Cricotracheal Resection in Children

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Objective: To review our experience with cricotracheal resection in a pediatric population.

Design: Prospective case review of a cohort of patients undergoing cricotracheal resection.

Setting: Tertiary care pediatric hospital.


Main Outcome Measures: Decannulation rates.

Results: Thirty-eight (86%) of the 44 children are decannulated. The ultimate decannulation rate was independent of the presenting grade of subglottic stenosis. Fourteen children (100%) had a primary cricotracheal resection; all are decannulated. Twenty-one children had a salvage cricotracheal resection, and 19 (90%) are decannulated. Nine children had an extended cricotracheal resection, of whom 5 (56%) are decannulated. A primary cricotracheal resection was performed on a child on whom no previous open airway procedure had been performed. A salvage cricotracheal resection was performed on a child on whom previous open airway reconstruction had not resulted in an adequate airway. An extended cricotracheal resection was performed on a child on whom the cricotracheal resection was combined with a second procedure, either additional expansion cartilage grafting or an open arytenoid procedure. Most of these children had complex airway pathologic conditions.

Conclusion: Cricotracheal resection complements standard laryngotracheal reconstruction techniques in a pediatric population.


OVER THE LAST 30 years, reconstruction of the pediatric airway has rapidly evolved, fueled by the advent of prolonged neonatal intubation and the subsequent dramatic increase in the incidence of acquired subglottic stenosis.1,2 While many different techniques for reconstruction of the pediatric airway have been used, expansion laryngotracheal reconstruction (LTR) using cartilage grafts has stood the test of time and should be considered the standard criterion against which other techniques should now be measured.3 Our unit has vast experience with expansion LTR using cartilage grafts.4 Cricotracheal resection (CTR) is an alternative technique for managing subglottic stenosis and has been an established technique in the adult population for many years.5,6 The pediatric series was described by Monnier et al7 in 1993. Between January 1, 1993, and December 31, 1995, our unit performed 4 CTRs. The initial results were encouraging, and since 1996 we have performed between 10 and 15 pediatric CTRs each year, with initial results published in 1997.8 Subsequent reports have also been encouraging.9,10 Our increasing experience with CTR includes children with complex airway pathologic conditions, and with time the indications, limitations, and complications of CTR are becoming more established.

The technique of CTR involves the resection of the anterior cricoid arch and thinning of the posterior cricoid plate with preservation of a posterior mucosal flap. The transected normal trachea is then telescoped into the posterior cricoid plate and anastomosed to the mucosal flap and thyroid cartilage. This technique has been previously well described.7,8 Cricotracheal resection is more technically challenging than standard expansion LTR and there are recognized complications associated with the procedure including recurrent laryngeal nerve damage and anastomotic dehiscence.

RESULTS

Between January 1, 1993, and December 31, 1998, 44 (19 females and 25 males) consecutive children underwent CTR. The follow-up period ranged between 12 and 67 months. The patients’ ages at the time of CTR ranged from 13 months to 19 years (mean age, 73 months). Forty children were operated on since 1996. Twenty-four children were former premature infants, 14 children were receiving antireflux medication at the time of CTR, and 6 more children had a history of previous Nissen fundoplication.
MATERIALS AND METHODS

A prospective database analysis was undertaken of all patients in whom CTR had been performed between January 1, 1993, and December 31, 1998. No patients were lost to follow-up. A minimum of 12 months' follow-up information was available for all patients. The data collected included the surgical airway history prior to CTR, the preoperative grade of the subglottic stenosis, the decannulation status of each patient, and whether the patient had required a further procedure prior to decannulation.

The patients were further subdivided into primary, salvage, and extended CTR. A primary CTR was defined as a CTR performed on a child on whom no previous open airway procedure had been performed. A salvage CTR was defined as a CTR performed on a child on whom previous open airway reconstruction had not resulted in an adequate airway. An extended CTR was defined as a CTR performed on a child on whom the CTR was combined with a second procedure, either additional expansion cartilage grafting or an open arytenoid procedure.

