Laser Epiglottopexy for Laryngomalacia

10 Years’ Experience in the West of Scotland

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Objectives: To determine the results of laser epiglottopexy and to compare them with other surgical techniques for severe laryngomalacia.


Setting: Royal Hospital for Sick Children, Glasgow, Scotland.

Patients: The study population comprised 52 male and 24 female children who underwent surgery for laryngomalacia between January 1, 1993, and December 31, 2002. In all children except 2, the indication for surgery was stridor associated with poor feeding and failure to thrive. The age at presentation ranged from 5 days to 32 months (mean, 16 weeks). Three had neurological problems, in 3 a syndrome was diagnosed, and 2 were described as dysmorphic and no syndrome was diagnosed; 5 had a cardiac abnormality. Complete follow-up data were available for 59 children (78%).

Intervention: Laser epiglottopexy.

Main Outcome Measure: Resolution of stridor and growth velocity.

Results: Resolution of stridor was complete in 34 children, with mild residual stridor in 4 and persistent stridor but good weight gain in 5 (73% improved sufficiently with 1 procedure). Improvement was documented objectively by measuring growth velocity. Two children required a brief period of intubation postoperatively, and 4 had postoperative respiratory tract infections. Seven children (12%) required revision endoscopic laser surgery to control symptoms. There were no cases of supraglottic stenosis. One child died of cardiac abnormalities, and 8 (14%) required a tracheostomy, of whom 6 had neurological or syndromal abnormalities and 2 had associated tracheomalacia.

Conclusions: We describe a technique of laser epiglottopexy for laryngomalacia and present objective evidence of its efficacy by means of growth velocity charts in a retrospective review of laryngomalacia surgery over a 10-year period. We believe this to be a safe method for treating a self-limiting condition. We have had comparable success to other surgical techniques without having the risks of permanent scarring to the supraglottis.


Laryngomalacia is the most common condition causing stridor in children. Its etiology is unknown. Only 10% to 20% of children with laryngomalacia will require surgical intervention, with the majority being managed conservatively.

The mainstay of surgical treatment is some form of supraglottoplasty. This procedure has many variations including the division of the aryepiglottic folds, with or without debulking of the arytenoid mucosa and cuneiform cartilage, and trimming of the lateral edges of the epiglottis and epiglottopexy. These procedures may be performed using either cold steel microinstruments or carbon dioxide laser or sometimes using both types of instruments in combination. The aim of supraglottoplasty is to decrease the amount of supraglottic soft tissue collapsing into the laryngeal inlet during inspiration, thereby improving the stridor and decreasing the effort of breathing. The main clinical measures of effectiveness of treatment are the requirement for tracheostomy or additional airway support, resolution of feeding difficulties, and weight gain.

We present herein our own results in a retrospective case series of carbon dioxide laser epiglottopexy. To our knowledge, this technique has not been previously described in the published literature. The use of weight gain, documented on
age-appropriate percentile charts, as an objective outcome measure in laryngomalacia surgery is also novel.

**METHODS**

**SURGICAL TECHNIQUE**

The surgical technique used for severe laryngomalacia by the senior author (N.K.G.) is carbon dioxide laser epiglottopexy. The child is anaesthetized without endotracheal intubation, maintaining spontaneous respiration with oxygen and halothane delivered via a nasopharyngeal airway. This allows for a complete, dynamic assessment of the airway to confirm the diagnosis and exclude other airway abnormalities.

A pediatric laryngoscope is placed in the vallecula and suspended. An operating microscope is used, and the epiglottis is stabilized with a pair of microlaryngeal forceps. The carbon dioxide laser (10 W, continuous) is applied to the lingual surface of the epiglottis in a linear fashion (Figure 1). The epiglottis curls away from the laryngeal inlet (Figure 2 and Figure 3). The laser may also be applied to any redundant mucosa on the posterior aspect of the arytenoids, causing them to curl back away from the laryngeal inlet. It is not necessary to divide the aryepiglottic folds or excise mucosa. A final assessment of respiration is made as the child wakes up.

**STUDY METHOD**

Case notes of patients who had had surgery for laryngomalacia were identified by searching the hospital’s theater computer database for keywords. A 10-year period was chosen (January 1, 1993–December 31, 2002), and 160 case notes were identified in which the child had possibly undergone surgery for laryngomalacia. These notes were examined individually, and data were extracted from the handwritten operation notes, anesthetic notes, and subsequent entries. The data were recorded and stored for analysis.

