Pediatric Primary Anterior Laryngotracheoplasty

Thyroid Ala vs Costal Cartilage Grafts

Carolyn V. Nguyen, MD; John P. Bent, MD; Maulik B. Shah, MD; Sanjay R. Parikh, MD

Objective: To compare outcomes with the use of thyroid ala cartilage (TAC) and costal cartilage (CC) grafts in pediatric primary anterior laryngotracheoplasty (LTP).

Design: Retrospective comparison study.

Setting: Tertiary, academic children's hospital.

Patients: Of 45 laryngotracheal operations performed between June 2001 and October 2008 for laryngotracheal stenosis, 29 were primary anterior LTPs. The procedures used either TAC (n=24) or CC (n=5) grafts and were planned as either single-stage (TAC group, 22 patients; CC group, 2 patients) or multistage (TAC group, 2 patients; CC group, 3 patients).

Main Outcome Measures: Operative time, length of intubation, graft-specific complications, need for additional airway procedures, and overall decannulation rate.

Results: The mean (SD) operative times were 222 (56) minutes for TAC grafts and 363 (59) minutes for CC grafts (P = .005). For single-stage LTPs that were decannulated, the mean (range) length of intubation was 3.3 (1-11) days for TAC grafts (n=18) and 3 (1-5) days for CC grafts (n=2) (P = .90). Graft-specific complications occurred in 17% of TAC grafts (n=4) and 20% of CC grafts (n=1) (α > 0.05). Symptomatic stenosis requiring additional surgical intervention occurred in 43% of TAC grafts (n=10) and 60% of CC grafts (n=3) (α > 0.05). Patients underwent decannulation in 83% of TAC grafts (n=19) and 80% of CC grafts (n=4) (α > 0.05).

Conclusions: In primary anterior LTPs, TAC grafts require significantly less operative time than CC grafts (P = .005). There were no statistically significant differences in length of intubation, frequency of graft-specific complications, or decannulation rates between TAC and CC grafts in primary anterior LTPs.


LARYNGOTRACHEOPLASTY (LTP) using a cartilage interpositional graft was first described by Fearon and Cotton in 1972 and has since become the most commonly accepted technique for the repair of established laryngotracheal stenosis (LTS) in children. In LTP, the surgeon divides the stenotic laryngotracheal segment in the sagittal plane and then expands and stabilizes the framework with autologous cartilage. Reported decannulation outcomes for single-stage and multistage LTP have ranged from 81% to 96%. Variations in technique include anterior or combined anterior-posterior augmentation using a graft commonly harvested from auricular, thyroid, or costal cartilage (CC).

A graft donor site is selected based on LTS severity and the required graft size and strength. Each graft donor site has advantages and disadvantages. Costal cartilage grafts can be harvested with the largest dimensions but carry the risk of additional morbidity from a second surgical site, including possible pneumothorax. Auricular cartilage grafts also have second surgical site morbidity and may lack the needed structural support.

Using thyroid ala cartilage (TAC) grafts for augmentation has several potential advantages. First, the ability to harvest a TAC graft through the same surgical incision required for LTP eliminates second surgical site morbidity and potentially reduces operative time. Second, the natural thickness of a TAC graft closely approximates the thickness of laryngotracheal cartilages, particularly the cross-sectional dimensions of the anterior cricoid cartilage, where it is most commonly applied. The better match in thickness theoretically reduces the risks of intratracheal graft prolapse and formation of granulation tissue. Thyroid ala cartilage grafts are limited

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in size according to the dimensions of the ala region and therefore cannot be used for posterior or large anterior laryngotracheal defects. Pharyngolaryngeal deformities have not been demonstrated when the internal perichondrium of the thyroid ala is left intact.9-11

Prior studies have reported outcomes with different reconstruction techniques and with different grafts, but, to our knowledge, they have not compared 2 different grafts for the same surgical approach.2-8,12 This study, which compares 2 different grafts for the same surgical approach, reduces the impact of confounding variables that can be introduced when a spectrum of airway abnormalities and reconstruction techniques are being compared. This study focused specifically on the outcomes of primary repair of LTS via anterior LTP using TAC and CC grafts. We hypothesized that the TAC group would demonstrate advantages over the CC group, including shorter operative times and a higher decannulation rate, which would further support its use for primary anterior LTP.

| Table 1. Types of Primary Anterior Laryngotracheoplasty Performed

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>TAC Group</th>
<th>CC Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-stage</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Multistage</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviations: CC, costal cartilage; TAC, thyroid ala cartilage.

| Table 2. Study Population

<table>
<thead>
<tr>
<th>Variable</th>
<th>TAC Group (n=24)</th>
<th>CC Group (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Age, mean (SD), mo</td>
<td>34.5 (35.7)</td>
<td>53.0 (36.9)</td>
</tr>
<tr>
<td>Weight, mean (SD), kg</td>
<td>11.5 (6.2)</td>
<td>14.2 (3.5)</td>
</tr>
</tbody>
</table>

Abbreviations: CC, costal cartilage; TAC, thyroid ala cartilage.

endoscopic airway interventions, need for postreconstruction airway procedures, comorbidities, and developmental history), and operative variables (surgeon, procedure, graft donor site and size, operative time, postoperative complications, length of intubation, and decannulation).