This cohort of 44 children included 3 with a history of laryngotraceoesophageal clefting. All 3 had required previous LTR, using expansion cartilage grafting techniques. Two are decannulated. An additional child with a Wegener granulomatosis, is decannulated and symptom free 56 months following CTR.

A variety of stenting techniques were used, with 22 patients having single-stage procedures, 16 patients requiring a T tube, 4 patients having a suprastomal stent, and 2 patients having no stent. Of the 4 children with suprastomal stents, 3 remain tracheotomy dependent, all of whom had extended CTRs.

Ten patients had a grade 4 subglottic stenosis (Myer-Cotton grading scale). Nine are decannulated, although 1 required an LTR with expansion cartilage grafting 8 months following CTR to achieve decannulation. A second child required a subglottic laser procedure to achieve decannulation. The 10th patient has had a revision LTR and awaits decannulation.

Thirty-two children had a grade 3 subglottic stenosis. Of these 27 (84%) are decannulated. Of these 27, 3 required a subsequent LTR using expansion cartilage grafting to achieve decannulation. Two children could not be adequately graded as they had subglottic collapse due to preexisting damage to the anterior cricoid cartilage resulting from a previous LTR rather than fixed subglottic stenosis. Using the endotracheal tube method, one of these children could be sized as having a grade 2 subglottic stenosis, but both children functionally behaved as if they had a grade 3 subglottic stenosis due to the subglottic collapse of the airway. Both children were decannulated following CTR.

The overall decannulation rate for the series is 86%, with 38 of 44 children being decannulated. The 6 children who are still tracheotomy dependent are described in the Table. Three of these children (patients 1, 4, and 6) have a markedly improved airway following CTR, but will still require another airway procedure prior to decannulation. One child with a history of a laryngotraceoesophageal cleft (patient 2) and a very deficient pos-
terior cricoid continues to have subglottic collapse following CTR, as he did prior to CTR. He maintains an excellent lumen with a T tube in situ, but the airway collapses on removal of the T tube. He also requires additional airway reconstruction. The final 2 children (patients 3 and 5) are the only 2 examples in our series in which the airway was not improved following CTR. In one case a grade 3 stenosis was converted to a grade 4 stenosis, and in the other case a grade 4 stenosis remained grade 4 following CTR. In both cases a significant postoperative wound infection was believed to be responsible. Pseudomonas species in one case and methicillin-resistant *Staphylococcus aureus* in the other case. One has already had a further reconstruction and is awaiting decannulation; the other awaits further surgery.

### COMMENT

Over the period of this review there has been an evolution, not only of surgical technique, but also a better appreciation of the indications, limitations, and complications of CTR. In the initial stages of the series we routinely performed a suprahyoid release. This occurs in less than 50% of cases as long as there is no undue tension on the anastomosis. Similarly, chin to chest sutures were routine initially, and more recently less than 30% of children had required chin to chest suturing. However, although there have been no anastomotic dehiscences in our series, subsequently we have had experience with anastomotic dehiscence and have returned to using chin to chest sutures in most cases. In this series most children had a tracheostomy preoperatively. Intraoperatively, the stoma may be included in the resected tracheal specimen, or maybe left intact. The key is to anastomose healthy trachea to the thyroid cartilage whether above or below the level of the preexisting tracheostomy stoma. We have also become more selective about the drilling of the posterior cricoid plate, and in almost half of our current cases minimal drilling or no drilling is performed, dependent on the amount of scar tissue present.