Seventy-six children were confirmed as having undergone surgery for laryngomalacia during the study period. All underwent laser epiglottopexy as described in
Table. Summary of Published Series for Surgically Treated Laryngomalacia

<table>
<thead>
<tr>
<th>Source</th>
<th>Operative Technique(s)</th>
<th>Complete Resolution of Stridor, No. (%)</th>
<th>Revision Surgery, No. (%)</th>
<th>Complications</th>
<th>Tracheostomy, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>Laser epiglottopexy (n = 76) A-E fold division plus trimming of redundant mucosa (n = 136)</td>
<td>34 (58) 113 (83) 11 (8)</td>
<td>Respiratory tract infection (n = 4; 7%) Supraglottic stenosis (n = 5; 3.7%) granulomas (n = 2; supraglottic edema (n = 2; small web) (n = 1)</td>
<td>8 (14) 3 (2)</td>
<td></td>
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<tr>
<td>Denoyelle et al,4 2003</td>
<td>Mostly A-E fold excision (n = 115)</td>
<td>68 (59) 9 (8)</td>
<td>Delayed extubation (n = 2) laryngeal granulomas (n = 2; dysphagia (n = 2)</td>
<td>2 (2)</td>
<td></td>
</tr>
<tr>
<td>Roger et al,3 1995</td>
<td>Bilateral A-E fold excision (n = 59)</td>
<td>1. 55 (93) 2. 45 (96) 1. 3 (7) 2. 7 (15)</td>
<td>1. Supraglottic stenosis (n = 2) and aspiration (n = 2) 2. Aspiration (n = 4)</td>
<td>1. 13 (22); 2. 6 (13)</td>
<td></td>
</tr>
<tr>
<td>Reddy and Matt,6 2001</td>
<td>Mostly A-E fold excision (n = 100)</td>
<td>50 (55) 8/16 (50) for unilateral surgery, not stated for bilateral</td>
<td>Post-op NG feeding required (n = 5) (2 long term) hemorrhage (n = 1) aspiration of feeds (n = 6; initial worsening of stridor (n = 10)</td>
<td>1 (1)</td>
<td></td>
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<tr>
<td>Toynton et al,2 2001</td>
<td>A-E fold division plus trimming of redundant mucosa (n = 40)</td>
<td>37 (93) Not stated</td>
<td>2. Aspiration (n = 1) Post-op airway support required (n = 13; 33%) intubated overnight (n = 7) intubated 48 h (n = 1) unable to be decannulated (n = 3) Post-op croup (n = 4) and croup requiring intubation (n = 1)</td>
<td>3 (8)</td>
<td></td>
</tr>
<tr>
<td>Prescott,4 1991</td>
<td>A-E fold division, trimming of mucosa on epiglottis and arytenoids (n = 40)</td>
<td>31 (79) 3 (8)</td>
<td>Failed extubation (n = 1) transient choking on feeds (n = 1) Post-op hemorrhage (n = 1) transient Post-op laryngeal edema (n = 2) and Post-op broncholiths requiring intubation (n = 1)</td>
<td>1 (3)</td>
<td></td>
</tr>
<tr>
<td>Polonovski et al,7 1990</td>
<td>Mostly A-E fold excision (n = 39)</td>
<td>22 (69) 2 (6)</td>
<td>Peri-op death (n = 1) and apneic episodes continue (n = 1)</td>
<td>1 (3)</td>
<td></td>
</tr>
<tr>
<td>Loke et al,4 2001</td>
<td>A-E fold division (n = 33)</td>
<td>17 (71) 4 (17)</td>
<td>Post-op intubation (n = 2) Peri-op death (n = 1)</td>
<td>1 (4)</td>
<td></td>
</tr>
<tr>
<td>McClurg and Evans,3 1994</td>
<td>A-E fold reduction or division, some trimming of epiglottis (n = 24)</td>
<td>16 (70) 3 (13)</td>
<td>Ventilated for &gt;1 wk (n = 8; 35%) prolonged NG feeding (n = 1) and nosocomial infections (n = 2)</td>
<td>4 (17)</td>
<td></td>
</tr>
<tr>
<td>Senders and Navarette,16 2001</td>
<td>Mostly A-E fold excision plus trimming of redundant mucosa (n = 23)</td>
<td>3 (8)</td>
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Abbreviations: A-E, aryepiglottic; NG, nasogastric; Peri-op, perioperative; Post-op, postoperative.

the “Surgical Technique” subsection of the “Methods” section, and all procedures were performed by the same surgeon (N.K.G.). In all children except 2, the indication for surgery was stridor associated with poor feeding and failure to gain weight appropriately. One child was investigated for an intensive treatment unit (ITU) admission for croup, and 1 had recurrent respiratory tract infections.

