Cricotracheal Resection in Children Weighing Less Than 10 kg

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Objective: To review cricotracheal resection (CTR) in children weighing less than 10 kg.

Design and Setting: Retrospective study of 17 patients (mean follow-up, 23 months) from 3 ear, nose, and throat pediatric centers.

Patients: Seventeen children (10 boys and 7 girls; mean age, 14.6 months; and mean weight, 7.6 kg) undergoing CTR from June 1995 to March 2003.

Main Outcome Measures: Decannulation rates and endoscopies.

Results: The cause was congenital subglottic stenosis in 2 children (12%) and acquired subglottic stenosis in 15 (88%). All but 1 had grade 3 or 4 stenosis. The mean hospitalization duration was 34 days. Single-stage CTR was performed in 11 children (65%), with peroperative decannulation in 7. Extubation of these patients occurred between days 3 and 9. Decannulation of the other 6 patients was performed after a median of 15 days. Sixteen (94%) of the 17 children were decannulated. Four patients required additional carbon dioxide laser treatment for subsequent glottic or subglottic edema or granulomas, but no reintubation was necessary. One child could not be decannulated because of bronchopulmonary disease, and subglottic stenosis recurred. Long-term tracheotomy was avoided in all other patients. Another child died of cardiac disease. All other patients remained free of significant subglottic stenosis at follow-up.

Conclusions: Cricotracheal resection in small children weighing less than 10 kg was a safe and effective procedure for severe subglottic stenosis. To our knowledge, this is the first reported attempt of CTR in this weight category, providing results comparable to those published in older children.


LARYNGOTRACHEAL STENOSIS in children can be congenital or acquired. Congenital stenosis is uncommon, and the clinical expression is variable, ranging from simple subglottic narrowing, which may be asymptomatic or associated with minor symptoms, to severe grade 3 or 4 stenosis. In the 1970s, the development of neonatal medicine and the need for prolonged intubation led to an increase in the incidence of acquired laryngotracheal stenosis. This was followed by progress in ventilatory techniques and the widespread use of artificial surfactant, which led to a decrease in the duration of intubation and even complete avoidance of intubation, thereby reducing the incidence of acquired stenosis. However, medical advances have had little effect on the incidence of congenital stenosis, other than a slight reduction largely due to termination of pregnancy following antenatal screening for trisomy 21 (Down syndrome).

At the same time, there have been considerable advances in the management of laryngotracheal stenosis by pediatric ear, nose, and throat teams using laryngotracheoplasty techniques. These techniques have been shown to produce good results in cases of grade 2 and 3 stenoses, but there is a nonnegligible rate of failure for severe grade 3 and 4 stenoses.

In the 1990s, a new surgical concept was developed for the management of these stenoses. Up until then, the various techniques consisted of enlargement of the structures involved, via a median and vertical approach, which was safe with respect to the adjacent neural structures, in particular, the recurrent nerves. In adults, a more aggressive approach toward laryngotracheal stenosis had already been used since the mid 1970s. This involved cricotracheal resection (CTR), in which the stenosed zone is excised with an end-to-end anastomosis of the distal healthy trachea to the thyroid cartilage. The reluctance to use this procedure in the pediatric
population was largely due to concerns about the risk of growth abnormalities of the laryngotracheal axis after such surgery. The first series to be published of CTR in children, by Monnier et al\(^1\) in 1993, allayed these fears. Successful outcomes had been earlier suggested by the experimental work of Fearon and McMillin,\(^2\) published in 1985, on CTR in growing primates, subsequently confirmed by Ward and Triglia\(^3\) in a rabbit model. Published series have now established the absence of growth abnormalities of the laryngotracheal axis after CTR and documented good results in children with severe grade 3 and 4 stenoses, as well as in laryngotracheoplasty failures.\(^4,10,17-21\)

This article does not aim to address the issue of the exact role of CTR in the management of laryngotracheal stenosis in children, a subject that has been dealt with in the past. Rather, we investigated whether there is a lower limit to the weight or age at which CTR can be performed, variables that have rarely been looked at in the literature.\(^4,18,19\)

The experience at 3 pediatric centers is presented, and the advantages of early surgical management are discussed.

### METHODS

A retrospective search from June 1995 to March 2003 was performed to identify patients treated for subglottic stenosis at 3 different centers (pediatric ear, nose, and throat departments in Paris, Marseille, and Lyon) with a presentation weight of less than 10 kg and for whom an endoscopy result was available after 1-year follow-up. Seventeen patients were identified, 10 boys and 7 girls.

Eleven patients (65%) (median age, 8.5 months; and median weight, 7.5 kg) had a single-stage CTR, with peroperative decannulation in 7 patients and without the need for a tracheotomy in the other 4 patients. In the remaining 6 patients (median age, 18.0 months; and median weight, 9.0 kg), the tracheotomy was removed a median of 15 days after CTR.