Previous endoscopic airway interventions were defined as endoscopic procedures, including laser and balloon dilations, excision of subglottic cysts, and excision of suprastomal granulation tissue but excluding diagnostic procedures and tracheotomy. Graft-specific complications included graft prolapse, graft dehiscence with tracheocutaneous fistula, graft resorption, pneumothorax, and wound abscess. Additional postreconstruction airway procedures were defined as endoscopic laser or balloon dilation procedures, repair of graft prolapse or dehiscence, and tracheotomy. The main outcome measures evaluated were operative time, length of intubation after single-stage reconstructions, graft-specific complications, need for additional airway procedures, and overall decannulation rate.

DATA ANALYSIS

The significant clinical variability between patients makes direct statistical comparison challenging. Clinical trends, however, could be observed and are therefore reported.

RESULTS

DEMOGRAPHICS

A total of 29 children underwent primary anterior LTP using either a TAC (n=24) or a CC (n=5) graft. The procedures were planned as either single-stage (TAC group, 22 patients; CC group, 2 patients) or multistage (TAC group, 2 patients; CC group, 3 patients) (Table 1). The TAC group consisted of 13 boys and 11 girls with a mean (SD) age of 34.5 (35.7) months and weight of 11.5 (6.2) kg. The CC group consisted of 3 boys and 2 girls with a mean (SD) age of 53.0 (36.9) months and weight of 14.2 (3.5) kg (Table 2). The mean (SD; range) period of operative or clinical follow-up was 15.1 (14.1; 1.7-54.2) months for the TAC group and 8.1 (2.2; 4.7-10.2) months for the CC group.

CAUSE AND SEVERITY OF STENOSIS

A history of prolonged or multiple intubations was the suspected cause of LTS in 71% (n=17) and 80% (n=4) of patients in the TAC and CC groups, respectively (Table 3). A congenital glottic web with subglottic extension accounted for 2 patients, 1 in each group. The remaining patients in the TAC group had a history of...
trauma (n = 1), bilateral subglottic hemangiomomas (n = 1), bilateral subglottic cysts (n = 1), and congenital subglottic stenosis (n = 3). Given the variable styles in documenting the severity of stenosis (estimated size of remaining airway vs degree of stenosis), it was observed that patients in the CC group generally had either more severely narrowed airways or longer airway stenoses.

PREOPERATIVE INTERVENTIONS

Fifty percent of the TAC group (n = 12) had a preexisting tracheotomy at the time of their LTP compared with 100% of the CC group (n = 5). Excluding tracheotomy, 12% of the patients in the TAC group (n = 3) underwent prior endoscopic airway interventions (excision of bilateral subglottic cysts [n = 1], laser dilation [n = 1], and balloon dilation with partial excision of suprastomal granulation tissue [n = 1]) compared with 0% in the CC group.

OPERATIVE VARIABLES

The mean (SD) total operative times were 222.4 (59.3) minutes and 363.2 (59.3) minutes for the TAC group and the CC group, respectively (P = .005) (Table 4). Graft size, when specified, varied in length from 6 to 20 mm and 20 to 40 mm for the TAC group and the CC group, respectively. In the TAC group, 25% (n = 6) of the patients had a known air leak at the graft site during closure of the anterior neck soft tissues compared with 0% in the CC group.

POSTOPERATIVE OUTCOMES

Of the 18 patients in the TAC group and the 2 patients in the CC group who successfully underwent single-stage LTP (including intraoperative decannulation when applicable), the mean (range) length of intubation was 3.3 (1-11) days and 3 (1-5) days, respectively (P = .90) (Table 4). Graft-specific complications occurred in 17% of the patients in the TAC group (n = 4) and 20% of the patients in the CC group (n = 1) (α > 0.05) (Table 4). In the TAC group, the complications included 2 dehiscence grafts with resulting tracheocutaneous fistulas, 1 graft prolapse, and 1 neck abscess. One death occurred in the TAC group because of worsening desaturations and cardiac arrest on postoperative day 1 despite a widely patent airway that was confirmed by endoscopic evaluation. No complications occurred at the donor site. In the CC group, 1 patient had multiple complications, including contralateral pneumothorax after positive pressure ventilation for postextubation respiratory distress, delayed graft prolapse, a delayed obstructing graft site granuloma, and keloid formation at the chest wall donor site.

