>.25a</td>
</tr>
<tr>
<td>Age, median (IQR), y</td>
<td>7.5 (5.2-13.1)</td>
<td>5.2 (2.8-7.3)</td>
<td>.001a</td>
</tr>
<tr>
<td>BMI, median (IQR)</td>
<td>27.7 (18.0-37.6)</td>
<td>19.0 (16.2-23.2)</td>
<td>.002a</td>
</tr>
<tr>
<td>BMI z score, median (IQR)</td>
<td>2.22 (1.17-2.71)</td>
<td>1.66 (0.25-2.26)</td>
<td>.01a</td>
</tr>
<tr>
<td>Obesity, No. (%)</td>
<td>31 (60)</td>
<td>11 (30)</td>
<td>.004a</td>
</tr>
<tr>
<td>Asthma, No. (%)</td>
<td>20 (39)</td>
<td>14 (38)</td>
<td>.95a</td>
</tr>
<tr>
<td>Race/ethnicity, No. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>13 (25)</td>
<td>11 (30)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>30 (58)</td>
<td>21 (57)</td>
<td>.83a</td>
</tr>
<tr>
<td>Other</td>
<td>9 (17)</td>
<td>5 (14)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); ETA, extracapsular tonsillectomy and adenoidectomy; IQR, interquartile range; ITA, intracapsular tonsillectomy and adenoidectomy.

a Pearson χ² test. 
bMann-Whitney test.
Table 2. Intergroup and Intragroup Comparisons of Preoperative and Postoperative Clinical and Polysomnography Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>ETA (n = 52)</th>
<th>ITA (n = 37)</th>
<th>P Value for ETA Preoperative vs Postoperative</th>
<th>P Value for ITA Preoperative vs Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative or postoperative time, median (IQR), d</td>
<td>113.5 (51.8-216.8)</td>
<td>149.0 (90.8-258.8)</td>
<td>NA</td>
<td>107.0 (41.0-172.0)</td>
</tr>
<tr>
<td>Total sleep time, median (IQR), min</td>
<td>387.0 (333.5-425.6)</td>
<td>381.8 (322.9-418.3)</td>
<td>.67b</td>
<td>383.0 (320.5-431.0)</td>
</tr>
<tr>
<td>Sleep efficiency, median (IQR), %</td>
<td>84.1 (70.8-89.7)</td>
<td>86.3 (78.1-92.7)</td>
<td>.03b</td>
<td>86.9 (73.9-90.9)</td>
</tr>
<tr>
<td>Arousal index, median (IQR)</td>
<td>17.3 (11.2-28.2)</td>
<td>8.1 (5.9-12.2)</td>
<td>&lt;.001b</td>
<td>19.8 (10.5-35.0)</td>
</tr>
<tr>
<td>Obstructive apnea index, median (IQR)</td>
<td>0.8 (0.0-3.8)</td>
<td>0.0 (0.0-0.1)</td>
<td>&lt;.001b</td>
<td>1.5 (0.4-4.6)</td>
</tr>
<tr>
<td>Central apnea index, median (IQR)</td>
<td>0.6 (0.2-2.1)</td>
<td>0.3 (0.0-0.8)</td>
<td>&lt;.001b</td>
<td>1.0 (0.2-3.2)</td>
</tr>
<tr>
<td>oAHI, median (IQR)</td>
<td>17.0 (6.9-37.0)</td>
<td>1.7 (0.5-3.3)</td>
<td>&lt;.001b</td>
<td>24.1 (10.5-38.9)</td>
</tr>
</tbody>
</table>

| oAHI events/h, No. (%)                   | <2 | 0 | 31 (60) | 0 | 23 (62) | .001b | <.001b | .14 | .63 |
|                                          | ≥2 but <5 | 8 (15) | 10 (19) | <.001b | 1 (3) | 5 (14) | <.001b | .14 | .63 |
|                                          | ≥5 but <10 | 8 (15) | 5 (10) | 6 (16) | 2 (5) | <.001b | .40 | .78 |
|                                          | ≥10 | 36 (69) | 6 (12) | 30 (81) | 7 (19) | 36 (69) | 6 (12) | 30 (81) | 7 (19) |