Of these children 52 were male and 24 were female. The age range at presentation was 5 days to 32 months, with a mean of 16 weeks. Three children had a neurological disorder (1 child with cerebral palsy, 1 with cerebral palsy and microcephaly, and 1 with spina bifida and hydrocephalus). In 3 a syndrome had been diagnosed (Di Georges, Salla, and Opitz G/BBB syndromes), and 2 were described as being dysmorphic with no syndrome diagnosed. Five had a cardiac abnormality (ventricular septal defect requiring surgery, ventricular septal defect not requiring surgery, atrial septal defect with patent ductus arteriosus, tetralogy of Fallot, and perimembranous ventral septal defect with immobile tricuspid valve leaflet causing tricuspid regurgitation). Four children had been born preterm. Fourteen children (18%) had associated airway anomalies other than laryngomalacia (7 had tracheomalacia; 1, tracheobronchomalacia; 1, tracheomalacia with first-degree laryngeal cleft; 1, tracheobronchomalacia with first-degree laryngeal cleft; 1, first-degree laryngeal cleft; 1, subglottic stenosis; 1, microlarynx; and 1, aberrant subclavian artery causing pulsatile compression of the lower trachea).

Of the 76 children, the symptoms at presentation included apneic episodes in 9 (12%), cyanotic attacks in 9 (12%), feeding difficulties in 21 (28%), and failure to thrive in 30 (39%). Symptoms suggestive of gastroesophageal reflux were present in 8 (11%) of the 76 children (pH monitoring was not routinely performed).

Complete follow-up data were available for 59 children (78%). Seventeen children were lost to follow-up: 11 were discharged to be followed up at their local hospital, but there was no further correspondence; 3 moved...
away from Scotland; 2 failed to attend for follow-up; and 1 was transferred to the cardiac team for aortopexy for associated pulsatile tracheal compression caused by an anomalous right subclavian artery.

Of the 59 children with complete follow-up data, resolution of stridor was complete in 34 (58%), with mild residual stridor in 4 (7%) and persistent stridor but good weight gain in 5 (8%), giving a total of 43 children (73%) for whom 1 operation was successful. Age-appropriate weight gain was deemed a successful outcome, with resolution of stridor being a secondary measure.

Two children required a brief period of intubation postoperatively before full recovery. Four had postoperative respiratory tract infections, 2 of whom recovered without further problems. One child required treatment on ITU admission for sepsis before full recovery. One child was reintubated on ITU admission, and on recovering from the infection, he continued to be strident with poor weight gain. Following a second admission to the ITU for intubation, a tracheostomy was performed.

Seven children required revision endoscopic laser surgery to control symptoms. In 3 of these cases, symptoms resolved after 1 further procedure, and in 1 case 2 further procedures were required to control symptoms. After these repeated procedures using the same technique, 47 children (80%) were successfully treated. One child was still strident after 4 repeated procedures and had undergone a fundoplication by the pediatric surgeons prior to moving out of Scotland. Another 2 children with severe quadriplegic cerebral palsy had multiple repeated procedures that temporarily controlled strident and apneic symptoms.

One child died of cardiac abnormalities 17 days after laser epiglottopexy. Eight required a tracheostomy, of whom 6 had neurological or syndromal abnormalities and 2 had associated tracheomalacia. There were no cases of supraglottic stenosis in this series. Outcomes are summarized in the Table with figures from other published series for comparison. Thirty-four children had their weight recorded (growth charts used: Child Growth Foundation, January 1996 [United Kingdom cross-sectional reference data: January 1996], 2 Mayfield Ave, London W4 1PW, England) on at least 3 occasions: preoperatively, at the time of operation, and postoperatively, allowing their age-appropriate percentiles to be used as an objective marker of weight gain and therefore the success of the surgery (Figure 4). Of these 34 children, 30 showed an increase in growth velocity after surgery. Statistical significance was confirmed by calculating the mean change in percentiles per month for each child before and after surgery and performing a nonparametric within-subjects comparison (Wilcoxon signed rank sum test, P<.001).