We have used a variety of different stenting techniques, from using no stent at all in 2 children to using an endotracheal tube as part of a single-stage CTR in 22 children. In our opinion the choice of stent does not critically influence outcome. Our current preference is for a single-stage reconstruction with 7 to 10 days of postoperative intubation if the child is initially seen without a T tube, or if the child has a grade 3 subglottic stenosis. We rarely use T tubes smaller than 8-mm outer diameter to minimize the risk of secretions obstructing the lumen, and this usually requires the child to be at least 4 years old. In a child older than 4 years, who is already tracheotomy dependent, our preference is to use a T tube. In a child too small to use a T tube, and in whom we do not wish to use a single-stage technique, we place a suprastomal Cotton-Lorenz stent. We would not normally perform a single-stage CTR in a child with a grade 4 subglottic stenosis, or in a child requiring an extended CTR. In this series, 3 of the 4 children in whom a suprastomal stent was used remained tracheotomy dependent. However, all 3 of these children had extended CTRs, and we do not consider that the form of stenting influenced outcome.

The complications encountered in the series included recurrent laryngeal nerve palsy, postoperative infection, anastomotic webbing, or restenosis and arytenoid prolapse. Minor anastomotic webbing was virtually universal and usually asymptomatic. Significant restenosis occurred in 9 of 44 patients, severe enough to require or receive further airway reconstruction. Only 2 children had a worse airway following CTR and both

### Children Still Tracheotomy Dependent Following Cricotracheal Resection (CTR)*

<table>
<thead>
<tr>
<th>Patient No./Age, y</th>
<th>History</th>
<th>Operation</th>
<th>CTR Classification</th>
<th>Subglottic Stenosis (SGS) Grade†</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Comment</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td>Subglottic hemangioma, multiple laser procedures, and 7 LTRS</td>
<td>CTR and R arytenoidectomy</td>
<td>Extended (salvage)</td>
<td>3 (severe)</td>
<td>2</td>
<td>Plugs tracheotomy during day and intolerant at night</td>
<td>Further surgery planned</td>
<td></td>
</tr>
<tr>
<td>2/10</td>
<td>Type 3 LTEC, TEF, and LTR (once)</td>
<td>CTR</td>
<td>Salvage</td>
<td>3</td>
<td>10-mm T tube in place</td>
<td>Airway collapses if T tube removed</td>
<td>Further surgery planned</td>
<td></td>
</tr>
<tr>
<td>3/5</td>
<td>Prematurity and ADS (twice)</td>
<td>CTR and R CA release, and arytenoid lateralization</td>
<td>Extended (salvage)</td>
<td>4</td>
<td>4</td>
<td>Postoperative pseudomonal infection; the patient had had further LTR</td>
<td>Decannulation planned</td>
<td></td>
</tr>
<tr>
<td>4/9</td>
<td>Prematurity and LTR (once)</td>
<td>CTR</td>
<td>Salvage</td>
<td>3 (severe)</td>
<td>2</td>
<td>Awaits reevaluation</td>
<td>Further surgery may be required</td>
<td></td>
</tr>
<tr>
<td>5/4</td>
<td>Transverse myelitis, prolonged intubation, and BTVC</td>
<td>CTR and bilateral arytenoidopexy</td>
<td>Extended (primary)</td>
<td>3 (pinhole)</td>
<td>4</td>
<td>Postoperative methicillin-resistant <em>Staphylococcus aureus</em> infection</td>
<td>Further surgery planned</td>
<td></td>
</tr>
<tr>
<td>6/3</td>
<td>TEF and congenital SGS (abnormal cricoid)</td>
<td>CTR and anterior cartilage graft</td>
<td>Extended (primary)</td>
<td>3 (pinhole)</td>
<td>2</td>
<td>Intolerant of plugging</td>
<td>Further surgery required</td>
<td></td>
</tr>
</tbody>
</table>

*LTR indicates laryngotracheal reconstruction; LTEC, laryngotracheoesophageal cleft; TEF, tracheoesophageal fistula; ACS, anterior cricoid split; CA, cricoarytenoid joint; and BTVC, bilateral true vocal cord paralysis.

