Feeding Outcomes in Infants after Supraglottoplasty

Marcia Eustaquio, MD1, Erika Nevin Lee, MS, CCC-SLP2,3, and G. Paul Digoy, MD3,4

Abstract

Objective. Review the impact of bilateral supraglottoplasty on feeding and compare the risk of postoperative feeding difficulties between infants with and without additional comorbidities.

Study Design. Case series with chart review.

Setting. Children’s hospital.

Subjects and Methods. The medical records of all patients between birth and 12 months of age treated for laryngomalacia with bilateral supraglottoplasty by a single surgeon (GPD) between December 2005 and September 2009 and followed for a minimum of 1 month were reviewed. Infants with significant comorbidities were evaluated separately. Nutritional intake before and after surgery, as well as speech and language pathology reports, was reviewed to qualify any feeding difficulties. Age at the time of surgery, additional surgical interventions, medical comorbidities, and length of follow-up were also noted during chart review.

Results. Of 81 infants who underwent bilateral supraglottoplasty, 75 were eligible for this review. In the cohort of infants without comorbidities, 46 of 48 (96%) had no change or an improvement in their oral intake after surgery. Of the 2 patients with initial worsening of feeding, all resumed oral intake within 2 months. In the group of patients with additional medical comorbidities, 22% required further interventions such as nasogastric tube, dietary modification, or gastrostomy tube placement.

Conclusions. Supraglottoplasty in infants has a low incidence of persistent postoperative dysphagia. Infants with additional comorbidities are at a higher risk of feeding difficulty than otherwise healthy infants.

Keywords
laryngomalacia, sleep apnea, supraglottoplasty, pediatric, sleep endoscopy

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Laryngomalacia is a common cause of stridor in infants resulting from collapse of supraglottic tissue into the airway during inspiration. The anatomic abnormalities noted on laryngoscopic examination include a shortened aryepiglottic fold, long curled omega-shaped epiglottis, and bulky arytenoids that prolapse during inspiration.1,2 In addition, these abnormalities may also be exacerbated by neurological defects that contribute to hypotonia and decreased coordination. It has been suggested that concurrent airway abnormalities may be more commonly noted in infants with laryngomalacia compared with the healthy population.3 Resolution of symptoms typically occurs by 24 months of age. Severe cases that do require intervention occur in 5% to 30% of patients diagnosed with laryngomalacia.3,5

Symptoms of laryngomalacia that require surgical intervention include significant stridor causing difficulties breathing during sleep and at rest; feeding problems, including choking and or aspiration; failure to thrive; oxygen desaturations; and apneic events. At our institution, the initial interventions for symptomatic laryngomalacia include prone positioning and reflux medication. For more severe cases, CO2 laser-assisted supraglottoplasty is the first-line surgical intervention. Risks of the surgery include persistent airway obstruction, supraglottic stenosis, scarring or synchiae formation, intraoperative surgical complication (ie, anesthesia risk, vocal cord spasms, airway fire, etc), and dysphagia or aspiration.

Concern has been expressed regarding the ability of infants to adequately feed orally after supraglottoplasty as the supraglottic anatomy has been altered. There is no clear consensus in the literature regarding the incidence of aspiration after supraglottoplasty. Previous reports have separately looked at either...
the immediate postoperative period or the swallowing status of patients months after surgery. In a recently published study by Schroeder et al,6 37% of the infants undergoing supraglottoplasty had postoperative dysphagia on their first postoperative feeding. On the other hand, in a study by Richter et al,7 an average of 4 months after surgery, no patients had newly developed aspiration, and 86% of the infants with preoperative aspiration had resolution of their aspiration. Here we review the outcomes of supraglottoplasty at a single institution to assess the likelihood of postoperative feeding difficulties with an average follow-up period of 8 months (median 6 months). We also explored whether children with additional comorbidities are at an increased risk of dysphagia after surgical intervention.

Methods
After obtaining approval from the University of Oklahoma Institutional Review Board, the medical records of 81 children from the ages of 2 weeks to 1 year who underwent supraglottoplasty at a children's hospital by the senior author from December 2005 to September 2009 were reviewed. Indications for surgery in this study included failure to thrive and severe airway obstruction (including severe stridor, suprasternal/substernal retractions, and obstructive sleep apnea syndrome). Isolated dysphagia without obstructive breathing symptoms was not an indication for surgery. When an infant is found preoperatively to have significant symptoms of reflux disease, diagnosed by overnight pH probe or indirect laryngoscopy, our standard practice is a trial of reflux therapy, including a proton pump inhibitor and standard reflux precautions (such as head-of-bed elevation and prevention of overfeeding) for approximately 1 month. When no clinical evidence of reflux was present, reflux therapy was used only in the postoperative healing period.