Of the remaining children, 1 had persistent failure to thrive due to Hirschsprung disease. Another child proceeded to grow along a lower percentile line with no other health concerns. The third child’s stridor resolved and continued to grow along the 50th percentile line on which they were born. The fourth child who was referred from outside the hospital’s catchment area was listed for a repeated procedure but failed to attend and was lost to follow-up. The 30 children described in the case notes as failure to thrive faired well, with outcomes at least as good as that for the group as a whole. There were weight data for 15 of these 30 children. Of these 15 children, 13 had 1 operation with return to appropriate weight gain. Two children required a repeated procedure, with 1 going on to have a tracheostomy.

**COMMENT**

It can be difficult to compare the results of different surgical procedures for laryngomalacia as all published reports are retrospective and many consist of various pro-
cedures performed by different surgeons. We present herein a single-surgeon series using a consistent technique.

Our study population is broadly comparable to those in other series, with the majority being neonates and young infants and with a male-to-female ratio of 2:1.

We have included children with associated anomalies (syndromal, cardiac, neurological, and airway anomalies), although some other authors excluded these children from their series because they are known to have poorer outcomes from supraglottic surgery.

Published reports of laryngomalacia surgery mostly rely on a subjective assessment of whether the child has improved. Tracheostomy is more objective but is necessary in only a small proportion of children, and the need for tracheostomy is more dependent on the child's co-morbidity than on the effectiveness of the supraglottic surgery. For example, published series with a high proportion (50% or more) of neurologically impaired children report the highest tracheostomy rates of 17% to 22%. Certainly, we found that the only children who required tracheostomy in our series, representing an unequivocal failure of supraglottic surgery, were those with neurological disorders, syndromes, or tracheomalacia.

The need for revision surgery can be used as another semiojective outcome, although it depends on the surgeon's opinion of whether the child needs another operation. In our series, 7 children (12%) required revision surgery. Although this is higher than some of the other reported series, we believe that it is better to perform multiple, more conservative procedures on a few children for a self-limiting condition rather than use a technique with a higher success rate and the possible risk of causing permanent scarring. Our results with this approach are not noticeably worse than those reported for bilateral aryepiglottic fold division and/or mucosal excision, for which revision surgery is required in 4% to 17%.

An alternative approach to reduce the risk of complications is to operate only on 1 side of the larynx, but this carries a revision rate of 15% to 50%.

Complication rates are also objective to some degree, although they may not always be accurately quantified in a retrospective review. The laser technique described herein has the advantage of avoiding mucosal excision or incision, and therefore we believe it has a significantly lower risk of causing supraglottic stenosis compared with other techniques. Supraglottic stenosis rates approximating 4% have been reported by some authors after surgery involving aryepiglottic fold division and mucosal debulking. Such complications can be difficult to treat and should be avoided if at all possible. We have not had any cases of supraglottic stenosis in our series. Overall, complications have been few and minor in nature.

The resolution of stridor was 58% in this series. This is comparable to 2 other series listed in the Table. However, we favor using weight gain as the primary outcome measure. Laser epiglottopexy has a success rate of 73% according to weight gain. We accept that some children may have mild residual stridor that will be self-limiting and does not require revision surgery as long as their weight gain is appropriate.

Weight is an objective measure that can be standardized for age by means of the percentile chart. We have routinely used, for some time now, the weight percentile chart as a means to monitor children during management of laryngomalacia, both for those undergoing surgery and those being managed conservatively. We find it to be a sensitive indicator of an adequate airway in a child. To our knowledge, this study is the first to report weight percentiles before and after surgery, showing impaired growth velocity preoperatively, with catch-up growth postoperatively (Figure 4). Success can be defined as a child who attains a normal height and weight and growth rate pattern for his or her appropriate gestational age without the requirement of a tracheostomy or supplemental feeding.

We believe that our data support the view that laser epiglottopexy is a safe and effective treatment option for children with laryngomalacia. We recommend the use of weight percentiles as an objective outcome measure in future studies on this subject.

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REFERENCES