| Baseline oxygen, median (IQR), %         | 99.0 (98.0-100.0) | 100.0 (99.0-100.0) | .03b | 100.0 (98.0-100.0) | 100.0 (99.0-100.0) | .07b | .91 | .50 |

| Oxygen nadir, No. (%)                    | 90%-100% | 13 (25) | 32 (62) | 5 (14) | 24 (65) | <.001c | 13 (35) | 10 (27) | <.001c | .40 | .78 |
|                                          | 80%-89% | 18 (35) | 17 (33) | <.001c | 13 (35) | 10 (27) | <.001c | .40 | .78 |
|                                          | ≤79% | 21 (40) | 3 (6) | 19 (51) | 3 (8) | 21 (40) | 3 (6) | 19 (51) | 3 (8) |

| End-tidal carbon dioxide, median (IQR), mm Hg | 41.0 (36.0-45.0) | 41.0 (36.0-44.0) | .79b | 40.0 (36.0-43.5) | 40.0 (34.0-44.0) | .44b | .60 | .80 |
|                                                | 52.0 (47.0-55.0) | 51.0 (48.0-53.0) | .18b | 53.0 (51.5-58.0) | 50.0 (47.0-52.0) | <.001b | .05 | .52 |

Abbreviations: ETA, extracapsular tonsillectomy and adenoidectomy; ITA, intracapsular tonsillectomy and adenoidectomy; NA, not applicable; oAHI, obstructive apnea-hypopnea index.

Subanalysis
Regression analysis was performed to determine if there was any association between treatment failure and independent variables such as procedure type (ETA or ITA), age, preoperative oAHI, and obesity. Of the 88 patients who had a calculated BMI z score, this model showed that 20 patients had treatment failure. There was no significant association between procedure type, age, or BMI z score and treatment failure. This model had a Cox and Snell R² = 0.166 and a Nagelkerke R² = 0.253. The model showed no significant association with procedure type irrespective of whether the oAHI cutoff values were at least 2, 3, 4, or 5 events per hour.

An additional unadjusted regression analysis was performed to determine if having comorbid diagnoses of asthma and obesity was associated with treatment failure. Of the 88 patients, 71 (81%) did not have both comorbid diag-
In those patients without asthma and obesity, there was no significant association between procedure type and postoperative oAHI irrespective of whether the oAHI cutoff value was at least 2, 3, 4, or 5 events per hour.

Discussion

Increasingly, OSAS is becoming recognized as a cause of significant morbidity in children, and inadequate treatment of OSAS remains a challenging health concern. Our study showed that patients undergoing ETA or ITA had similar results in terms of treating their OSAS. Both groups of patients had significant improvement in almost all postoperative PSG measures. There were demographic differences between the ETA and ITA groups in that patients undergoing ETA were older and had a higher BMI z score, which may be partially reflective of the criteria used by the otolaryngologists at The Children’s Hospital at Montefiore to recommend ETA or ITA. However, no consistent criteria are used to determine this stratification, and the decision to perform either procedure is ultimately made after an informed discussion with the parent.

We found no clinically meaningful differences in surgical outcomes when comparing children who underwent ETA vs ITA for treatment of OSAS. It has been reported that ITA has a lower rate of complications, but the rate was not lower in our study, likely because of the small sample size and the fact that the ITA group contained younger children, whose parents are likely to seek out the acute postoperative care their children merit.

This study demonstrates that ITA may be an adequate option for otherwise healthy children. However, a true assessment of equivalency requires the assessment of outcomes in many more patients. Furthermore, this investigation was a retrospective study, and our study population likely had more severe or more insidious disease that is more likely to be refractory to treatment with ETA or ITA and warranted both preoperative and postoperative PSG for further evaluation. Also, unlike prior investigations comparing surgical techniques for adenotonsillectomy in treating OSAS, we did not exclude patients with obesity, who are known to have worse surgical outcomes. In this context, the results of this study suggest that ITA may be an option even in those patients with severe disease or obesity.

To further examine this finding, we conducted a regression analysis to identify what patient characteristics are associated with treatment failure. We found that patients who have a comorbid diagnosis of asthma and obesity are more likely to be refractory to treatment with ITA compared with ETA. This analysis was repeated using additional postoperative oAHI cutoffs, and the results approached significance as the oAHI cutoff was increased from at least 2 to at least 4 events per hour. This finding needs further investigation. While this study had few patients, a larger study may identify differences in procedure outcomes even for lower postoperative oAHI values.