Preoperative Care
All infants underwent a nonsedated flexible indirect laryngoscopy to assist in the decision to proceed with surgery. During the time period of this study, the practice of the senior author (GPD) was to get a videofluoroscopic swallow study/modified barium swallow study (VSS) with speech pathology only when there was evidence of preoperative dysphagia. During the time period of this review, the demand for this study (VSS) at our institution was great, and some patients had breathing symptoms that were too great to wait for this preoperative assessment, especially considering it would not change the decision for surgery. Furthermore, it is our experience that modified barium swallow (MBS) studies are not very sensitive, as they commonly do not detect aspiration even when the child has positive symptoms of choking with feeds.

Indications for surgery in this study included failure to thrive and severe airway obstruction (including severe stridor, suprasternal/substernal retractions, and obstructive sleep apnea syndrome). Isolated dysphagia without obstructive breathing symptoms was not an indication for surgery.

Postoperative Care
A twice-daily proton pump inhibitor was given to the patient for a minimum of 1 month after surgery, and steroids were administered for less than 24 hours postoperatively. If the child was otherwise healthy, he or she was kept overnight for observation and sent home the next day provided the child did not have any significant respiratory events and was tolerating an infant diet without difficulties. Patients were then seen in the clinic after 1 week and then again at 1 month. The method of oral intake before and after surgery was noted. If at any time the parents expressed concern for the patient's ability to tolerate oral intake or there was not appropriate weight gain, the child was referred for a VSS and evaluation by speech and language pathology. Often if the infant had additional medical problems or preoperative difficulties with feeding, he or she had received a VSS and consultation with speech and language pathology prior to surgery as well.

Results
Eighty-one infants between the ages of 2 weeks and 12 months underwent supraglottoplasty between October 2005 and September of 2009. Six children did not have sufficient follow-up and were excluded from the study. This left 75 infants included in the study. The age at surgery ranged from 2 weeks to 12 months with an average age of 4.5 months. Thirty-eight infants were female and 37 were male. Follow-up ranged from 1 to 26 months with an average of 8 months and

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Table 1. List of Comorbidities for Patients in Group I

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Other chromosomal abnormality</th>
<th>Micrognathia</th>
<th>Prematurity (&lt;30 weeks)</th>
<th>Hydrocephalus</th>
<th>Significant cardiac abnormalities</th>
<th>Seizure disorder</th>
<th>Cleft palate</th>
<th>Bronchopulmonary dysplasia</th>
<th>Macroglottia</th>
<th>Vocal cord paresis</th>
<th>Severe tracheomalacia</th>
<th>Airway hemangiomas</th>
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<tr>
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<td>Macroglottia</td>
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<td>Vocal cord paresis</td>
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<td>Airway hemangiomas</td>
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</table>

At least one of the listed disorders was present in each infant included in group I.

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The table lists the comorbidities of the infants included in the study. This information is crucial for understanding the background and context of the study. The table shows a variety of conditions that may influence the outcomes of supraglottoplasty. The presence of these comorbidities can affect the surgical approach and postoperative care. The table also highlights the importance of a multidisciplinary approach, including speech and language pathology, to evaluate and manage these infants comprehensively.
**Table 2. Infants with Comorbidities Requiring Intervention for Feeding after Supraglottoplasty**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Medical Diagnoses</th>
<th>Preoperative VSS</th>
<th>Age at Surgery</th>
<th>Postoperative VSS</th>
<th>Feeding Intervention</th>
<th>Duration of Intervention</th>
<th>Additional Airway Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vocal cord paralysis, prematurity</td>
<td>NA</td>
<td>3 wk</td>
<td>Penetration</td>
<td>G-tube</td>
<td>Resolved within 12 months</td>
<td>Tracheostomy</td>
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<td>2</td>
<td>Hydrocephalus, PDA, encephalopathy</td>
<td>Normal</td>
<td>10 mo</td>
<td>Penetration</td>
<td>G-tube</td>
<td>Continued dependence at 3 months</td>
<td>Adenoidectomy</td>
</tr>
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<td>3</td>
<td>BPD, hydrocephalus, subglottic stenosis, prematurity</td>
<td>Normal</td>
<td>7 mo</td>
<td>Penetration</td>
<td>G-tube</td>
<td>Continued dependence at 10 months</td>
<td>Tracheostomy</td>
</tr>
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<td>4</td>
<td>BPD, subglottic stenosis</td>
<td>Insufficient caloric intake</td>
<td>3 mo</td>
<td>Penetration thin only</td>
<td>NG, fundoscopy</td>
<td>Resolved within 3 months</td>
<td>Genioglossal division</td>
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<tr>
<td>5</td>
<td>Prematurity with failure to thrive</td>
<td>Uncoordinated swallow</td>
<td>3 mo</td>
<td>Insufficient caloric intake</td>
<td>NG</td>
<td>Resolved by 6 weeks</td>
<td>None</td>
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<tr>
<td>6</td>
<td>Micrognathia, abnormal glossopharyngeal fold</td>
<td>NA</td>
<td>3 mo</td>
<td>Aspiration</td>
<td>NG (5 wk), thickened feeds</td>
<td>Resolved within 4 months</td>
<td>Division of glossopharyngeal fold</td>
</tr>
</tbody>
</table>

