**Objectives:** To study the failures and complications of bilateral supraglottoplasty in children with severe laryngomalacia and to compare children with isolated laryngomalacia (IL) with those who have additional congenital anomalies (ACAs).

**Design:** Retrospective medical record review.

**Setting:** Two tertiary referral centers.

**Subjects:** A total of 136 consecutive patients, aged 3 days to 60 months (median age, 3 months) who underwent laser or instrumental bilateral supraglottoplasty. Isolated laryngomalacia occurred in 102 children, aged 3 days to 19 months; ACAs were found in 34 children, aged 3 weeks to 60 months.

**Outcome Measures:** Persistence of dyspnea, sleep apnea, and/or failure to thrive; need for further treatment; minor complications (defined as granuloma, edema, or small web); or major complication (supraglottic stenosis).

**Results:** Failures or partial improvement were observed in 12 (8.8%) of 136 cases, all having ACAs. The overall rate of complications was 7.4% (10/136). There were no significant differences between the IL and ACA groups concerning the rate of recurrence needing revision surgery (3/102, 2.9% vs 3/34, 9%), the rate of minor complications (4/102, 3.9% vs 1/34, 3%), or the rate of supraglottic stenosis (4/102, 3.9% vs 1/34, 3%). Supraglottic stenosis was managed by revision surgery in 4 cases and/or noninvasive ventilatory assistance in 2 cases. The long-term outcome appeared to be better when reintervention could be avoided or was kept to a minimum.

**Conclusion:** Failure of supraglottoplasty was only observed in cases of laryngomalacia with ACAs. The complication rate was similar whether or not ACAs were present.

**Arch Otolaryngol Head Neck Surg. 2003;129:1077-1080**

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**LARYNGOMALACIA** is the most common cause of stridor in children. Laryngomalacia consists of upper airway obstruction due to a supraglottic collapse with involvement of the arytenoid mucosa, the aryepiglottic folds, and the epiglottis. Many theories have been proposed to explain this condition without any consensus, and, to date, the pathophysiology of the condition is still not well understood. Laryngomalacia is probably responsible for a variety of diseases. Apart from the frequent association with gastroesophageal reflux, most cases are isolated; however, the forms that are associated with other conditions or that represent part of a recognized syndrome are frequent in series reports of severe cases: 17% to 47%. In most cases, the airway obstruction is well tolerated, causing a stridor, which is usually present at birth and worsens up until age 4 to 6 months and then decreases and resolves by age 18 to 24 months.

From 5% to 10% of the children with laryngomalacia have a severe form with chronic dyspnea, failure to thrive, and/or obstructive sleep apnea. The management of these cases has been radically modified by the development of endoscopic surgery as an alternative to tracheotomy or to prolonged feeding via a nasogastric tube. After some isolated descriptions of successful endoscopic procedures during the first half of the 20th century, Lane et al in 1984 and then Seid et al in 1985 using microinstruments or a carbon dioxide laser reported endoscopic surgery to be an effective treatment for laryngomalacia. Following these reports, several larger series (Zalzal et al, 10 cases; Polonovski et al, 39 cases; and McClurg and Evans, 24 cases) showed good results and only minor adverse effects with this approach, referred to as a...
supraglottoplasty or aryepiglottic fold division or excision. In 1987, Solomons and Prescott described the first supraglottic stenosis secondary to this procedure, and interarytenoid adhesion has been reported by Katin and Tucker and Jani et al. The aim of our study, performed in 2 referral centers, was to determine the rate of failures and minor and major complications with supraglottoplasty in children and to investigate if this was correlated with the presence of associated disease.

### METHODS

This retrospective study was conducted from January 1990 to December 2000 in the Pediatric Otolaryngology Departments of the Armand-Trousseau Children’s Hospital in Paris and the Gui de Chauliac Hospital in Montpellier, France. A total of 136 consecutive patients, aged 3 days to 60 months at the time of surgery, underwent a supraglottoplasty during this period and were included in the study.

All patients were classified as having severe laryngomalacia because of chronic dyspnea and/or failure to thrive with growth retardation and/or obstructive sleep apnea. In most cases, the diagnosis of laryngomalacia was made during the initial consultation using a flexible laryngoscope after applying local anesthesia to the nostril. The diagnosis was confirmed after complete endoscopic assessment and videotape recordings in the operating room, including another laryngoscopy while the patient was awake, followed by a rigid laryngotraceobronchial endoscopy during spontaneous breathing while the patient was anesthetized.