Symptomatic stenosis requiring additional surgical intervention occurred in 44% of the patients in the TAC group (n = 10) and 60% of the patients in the CC group (n = 3) (α > 0.05) (Table 4). In the TAC group, 3 patients required repair of graft prolapse or dehiscence, 7 required serial endoscopic laser or balloon dilations, and 4 underwent postreconstruction tracheotomy. The 4 patients who underwent postreconstruction tracheotomy are still dependent on their tracheotomy tubes. In the CC group, 1 patient required serial endoscopic laser dilation, 1 required multiple repairs of graft prolapse and granulomas, and 1 never underwent decannulation because of dynamic complete suprastomal collapse. The overall decannulation rates were 83% in the TAC group (n = 19) and 80% in the CC group (n = 4) (α > 0.05) (Table 4).

At our institution, we use CC grafts for all cases selected for combined anterior-posterior LTP as well as for cases of long-segment anterior LTP, and we perform all shorter-segment anterior LTPs with TAC grafts. The differences in airway abnormalities that affect children will inherently introduce a selection bias indicating that children with more severe stenoses will undergo LTP with CC grafts and likely have worse prognoses than those with TAC grafts. While it is challenging to compare these patients retrospectively, we attempted to reduce the impact of preoperative differences in the patient populations by focusing on patients undergoing primary LTP (not revision or salvage procedures) who required only anterior augmentation. Our inclusion criteria subsequently reduced the number of patients included in the CC group as we used CC grafts primarily for patients requiring both anterior and posterior grafts. Our outcomes suggest that the mean operative time for TAC grafts (222.4 minutes) is significantly shorter than that for CC grafts (363.2 minutes) (P = .005). The mean difference of 140 minutes is likely attributable to several factors, including more time required to harvest a CC graft from a second surgical site and more time to carve and inset a CC graft, which we used for narrower or longer airway stenosis.

Table 4. Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>TAC Group (n=24)</th>
<th>CC Group (n=5)</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time, mean (SD), min</td>
<td>222.4 (59.3)</td>
<td>363.2 (59.3)</td>
<td>P = .005</td>
</tr>
<tr>
<td>Length of intubation for ssLTP, mean (range), d</td>
<td>3.3 (1-11)</td>
<td>3.0 (1-5)</td>
<td>P = .90</td>
</tr>
<tr>
<td>Graft-specific complications, %</td>
<td>17</td>
<td>20</td>
<td>α &gt; 0.05</td>
</tr>
<tr>
<td>Postoperative symptomatic stenosis, %</td>
<td>44</td>
<td>60</td>
<td>α &gt; 0.05</td>
</tr>
<tr>
<td>Decannulation rate, %</td>
<td>83</td>
<td>80</td>
<td>α &gt; 0.05</td>
</tr>
</tbody>
</table>

Abbreviations: CC, costal cartilage; ssLTP, single-stage laryngotracheoplasty; TAC, thyroid ala cartilage.
Graft-specific complications occurred in 17% of the TAC grafts and 20% of the CC grafts (α > 0.05), which is not statistically significant. Classification of graft-specific complications may be inaccurate in that complications such as infections, prolapse, and fistulas are most likely unrelated to the donor graft material. Naturally, TAC grafting avoids complications at a second site, such as a chest wall keloid.

Symptomatic stenosis requiring additional surgical intervention occurred in 44% of the patients in the TAC group and 60% of the patients in the CC group (α > 0.05). This difference is partially attributable to selection bias when the graft site is chosen, as there is a known trend toward more reimplantations and tracheotomies in children with more severe stenosis.6 Because our surgeons tended to use CC grafts for more severe stenosis, a higher rate of restenosis would be expected in this group.

The decannulation rates were comparable in the TAC (83%) and CC (80%) groups (α > 0.05). At the time of this study, most of the 5 children in whom decannulation failed were still actively undergoing evaluation. Revision procedures are planned in 2 children, and 1 child has a patent proximal airway after reconstruction but is awaiting aortopexy to address her severe distal tracheomalacia. One child remains tracheotomy dependent because of dynamic suprastomal collapse, and 1 child has moved out of our region but reportedly shows readiness for decannulation. We expect to have higher overall success rates with longer follow-up.

This study further supports the finding that TAC grafting is a viable option for pediatric LTP. In comparison to CC grafts, TAC grafts do not provide as much length or thickness, but TAC harvesting allows shorter operative time and eliminates second surgical site morbidity.

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Author Contributions: Drs Nguyen, Bent, and Parikh had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Bent. Acquisition of data: Nguyen, Bent, Shah, and Parikh. Analysis and interpretation of data: Nguyen, Bent, and Parikh. Drafting of the manuscript: Nguyen. Critical revision of the manuscript for important intellectual content: Nguyen, Bent, Shah, and Parikh. Statistical analysis: Nguyen. Administrative, technical, and material support: Bent and Parikh. Study supervision: Bent and Parikh.

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REFERENCES