Medical diagnosis in addition to laryngomalacia, the age at the time of supraglottoplasty, the type of feeding intervention, the duration of intervention, and any additional airway procedures during follow-up are listed. BPD, bronchopulmonary dysplasia; G-tube, gastrostomy tube; NA, not available; NG, nasogastric; PDA, patent ductus arteriosus; VSS, videofluoroscopic swallow study/modified barium swallow study.

A median of 6 months. Of the 75 included infants, 27 had additional medical diagnoses as listed in Table 1. Concurrent airway abnormalities included 3 infants with subglottic steno-sis, 2 with vocal cord paresis, 2 with macroglottis, 2 with airway hemangiomas, and 1 with severe tracheomalacia. These children were all placed in the first cohort (group I). The second cohort of patients included 48 infants with no additional medical comorbidities (group II).

Four of the 27 children in group I required gastrostomy tube (G-tube) placement prior to supraglottoplasty. Two of these children eventually were able to maintain sufficient oral intake 4 and 13 months after supraglottoplasty and no longer required the G-tube. Two other children had a nasogastric (NG) tube placed prior to supraglottoplasty. After surgery, they continued to have difficulty with oral feeds and required G-tube placement 1 and 2 months after supraglottoplasty. Of these 2 children, 1 had a cleft palate and macroglottis, and the other was diagnosed with hydrocephalus, an atrial septal defect, and bronchopulmonary dysplasia. These children, although not significantly improved in their feeding after supraglottoplasty, were not considered surgical complications as their ability to feed did not decline noticeably from their preoperative status.

Table 2 lists 6 of 26 infants with comorbidities who required an intervention for feeding after supraglottoplasty. Medical diagnosis in addition to laryngomalacia, the age at the time of supraglottoplasty, the type of feeding intervention, the duration intervention required, and any additional airway procedures during follow-up are listed. Patients 4 and 5 were unable to maintain sufficient oral intake after surgery and required NG tube placement. Patient 5 had difficulty with swallowing preoperatively, and the requirement of an NG tube may not have been related to surgery. We listed this child in this category because the NG tube was not present preoperatively. Patient 6 had a very abnormal glossopharyngeal fold and retrognathia. He had severe airway obstruction that did not respond to a supraglottoplasty but responded to the division of both glossopharyngeal folds. This intervention was published as a case report. His postoperative difficulties with swallowing may have been related to the glossopharyngeal fold release and not from the supraglottoplasty.

In group II, 2 patients (4%) required intervention for feeding postoperatively. Details of these patients are shown in Table 3. Patient A had a supraglottoplasty at 1 month of age. A swallow study completed 2 months after surgery revealed deep penetration, and she was started on thickened feeds with Enfamil AR (Mead Johnson, Evansville, Illinois). She tolerated this adjustment well and did not require further intervention. Patient B, a 3-month-old girl, had new-onset choking episodes with feeding after surgery. Penetration was seen on VSS, and she was started on thickened feeds. She was changed back to normal oral intake without any difficulty after an additional month. It is not known with certainty that these infants did not have abnormal swallowing preoperatively as they did not have objective swallowing studies in the preoperative setting.

Adjunctive airway procedures were required in 5 children without additional comorbidities and 14 children with other medical problems during the follow-up period. These procedures included adenoidectomy, adenotonsillectomy, genioglossal release, laryngotracheal reconstruction, tongue lip adhesion (for Pierre Robin sequence), and epiglottoplasty.
Four of the 75 children eventually required a tracheostomy. All of the infants who underwent a tracheostomy had other medical diagnoses in addition to laryngomalacia. The time between supraglottoplasty and tracheostomy varied from 2 days to 26 months. Two revision supraglottoplasties were also performed in cases of suboptimal results to remove additional supraglottic tissue.

Discussion

Articles on outcomes after supraglottoplasty have reported varying degrees of feeding outcomes after laser supraglottoplasty for severe laryngomalacia. In this experience, supraglottoplasty improves the infant’s ability to feed and gain weight in most instances. We find in this series that infants who have significant comorbidities that may contribute to poor growth and development are at an increased risk of postsurgical feeding difficulties.