Supraglottoplasty was usually performed as a separate procedure after completing the endoscopic assessment and after informing the parents about the benefits and risks of the surgery. The surgical procedure was generally conducted under spontaneous breathing anesthesia to allow the best views of the posterior supraglottic region without an endotracheal tube. In some cases, preglottic jet ventilation or endotracheal intubation was necessary. The laryngoscope was placed under suspension, and the supraglottoplasty was performed using either carbon dioxide laser (superpulse mode, 3-5 W) (17 cases) or laryngeal microinstrumentation (119 cases). The mucosa of the aryepiglottic folds was first divided. The redundant mucosa, identified by the “suction test,” was then removed along with the aryepiglottic folds and the lateral epiglottis in some cases.

On completion of surgery, some patients needed to be intubated until the complete reversal of anesthesia. During the first 2 years of this study, patients were observed for 24 hours in the intensive care unit, and some of them were intubated for 24 hours. All the patients who required intubation during the procedure were extubated at the end of the procedure and observed for a minimum of 3 hours in the recovery room before being transferred to the otolaryngology department. Corticosteroid therapy (betamethasone, 125 μg/kg) was routinely used for 5 days after the procedure, and antibiotics (amoxicillin–clavulanic acid) were given for 7 days. All patients received antireflux therapy with cisapride when the diagnosis of severe laryngomalacia was made, and this treatment was maintained after surgery. After 1997, systematic antiresecretory treatment was added, using ranitidine (10 mg/kg) or omeprazole (1 mg/kg). An endoscopic examination under local anesthesia was performed 5 to 8 days after surgery to evaluate healing of the laryngeal mucosa.

Medical charts were reviewed to evaluate preoperative symptoms, associated disease, surgical technique (laser or microinstruments), postoperative outcome (persistence of dyspnea, sleep apnea, and/or failure to thrive), need for further treatment, minor complications (defined as granuloma, edema, or small web), and major complication (supraglottic stenosis). The surgery was regarded as successful when the original symptoms disappeared without the need for any other treatment and when the clinical evolution was satisfactory, especially with respect to the height and weight charts. Children with a well-tolerated residual stridor were included in this group. Some cases were classified as “partial improvement,” namely, those children who had both respiratory and feeding problems. Surgery improved the dyspnea (no oxygen therapy or further treatment was necessary after surgery) but had no benefit on feeding problems (ie, nasogastric feeding was still required).

We considered a “recurrence” to be the reappearance of symptoms of severe laryngomalacia (ie, chronic dyspnea and/or failure to thrive with growth retardation and/or obstructive sleep apnea) 4 weeks or more after surgery in children initially free of these symptoms after postsurgical healing of the mucosa. Cases classified as a “failure” had no improvement of the initial symptoms and required further therapy (tracheotomy, noninvasive ventilation, oxygen therapy, or nasogastric feeding).

### RESULTS

The 136 patients included were aged 3 days to 60 months (median, 3 months) at the time of surgery. No associated disease—isolated laryngomalacia (IL)—was found in 102 children, aged 3 days to 19 months. Associated congenital anomalies (ACAs) were found in 34 children, aged 3 to 60 months. These were mainly Pierre Robin or “Robinlike” syndromes (retrog Thornton, glossop tosis, and pharyngolaryngomalacia) and encephalopathies (Table 1).

The overall success rate was 79% (108/136). Success was clearly achieved in a higher proportion of cases in the IL group than in the ACA group: 89.2% (91/102) vs 50% (17/34) (P=.001). Failures or partial improvement were observed in 12 (8.8%) of the 136 cases, all having ACAs (Table 2). Failures were managed in 3 cases by tracheotomy, in 1 case by noninvasive ventilatory assistance, and in 1 case by nursing, nasogastric feeding, and oxygen therapy. There were no significant differences between the IL and ACA groups in the rate of recurrence needing revision surgery (3/102, 2.9% vs 3/34, 9%; P=.18), the rate of minor complications (4/102, 3.9% vs 1/34, 3%; P>.99), and the rate of supraglottic stenosis (4/102, 3.9% vs 1/34, 3%; P>.99) (Table 2).

Ten (7.4%) of 136 patients experienced complications. Five patients had successful outcomes after minor complications diagnosed during the control endoscopy. Two of these had granulomas that were removed.