Sixteen (94%) of the 17 patients have been decannulated (or were never cannulated) and do not have any respiratory difficulties, with a minimum endoscopic follow-up of more than 12 months in all patients. The mean follow-up was 23 months (range, 12-48 months).

One patient still has a tracheotomy for the management of an adjacent bronchial chondromata (with multiple airway site involvement).\(^22\) After an initially satisfactory result, it was impossible to extubate this child because of bronchial hypersecretion. At day 50 after surgery, a tracheotomy was performed to allow regular bronchial aspiration. This patient has relapsed with a grade 3 subglottic stenosis. Another patient died of an underlying cardiac condition 12 months after CTR. This child did not experience any respiratory difficulty after the surgery.

Of the 13 patients with a preoperative tracheotomy, 6 retained the tracheotomy in the immediate postoperative period, and they were decannulated between days 14 and 180. Five patients required a Silastic stent (a roll made with a sheet of thin Silastic, tailored according to need) for 15 to 33 days with a tracheotomy (which was removed at the same time as the stent in 3 patients and later in 2 patients). Extubation of the patients who did not have a postoperative tracheotomy occurred between days 3 and 9 (mean, day 3.9).

### RESULTS

Table 1 summarizes the preoperative data of the patients, while Table 2 details the surgical management. All but 1 patient had grade 3 or 4 stenosis. There was no supraglottic stenosis, and the mobility of the vocal cords was normal in all patients. Two patients (12%) had congenital stenosis (grades 3 and 4). The remaining 13 patients (88%) had acquired stenosis secondary to prolonged or repeated intubation. Eleven patients had different malformations, the surgical treatment of which was often the cause of prolonged intubation, which then led to laryngotracheal stenosis. Thirteen patients (77%) had a tracheotomy before surgery, and CTR was the first intervention in all patients.

<table>
<thead>
<tr>
<th>Patient No./ Sex/Age, mo</th>
<th>Weight, kg</th>
<th>Medical History and Associated Pathologic Conditions</th>
<th>Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/14</td>
<td>8.5</td>
<td>Urologic surgery</td>
<td>Congenital No</td>
</tr>
<tr>
<td>2/M/7</td>
<td>5.5</td>
<td>Polymalformation anorectal atresia</td>
<td>Acquired Yes</td>
</tr>
<tr>
<td>3/F/7</td>
<td>5.3</td>
<td>Cardiac surgery</td>
<td></td>
</tr>
<tr>
<td>4/F/6</td>
<td>5.0</td>
<td>Cardiac surgery</td>
<td></td>
</tr>
<tr>
<td>5/M/14</td>
<td>6.5</td>
<td>Cardiac surgery</td>
<td></td>
</tr>
<tr>
<td>6/F/18</td>
<td>9.0</td>
<td>Bronchopulmonary dysplasia</td>
<td></td>
</tr>
<tr>
<td>7/F/12</td>
<td>7.5</td>
<td>Bronchial chondromatosis</td>
<td></td>
</tr>
<tr>
<td>8/F/22</td>
<td>9.0</td>
<td>Pierre Robin triad</td>
<td></td>
</tr>
<tr>
<td>9/M/5½</td>
<td>7.5</td>
<td>Subdustral hematoma</td>
<td></td>
</tr>
<tr>
<td>10/M/1½</td>
<td>3.8</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>11/M/16</td>
<td>9.0</td>
<td>Inguinal hernia repair</td>
<td></td>
</tr>
<tr>
<td>12/M/17</td>
<td>9.8</td>
<td>Bronchopulmonary dysplasia</td>
<td></td>
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<tr>
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<td>None</td>
<td></td>
</tr>
<tr>
<td>14/F/21</td>
<td>9.0</td>
<td>Encephalopathy</td>
<td></td>
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<tr>
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<td>8.9</td>
<td>Bronchopulmonary dysplasia</td>
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<td>6.0</td>
<td>Bronchopulmonary dysplasia and cardiac surgery</td>
<td></td>
</tr>
<tr>
<td>17/M/28</td>
<td>9.5</td>
<td>Cardiac surgery</td>
<td></td>
</tr>
</tbody>
</table>

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Four patients required additional carbon dioxide laser treatment (between days 7 and 13), for subsequent granulomas in 3 patients and subglottic edema in 1 patient. Neither reintubation nor recannulation was necessary in these patients. The mean total hospitalization duration for treatment of the subglottic stenosis was 34 days (range, 13-72 days), including a median intensive care unit stay of 8 days (range, 1-50 days; and mean, 14 days).

