

# Laryngotracheoplasty as an Alternative to Tracheotomy in Infants Younger Than 6 Months

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**Objective:** To compare the success rates of laryngotracheoplasty (LTP) with those of anterior cricoid split (ACS) performed over the same period in infants younger than 6 months.

**Design:** Case-control study.

**Setting:** Tertiary children's hospital.

**Participants:** Thirty-two infants younger than 6 months.

**Interventions:** Twenty-one infants younger than 6 months underwent single-stage LTP as an alternative to tracheotomy, and the outcomes were compared with those in 11 infants who underwent ACS as an alternative to tracheotomy.

**Main Outcome Measures:** Operation-specific success was defined as extubation without subsequent tracheotomy or revision open-airway procedure.

**Results:** Infants who underwent LTP had a greater percentage of grade 3 subglottic stenosis (71%-99% obstruction) ( $P = .02$ , Fisher exact test). Mean age of patients was similar (3.7 months in the LTP group vs 2.8 months in the ACS group) with no significant difference on  $t$  test ( $P = .12$ ). The operation-specific success rate was 81% (17 of 21) in the LTP group and 27% (3 of 11) in the ACS group ( $P = .006$ , Fisher exact test).

**Conclusions:** Single-stage LTP should be considered the first alternative to tracheotomy when subglottic stenosis is the primary airway lesion. The operation-specific success rate of 81% is comparable to reported operation-specific success rates for LTP in older children.

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**T**HE INCIDENCE OF ACQUIRED subglottic stenosis (SGS) in neonates has increased in part as a result of popularization by McDonald and Stocks<sup>1</sup> of long-term intubation for dependence on mechanical ventilatory assistance. The criterion standard for treatment of airway obstruction, including SGS, has been the tracheotomy first standardized by Chevalier Jackson. However, given the relatively high rates of morbidity and occasional mortality<sup>2,3</sup> associated with neonatal tracheotomy, there has been substantial impetus to find alternatives to treating SGS.

A recent review<sup>4</sup> of tracheotomies performed in the neonatal setting at a large tertiary care institution revealed that the most common indication for the procedure was SGS, accounting for approximately one-third of tracheostomies performed in infants. This indication was more common than chronic lung disease, craniofacial abnormality, and neu-

rologic disability. The rate of SGS observed in this 10-year review (1995-2005) of 10 248 patients was 0.2%, which is similar to that reported in previous articles published in the early 1990s<sup>5,6</sup> that indicated that the percentage of neonates requiring intervention because of SGS has been relatively stable over the last decade and a half.

Anterior cricoid split (ACS) was introduced in 1980 as an alternative to tracheotomy in neonates.<sup>7</sup> Indications for ACS were established and include the following: (1) failure to extubate twice because of subglottic pathologic disorders, (2) weight more than 500 g, (3) minimal mechanical ventilatory assistance for longer than 10 days, (4) minimal supplemental oxygen requirement, (5) no acute respiratory or cardiac problems, and (6) no antihypertensive medication. Extubation rates after ACS have ranged from 58% to 100%. Similar use of laryngotracheoplasty (LTP) consisting of ACS with costochondral,<sup>8</sup> auricular,<sup>9</sup> and, most re-

cently, thyroid alar cartilage grafting<sup>10</sup> has been reviewed, and results were comparable or favorable to those with ACS. Single-stage LTP, which was widely reported in the early 1990s,<sup>11,12</sup> has been the preferred method in these series, thereby avoiding a tracheotomy at any time in the infant's care.

At Cincinnati Children's Hospital Medical Center, both ACS and LTP have been used in infants to treat symptomatic SGS. The objective of this study was to compare the success rates of LTP with those of ACS performed over the same period in infants younger than 6 months.

## METHODS

Approval from our institutional review board was obtained before undertaking the present study. A database of all patients who have undergone airway reconstruction at Cincinnati Children's Hospital Medical Center has been maintained prospectively since 1992. Infants who underwent ACS or LTP before age 6 months were identified in this database. Patient information including sex, date of birth, stenosis grade, date of procedure, duration of intubation, date of extubation, and additional procedures required was obtained for this study. Medical records were reviewed for documentation of postoperative course and complications. Stenosis was graded using the Myer-Cotton grading system,<sup>13</sup> which was originally developed for evaluation of mature stenosis. To maintain regularity, this grading system was applied to all patients in the study including those with immature stenosis resulting from ongoing intubation. Operative technique and perioperative management have been described in detail elsewhere.<sup>7,14</sup> Thyroid alar cartilage grafts were harvested using methods similar to those described by Forte et al<sup>10</sup> in 2001.

## RESULTS

We identified 21 infants who underwent LTP and 11 infants who underwent ACS, all before age 6 months. Mean age of the LTP group was 3.7 months (age range, 12 days to 5 months); age of the ACS group was 2.8 months (11 days to 5 months). No significant difference in age was found between the 2 groups ( $P=.12$ ,  $t$  test). Seven patients in the ACS group and 9 in the LTP group had a history of prematurity.

In the ACS group, stenosis grade was reported as Myer-Cotton grade 1 (<50% obstruction) in 2 patients, grade 2 (51%-70% obstruction) in 8 patients, and grade 3 (71%-99% obstruction) in 1 patient. In the LTP group, degree of stenosis was reported as grade 1 in 1 patient, grade 2 in 7 patients, and grade 3 in 12 patients; stenosis grade was not recorded in 1 patient. The percentage of grade 3 stenosis was significantly higher in the LTP group ( $P=.02$ , Fisher exact test).