### Table 1. Associated Congenital Anomalies

<table>
<thead>
<tr>
<th>Anomaly</th>
<th>No. (%) of Patients (N = 136)</th>
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<tbody>
<tr>
<td>Pierre Robin or “Robinlike” syndrome</td>
<td>13 (38.2)</td>
</tr>
<tr>
<td>Psychomotor retardation, encephalopathy</td>
<td>7 (20.6)</td>
</tr>
<tr>
<td>CHARGE association</td>
<td>2 (5.9)</td>
</tr>
<tr>
<td>Down syndrome</td>
<td>2 (5.9)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>10 (29.4)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>34</strong></td>
</tr>
</tbody>
</table>

Abbreviation: CHARGE, coloboma (of eyes), hearing deficit, choanal atresia, retardation of growth, genital defects (male only), and endocardial cushion defect.

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under general anesthesia at the time of the endoscopy. Two others had significant edema at day 7 associated in 1 case with a granuloma at the top of the left arytenoid; in both cases these lesions resolved in a few days after extended antibiotic treatment and the introduction of ranitidine (not systematically used before 1997). One child had a posterior fibrous web between the arytenoids divided with microscissors.

Five (3.7%) of 136 patients developed a major complication (ie, a supraglottic stenosis). In case 1, supraglottoplasty was performed with microinstruments and laser at age 8 weeks in a boy affected by an IL with chronic dyspnea and failure to thrive. Several recurrences a few days after surgery were managed by revision surgery (3 procedures between age 3 and 15 months), with resection of fibrous supraglottic webs (Figure). Persistent dyspnea on effort promoted a final surgical intervention at age 7 years for adhesions. Freeing of the adhesions led to an improvement of the dyspnea.

Patient 2 was a 6-month-old boy with type 1 von Recklinghausen disease in whom surgery was indicated because of chronic dyspnea and failure to thrive associated with obstructive sleep apnea. Surgery was performed using microinstruments. Supraglottic stenosis was apparent at the first control endoscopy, and 2 revision procedures were performed 7 weeks and 12 months after the initial surgery. This child was lost to follow-up until he was 3 years old, at which point polysomnography confirmed the presence of obstructive sleep apnea due to laryngeal obstruction with very fibrous aryepiglottic folds. This was managed first by noninvasive ventilatory assistance and then by nocturnal nasal oxygen therapy. He is currently 6 years old and still managed by oxygen therapy.

Patient 3 was a 6-week-old girl with very severe laryngomalacia and major dyspnea. After supraglottoplasty with microinstruments, 3 revision procedures were performed for early recurrences of dyspnea caused by supraglottic adhesions. She is currently 3 years old and undergoing noninvasive ventilatory assistance to manage persistent obstructive sleep apnea.

Patient 4 was a 5-week-old girl who was operated on with microinstruments for an IL complicated by obstructive sleep apnea. Fibrous webs were detected at the first control procedure, and no revision surgery was performed. Dyspnea was persistent during crying and sleeping, but there was no growth retardation. She was managed with oxygen therapy and inpatient surveillance followed by a return home and several brief admissions during the first year of life for exacerbation of dyspnea during upper airway infections. Polysomnography when she was 12 months old showed hypopnea without apnea.

Patient 5 was operated on using a laser for chronic dyspnea with failure to thrive. Rapid recurrence of the dyspnea signaled a supraglottic stenosis, which was managed by partial epiglottectomy with microinstruments with a good improvement of the symptoms and no further recurrence.

**COMMENT**

Supraglottoplasty has been an undoubted success in the management of severe laryngomalacia in the newborn.

![Granuloma, edema, and small web.](Image)

Table 2. Results and Complications of Supraglottoplasty in 136 Children

<table>
<thead>
<tr>
<th>Result</th>
<th>Isolated Laryngomalacia (n = 102)</th>
<th>Associated Congenital Anomalies (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>91 (88.2)</td>
<td>17 (50)</td>
</tr>
<tr>
<td>Success after minor complications*</td>
<td>4 (3.9)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Partial improvement</td>
<td>0</td>
<td>7 (21)</td>
</tr>
<tr>
<td>Failure</td>
<td>0</td>
<td>5 (15)</td>
</tr>
<tr>
<td>Recurrence with revision surgery</td>
<td>3 (2.9)</td>
<td>3 (9)</td>
</tr>
<tr>
<td>Supraglottic stenosis</td>
<td>4 (3.9)</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

*Granuloma, edema, and small web.