We suspect that there are both neuromuscular and anatomic components to laryngomalacia. We also find that some infants diagnosed with laryngomalacia may have a greater neuromuscular component to their disorder. It has been suggested that the reason for failure of supraglottoplasty in children with laryngomalacia is unclear. In some infants, this may be a presenting symptom. It has been postulated that the increased subglottic pressure created by supraglottic obstruction may promote reflux of esophageal contents and subsequent aspiration. The discoordination of the floppy airway may also predispose to aspiration. The mechanism of new-onset dysphagia after an alteration of the supraglottic anatomy (supraglottoplasty) is poorly understood. We propose that the injury to the mucosa during the procedure may lead to altered laryngeal sensation and poor protective reflexes in the short term. It is also possible that the airway may become too enlarged and lead to spill-through of feedings when poorly protected by glottic closure.

The recently published study by Schroeder et al found that 37% of the infants undergoing supraglottoplasty had postoperative dysphagia. These patients were examined in the immediate postoperative setting. In this early period, the infant is experiencing a combination of postoperative discomfort and possible transient sensory loss. This infant may also be under some effect from the recent general anesthetic. It is possible that the return of sensation to the supraglottic larynx may play a role in the better long-term feeding results we have experienced. In this series, we found that supraglottoplasty in the majority of cases resulted in parents reporting an improved oral intake and in general did not lead to an increased risk of aspiration of dysphagia. This is similar to Toynton et al, who reported 82% of infants had an improvement or no change in oral intake after surgery, and only in children with neurological disorders was a postoperative NG tube placement required. Richter et al also saw an improvement after supraglottoplasty, with 81% of preoperative penetration and 86% of preoperative aspiration resolving. They proposed that the supraglottoplasty procedure may even improve laryngeal sensation.

We do not believe that the senior author’s (GPD) method of supraglottoplasty alters the airway protection offered by the vocal cords or the epiglottis. Approximately 1 to 2 mm of cuneiform cartilage was trimmed in most infants. The laser is used to assist a cold technique with laryngeal scissors to provide further precision in the reduction of the cuneiform cartilages. The laser was used at a 1.5-W intermittent pulse setting to limit thermal injury. In all cases, the laser was used sparingly.

We propose that after surgery, the infant is better able to coordinate his or her respiration, suck, and swallowing mechanism as well as decrease the subglottic pressure. In our review, additional intervention for feeding was required in only 4% (2/48) of children who did not have additional medical comorbidities. All of these children returned to normal intake during their follow-up period. In the infants with other medical conditions, 22% (6/27) required feeding intervention after surgery. Although supraglottoplasty may have contributed to some of their feeding difficulties, it is likely that these infants would have progressed and required feeding assistance without surgery.

Limitations of this study include its retrospective nature and nonuniform use of VSS. Future studies pertaining to dysphagia and supraglottoplasty should include both a pre- and postoperative evaluation by speech and language pathology with indicated studies. We would also consider that a normal VSS does not always indicate an absence of feeding difficulties. Another limitation of our study is the lack of preoperative vs postoperative objective feeding parameters, such as duration of feeding and/or actual quantity of intake per feeding.

Conclusion

In summary, supraglottoplasty using a combination of cold knife and CO2 laser has a low incidence of persistent postoperative dysphagia. In the otherwise normal infant, the risk of requiring postoperative intervention for feeding is 4%. Infants with additional comorbidities are at a higher risk of feeding difficulty after surgery. In our review, 22% of infants with additional medical comorbidities required intervention for postoperative feeding. In

### Table 3. Infants without Additional Medical Diagnoses That Required Intervention for Feeding after Surgery

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age at Surgery, mo</th>
<th>Postoperative VSS Result</th>
<th>Feeding Intervention</th>
<th>Duration of Intervention, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>Penetration</td>
<td>Thickened feeds</td>
<td>3</td>
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<tr>
<td>B</td>
<td>3</td>
<td>Penetration</td>
<td>Thickened feeds</td>
<td>1</td>
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</tbody>
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Abbreviation: VSS, videofluoroscopic swallow study/modified barium swallow study.
addition to the respiratory benefit offered by supraglottoplasty, preoperative counseling should inform the parents of a possible short-term period of postoperative dysphagia in some infants. Feeding difficulties beyond the first few days is an uncommon but possible outcome of surgery and is more likely in infants with additional medical conditions.

Author Contributions
Marcia Eustaquio, primary responsibility in gathering of data and composition of manuscript, including tables; Erika Nevin Lee, primary responsibility in reviewing swallowing studies and providing specialty-related additions to the manuscript; G. Paul Digoy, primary surgeon, primary researcher, carefully reviewed and participated in all aspects of this study, including review of research data and manuscript composition.

Disclosures
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Sponsorships: None.
Funding source: None.

References