In the LTP group, cartilage expansion was performed with an anteriorly placed thyroid alar cartilage graft in 16 patients, an anteriorly placed auricular cartilage graft in 1 patient, an anteriorly placed costochondral cartilage graft in 2 patients, a posteriorly placed costochondral cartilage graft in 1 patient, and both anterior and posterior costochondral cartilage grafts in 1 patient. A posterior cricoid split (without posterior cartilage grafting) accompanied anterior cartilage grafting in

6 patients. Anterior grafting was used in all patients except 1 who had a primarily posterior component of SGS. When anterior grafting alone seemed inadequate for airway expansion, a posterior split was used to further expand and decompress the airway. Placement of a posterior graft was performed if adequate cartilage was available for both anterior and posterior grafting without creating a new donor site (ie, when costochondral cartilage was already being used). All procedures were performed in a single stage.

In 17 of 21 patients in the LTP group and 3 of 11 patients in the ACS group, extubation was performed successfully with no further airway reconstruction. Overall, the operation-specific decannulation rate was 81% in the LTP group vs 27% in the ACS group.

No postoperative complications were recorded in the LTP group. One accidental extubation and 1 persistent tracheocutaneous fistula was observed in the ACS group.

## COMMENT

Single-stage LTP is a safe and effective alternative to tracheotomy in infants younger than 6 months who have symptomatic SGS. In infants who underwent single-stage LTP to treat SGS, extubation was successfully performed with no further intervention 81% of the time in this series compared with only 27% in the ACS group. The LTP group exhibited a higher percentage of severe (Myer-Cotton grade 3 or 4 [no detectable lumen]) stenosis than did the ACS group. The operation-specific success rate for LTP in this series is comparable to that reported in similar articles in older children.<sup>15</sup>

In the present study, LTP was successful at a higher rate than ACS for treatment of symptomatic SGS despite being performed in a cohort with more severe stenotic lesions. Inasmuch as higher stenosis grade has been associated with poorer outcomes for LTP in previous studies,<sup>15,16</sup> this result was unexpected. The primary difference between the 2 procedures is augmentation of the airway lumen with cartilage, providing structural stability to the newly expanded airway. Expansion alone is used in the ACS procedure with soft-tissue fibrosis expected to fill the anterior gap in the cricoid cartilage. These results indicate that cartilage augmentation of the airway is preferable to expansion alone, a concept verified in studies in older children.

The overall poor outcomes in the ACS group were surprising when compared with the overall body of English-language literature on ACS. The successful extubation rate of 27% is substantially lower than in other series, which reported success rates of 58% to 100% including the most recent update on ACS from our institution in 1991<sup>17</sup>; in that study, a success rate of 70% was observed. More recently, Leung and Berkowitz<sup>18</sup> reported a substantially lower rate of success with ACS. In the Leung and Berkowitz study, the primary objective was to characterize indications for tracheotomy in the neonatal intensive care unit. The authors reviewed a cohort of 20 infants who underwent ACS to treat SGS, only 7 of whom did not require tracheotomy. One potential complicating factor in our study was the high number (7 of

11) of infants with severe prematurity, that is, 28 weeks of gestational age or less. The relatively low grade of stenosis observed in the ACS group is also somewhat incongruent with the rate of decannulation, which suggests that other patient comorbidities may have had a role. Although pulmonary status and neurologic development seemed to be adequate for proceeding with surgery and extubation in these patients, there may have been less pulmonary reserve in these cases. Thus, as was suggested in the review of ACS results from our institution in 1991,<sup>17</sup> there may have been relaxation of adherence to the strict patient selection guidelines for ACS over time. The lower rate of prematurity in the LTP group may translate into better pulmonary reserve, thereby increasing the chance of successful extubation and explaining some of the difference between the 2 groups.

As in an earlier series by Forte et al,<sup>10</sup> thyroid alar cartilage was the preferred material for expanding the airway in our study. Thyroid alar cartilage is easily accessible during routine airway exposure, and dissection of the cartilage off the inner perichondrium above the level of the thyroid notch ensures that the endolaryngeal structures are not violated. The risks of costochondral cartilage grafting (including pain, splinting with subsequent atelectasis, pneumothorax, and the additional surgical site) are averted. An entire single-stage LTP with a thyroid alar cartilage graft may be performed through an incision only slightly larger than would be required for tracheotomy at the same level on the neck. If the procedure fails, tracheotomy may be performed through the same incision, thereby averting additional cosmetic deformity. When a thyroid alar cartilage graft is used, the procedure provides the advantage of a closed airway with minimal if any communication with the soft tissues of the neck compared with the open airway maintained after the ACS procedure. This advantage probably explains the low complication rate observed both in the present study and the study by Forte et al.<sup>10</sup>

In conclusion, when performed by an experienced pediatric otolaryngologist, single-stage LTP offers an excellent alternative in infants in whom tracheotomy is being considered because of SGS. Especially when a thyroid alar cartilage graft is used, LTP adds minimal if any additional risk or comorbidity over tracheotomy and may avert the long-term complications associated with pediatric tracheotomy tubes.

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**Author Contributions:** Dr White had full access to all of the data in the study and takes responsibility for the

integrity of the data and the accuracy of the data analysis. *Study concept and design:* White, Bravo, Vijayasekaran, Rutter, Cotton, and Elluru. *Acquisition of data:* White, Bravo, and Vijayasekaran. *Analysis and interpretation of data:* White, Vijayasekaran, Rutter, Cotton, and Elluru. *Drafting of the manuscript:* White and Bravo. *Critical revision of the manuscript for important intellectual content:* White, Vijayasekaran, Rutter, Cotton, and Elluru. *Statistical analysis:* Vijayasekaran. *Administrative, technical, and material support:* White and Bravo. *Study supervision:* Bravo, Vijayasekaran, Rutter, Cotton, and Elluru.

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