However, after an initial period from 1987 to 1995, when the different teams performed classic bilateral supraglottoplasty, several studies were published reporting less invasive techniques, probably traducing the problems of supraglottic webs or stenosis encountered by many pediatric otolaryngologist teams. In the present study, 3.7% of the patients developed a supraglottic stenosis, and this rate is very similar to that reported by Reddy and Matt12 (2/57 cases or 4%). Kelly and Gray13 and Reddy and Matt12 have studied the results of the unilateral surgical procedure: 3 (17%) of 18 and 7 (17%) of 42 children, respectively, needed a contralateral procedure; but neither author observed supraglottic stenosis following unilateral surgery. Loke et al14 reported a series of 33 patients treated by simple division of the aryepiglottic folds without complications. In 1 case with associated disease, the treatment failed, and a tracheotomy was required; in 2 cases (6%) revision surgery was needed to remove the redundant mucosa.14 No supraglottic stenosis was observed.

These more conservative procedures seem to be safer, but the success rate is lower. Knowing the risk factors predictive of complications would be particularly use-
ful in deciding which type of surgery is indicated. Authors who reported cases of supraglottic stenosis did not highlight specific risk factors. We found that the presence of ACAs is a risk factor for failure or partial failure, but the complication rate is similar to that observed in children with IL. The use of laser vs microinstruments was not statistically a risk factor for supraglottic stenosis in the present study (2/17 laser vs 3/119 microinstruments; P > .05). The role of gastroesophageal reflux could be a factor. However, despite the systematic use of ranitidine or omeprazole during the last 4 years of our study, we observed 2 supraglottic stenoses during this period.

To date, there are no reliable predictors for the development of fibrous webs or adhesions after supraglottoplasty. However, better management of these complications could avoid more iatrogenic lesions. When analyzing our 5 case reports of major complications, we found that the long-term outcome seemed better when reintervention could be avoided or kept to a minimum. Noninvasive ventilatory assistance in patients with laryngomalacia has been developed in Armand-Trousseau Children's Hospital by Fauroux et al.15 These authors have demonstrated the benefit (on gas exchange and growth) of long-term, home, noninvasive ventilatory assistance in children with laryngomalacia complicated by obstructive sleep apnea. This technique allowed a tracheotomy to be avoided in several children.

As a result of the findings in the present study, in our practice we now (1) avoid large mucosal resections, especially if the resected areas of mucosa are facing each other on either side of the aryepiglottic fold, and (2) propose to the parents to first attempt nasogastric feeding, oxygen therapy, or noninvasive ventilatory assistance to try to avoid revision surgery in cases of postoperative stenosis when the airway obstruction is not major.

In conclusion, the presence of associated disease with laryngomalacia was a risk factor for surgical failure, but no predictive factors for the development of minor or major complications were found. The complication rate was 7.4%, and half of these complications were severe, requiring prolonged follow-up. By avoiding large mucosal resections during the initial surgery and by opting for noninvasive treatments for early stenoses and limiting surgical reintervention, surgeons might reduce the rate of severe complications.

Submitted for publication October 10, 2002; accepted December 5, 2002.

This article was presented at the 17th Annual Meeting of the American Society of Pediatric Otolaryngology; May 14, 2002; Boca Raton, Fla.

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Editorial Comment

This article is an honest appraisal of 136 pediatric patients with laryngomalacia, and in some cases ACAs, who underwent bilateral supraglottoplasty. The overall complication rate was 7.4%, and the authors note failure of supraglottoplasty only in patients with ACAs.

Most authors are reluctant to publish data concerning complications, for obvious reasons. The honesty with which these authors discuss the risks and complication rate as well as failure rate among the large numbers of patients undergoing supraglottoplasty at these tertiary care hospitals is refreshing. Discussions relating to failure and complication rates are usually reserved for author-to-author conversations at conferences rather than in published literature.

Nonetheless, a number of other authors have commented on the increasing chance of failure when laryngomalacia occurs in patients with other abnormalities. The findings of Denoyelle et al reinforce this fact. Articles such as “Failures and Complications of Supraglottoplasty in Children” enumerate the risk involved when this simple procedure is applied to a large number of children and fails for some, who then need further surgery to treat their stenosis. This allows better understanding of such an operation in the greater scheme of what can be offered to the child with severe laryngomalacia.

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REFERENCES