One reason why ETA may be a more successful procedure in patients with obesity is that these individuals have increased neck adiposity and greater volume of the soft palate and tongue, which may restrict the size of the airway during sleep. Therefore, the small amount of residual lymphoid tissue left after ITA may be enough to compromise the airway. While individual response to ETA or ITA is likely multifactorial, an important tool that may help determine which...
procedure is best suited for each patient is sleep endoscopy. A study of sleep endoscopy findings among patients with obstructive sleep apnea found that children with small tonsils (grades 1 to 2) can still have significant lateral pharyngeal collapse, leading to airway obstruction. These patients may be better candidates for ETA because they are at increased risk of having a suboptimal response to ITA because tonsillar hypertrophy in itself is not the only factor contributing to airway obstruction.

The role of a diagnosis of asthma in our patients is particularly notable because several investigations have recently implicated a link between OSAS and asthma. Indeed, our baseline prevalence rates of asthma among both the ETA and ITA groups (38% [20 of 52] and 38% [14 of 37], respectively) are much higher than the national average of 9.3% reported by the Centers for Disease Control and Prevention or the 15.5% reported from a school-based sample of children in the Bronx, New York. Several studies have confirmed that patients with asthma are more likely to develop symptoms of OSAS. A recent study also found that after adenotonsillectomy, children with asthma had a significant reduction in asthma exacerbation, hospitalization, and emergency department visits. Based on our results, it would be relevant to identify if there was any variance in resolution of asthma symptoms according to the specific type of surgical technique for adenotonsillectomy that was performed. Similar to obesity, the residual tissue left in patients with asthma after ITA may be enough to compromise or obstruct the upper airway even during wakefulness, which could lead to a worsening of asthma symptoms when combined with an exacerbation that is also causing significant lower airway obstruction.

Obesity, asthma, and tonsillar hypertrophy are independent risk factors for the development of OSAS. When coexistent, the additive effects of these disorders can contribute to OSAS treatment failure and may warrant a multidisciplinary treatment approach that includes weight loss to reduce hypoventilation during sleep, optimization of asthma control to minimize chronic lung disease, and ETA to decrease airway restriction. Our study highlights the importance of taking into consideration a diagnosis of asthma and obesity when planning for adenotonsillectomy and identifying an appropriate surgical intervention in those patients who are at greatest risk of being refractory to treatment of OSAS with adenotonsillectomy. Ultimately, adequate treatment of OSAS requires targeting not only tonsillar hypertrophy but also each individual’s predisposing conditions.

Aside from the study design, there are several limitations to our study. Because this study was performed at a teaching hospital, residents assisted in all adenotonsillectomies, which may affect surgical time, adequate removal of tissue, and the other outcomes. There were attending otolaryngologists supervising all procedures to ensure adequate results, and the effect of resident participation should be consistent across both groups for the purpose of making comparisons between procedures. Also, our rate of treatment success based on postoperative PSG in both the ETA and ITA groups (79% [41 of 52] and 76% [28 of 37], respectively) is still well above the reported average of 66.2%. Another limitation of our study is the short follow-up period. While this follow-up time allows us to more confidently state that changes in PSG variables are mostly attributable to surgical intervention, it limits us in knowing if these effects are maintained in the long term. This concern especially relates to ITA, in which there is an increased incidence of tonsillar regrowth in younger patients.

Conclusions

This study reinforces the findings that ETA and ITA have similar outcomes on short-term follow-up in treatment of OSAS in children and that both procedures remain adequate options in otherwise healthy children. To our knowledge, this study is the first to support performing ETA over ITA in patients with comorbid diagnoses of both asthma and obesity. However, these findings should be further examined using a prospective, randomized trial comparing ETA and ITA for OSAS. Long-term follow-up would also allow for better assessment of maintenance of treatment effects and evaluation for possible tonsillar regrowth requiring additional treatment.

Conflict of Interest Disclosures: None reported.

Previous Presentation: This study was previously presented as an abstract at the American Thoracic Society International Conference; May 18, 2014; San Diego, California.

REFERENCES