†Adapted from Myer et al.11
of these children had postoperative infections following extended CTRs. These were the only 2 significant postoperative infections in the series. Arytenoid prolapse was a common postoperative finding, though it could present very late, and was asymptomatic in most patients. Eight patients required laser partial arytenoidectomy, and while efficacious, this procedure should be done as conservatively as possible, as there is an attendant risk of supraglottic stenosis or collapse. This occurred in 2 of our patients who require nocturnal continuous positive airway pressure. In this series there were no cases of anastomotic site dehiscence, though subsequently we have noted this in 2 patients operated on after 1998.

This series is unusual in that 9 (90%) of the 10 children with a grade 4 subglottic stenosis have been decannulated, and the other awaits decannulation, while only 84% of the children with grade 3 subglottic stenosis are decannulated. There are 2 possible explanations for this. First, most grade 4 stenoses occur low in the subglottis, and these children are, therefore, ideal CTR candidates. Meanwhile many grade 3 lesions occur higher in the subglottis and may even involve the vocal cords, making them less ideal CTR candidates. The alternative explanation, and the one that we favor, is that this result reflects the small sample size rather than the disease. Similarly, the 100% decannulation rate for the primary CTRs is likely to represent the small sample size rather than the disease, and it is notable that in 4 of these cases a subsequent LTR was required prior to decannulation.

In our experience we have found that CTR had particular utility for salvaging airways where a previous LTR with expansion cartilage grafting had failed. Several children had multiple failed LTR procedures, yet 90% of the salvage CTRs were able to be decannulated, with none requiring further airway reconstruction. This figure, however, does not include the 7 extended CTRs that were salvage procedures, of whom only 5 achieved decannulation.

The results of extended CTR were more disappointing with only 56% achieving decannulation. However, it is our opinion that this reflects the severity of the presenting problem rather than the reconstructive procedure itself. Most of these children had pathologic airway conditions affecting multiple levels.

In this sense, our series has differences to the experience in other centers performing pediatric CTR, in that we have primarily used CTR for the most challenging cases of subglottic stenosis. This series includes children referred to us with airway burns, laryngotracheoesophageal clefts, Wegener granulomatosis, multiple failed LTRs, and children with second airway lesions including glottic stenosis, arytenoid prolapse, arytenoid fixation, and bilateral true vocal cord paralysis.

This experience has helped to refine our indications for CTR. We believe that CTR is particularly well suited to manage grade 4 subglottic stenosis, grade 3 subglottic stenosis with concentric low subglottic scarring (≥ 3 mm below the vocal cords), airway salvage following failed LTR, inflammatory scarring of the subglottis, and airway collapse due to cartilage damage of the anterior cricoid. While these are the ideal candidates, CTR need not necessarily be limited to these patients, but on an individualized basis may be applied to children with multiple level pathology, a deficient posterior cricoid plate, and where the stenosis is closer to vocal cord level. While a limitation, vocal cord involvement is not an absolute contraindication.

Cricotracheal resection has not replaced LTR techniques using cartilage extension in our practice. In fact, we still perform more than twice the number of LTRs for subglottic stenosis as we do CTRs. Cricotracheal resection is more technically challenging than LTR and we do not believe that CTR is justified where an anterior cricoid graft would suffice. Most grade 2 subglottic lesions and many grade 3 lesions respond adequately to anterior cricoid grafting alone. Anterior and/or posterior cartilage grafting remains ideal for the management of grade 3 subglottic stenosis due to lateral shelving. Laryngotracheal reconstruction also remains the first consideration for subglottic stenosis that involves the vocal folds, unless there is a good reason to consider CTR (such as failure following multiple previous LTRs).

**CONCLUSIONS**

Cricotracheal resection is a valuable addition to the management options for severe laryngotracheal stenosis in children. It does not so much replace LTR using cartilage expansion techniques, as it is to be considered as complementing LTR. It is particularly suited to the management of grade 4 subglottic stenosis, severe grade 3 subglottic stenosis particularly with concentric scarring in the low subglottis, and salvage of the airway when standard LTR techniques have failed.

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**REFERENCES**


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