To our knowledge, this is the first series to be published of CTR in children weighing less than 10 kg. Various series in the literature have dealt with older children, most notably the series reported by Rutter et al., in which the mean age of subjects was 6 years. Monnier et al reported on a large series of 60 patients, which included 6 infants younger than 1 year (the exact ages were not specified). In the literature, the weight of children is not systematically reported, although 1 study stated that a minimum weight of 10 kg is desirable for surgery. In our study, the mean weight was less than 10 kg.

The results of our series, with respect to decannulation in 94% of subjects without any respiratory difficulties, are identical to those in the literature. The small number of patients in this series is due to the selection criterion of weight less than 10 kg. Nevertheless, the minimum follow-up was 12 months, with follow-up of at least 2 years in 8 patients, indicating that these results can be regarded as stable and definitive, despite the young age of the patients.

The postoperative outcomes were the same as those reported in the literature with respect to extubation (between days 3 and 9) and decannulation of patients still having a tracheotomy. The surgical technique was the same as that for older children, apart from the use of magnifying glasses or an operative microscope at times because of the small size of the structures being manipulated. In this series, there were no postoperative complications related to the young age or low weight of the patients. Glottic and sometimes subglottic edema appears to be more frequent than in older children but did not necessitate prolonged intubation. However, such interventions necessitate the availability of an on-site pediatric and neonatal intensive care unit that is familiar with such techniques and the active cooperation of other members of the pediatric team, in view of the high rate of associated malformations.

Although these initial results are encouraging, what is the value of early surgical management? Certain disorders that may be associated with stenosis, such as laryngomalacia, tracheomalacia, or impaired vocal cord mobility, are more frequent in infants than in older children and may complicate the surgical management. In our series, there was only 1 patient with any of these associated pathologic conditions, namely, suprastomal tracheomalacia, which was excised during CTR. No patient had impaired vocal cord mobility, despite a history of cardiac surgery in 5 patients. Therefore, in our series, there was no laryngotracheobronchial pathologic condition among infants that could have complicated the surgical management.

Thirteen patients (77%) had a tracheotomy before surgery, which is in keeping with results of other series. As CTR is largely reserved for grade 3 or 4 stenosis. Only 2 patients (12%) in our series had congenital stenosis, which is similar to or less than the incidence in the series with older children. Therefore, there was no overrepresentation of such cases in our series, which would create a more favorable surgical group.

Faced with a severe subglottic stenosis in a young child, it is possible to delay surgery, with or without a tracheotomy, until the child has attained a predetermined age and weight. The early surgical management reported herein (the youngest patient was 1½ months old and weighed 3.8 kg)
minimizes the risks of tracheotomy in newborns and may allow tracheotomy to be avoided. The complications and morbidity of tracheotomy in newborns and infants are far from negligible. As recently as 20 years ago, tracheotomy in infants and young children was considered a risky intervention in terms of morbidity and mortality. The various series in the literature of the 1970s and 1980s reported a complication rate of approximately 30%, mainly pneumomediastinum and pneumothorax, and a 2% to 3% mortality directly related to the tracheotomy (obstruction or decannulation).21-25 Technical advances and improved management have led to better results in the more recent literature.26,27 but there is still significant morbidity, and mortality is not zero. Although it is difficult to compare these series, with different populations, techniques, and indications, mortality among the largest and most recent studies27-29 is between 0.5% and 1%, and complications are frequent (>50% in 2 recent series of 142 and 450 patients).28,29 Furthermore, the decrease in mortality in the recent literature is largely due to parental education in the management of tracheotomies,27-29 which suggests a favorable social and familial context. In addition, the development of children with a tracheotomy is not as good as that of other children of the same age, partly because of the tracheotomy itself and partly because of associated pathologic conditions. The criterion of a minimum weight of 10 kg for surgery could delay intervention significantly, as sometimes it is necessary to wait to well beyond the age of 1 year for these children to reach a weight of 10 kg. Therefore, the early surgical management reported herein minimizes the risks of tracheotomy and may allow tracheotomy to be avoided.

In conclusion, the total duration of the management of these patients appears to be shortened by early surgery, thereby allowing parents to establish a normal social interaction (ie, without the tracheotomy) with their child as soon as possible. The economic cost to society is also reduced, as the total hospitalization related to the management of severe subglottic stenosis is generally less than 1½ months.

If the principle of early surgical intervention is accepted, the choice between laryngotracheoplasty and CTR still depends on standard criteria, including any previous interventions, the severity of the stenosis, the anatomical extent of the stenosis, the degree and progression of inflammation, and the mobility of the vocal cords. These criteria do not need to be modified for patients weighing less than 10 kg.

In conclusion, the results of this first published series, to our knowledge, of CTR in children weighing less than 10 kg are encouraging and similar to those of other series in the literature involving older children.20,21 There was no difference among the series in the surgical technique or postoperative management. Therefore, CTR is an option for severe subglottic stenosis in children weighing less than 10 kg and allows the risks of tracheotomy at this age to be avoided or at least minimized.

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REFERENCES