Single-Stage Laryngotracheal Reconstruction: The Great Ormond Street Experience and Guidelines for Patient Selection

Chapman T. McQueen, MD; Nina L. Shapiro, MD; Susanna Leighton, MD, FRCS; Xu G. Guo; David M. Albert, MD, FRCS

Objectives: To review all patients undergoing single-stage laryngotracheal reconstruction and to determine guidelines to predict successful outcomes and prevent the necessity of tracheotomy following laryngotracheal reconstruction.

Design: Chart review.

Setting: Tertiary care children’s hospital.

Patients: A retrospective chart review was performed at our institution involving all patients who underwent single-stage laryngotracheal reconstruction from 1993 through 1996. A total of 28 patients were reviewed.

Results: Based on this chart review, a statistically higher incidence of extubation complications (P = .045), ie, bleeding, reintubation, or subcutaneous emphysema, occurred in children who weighed less than 4 kg. Although not statistically significant (P > .99), the relative risks of failure, defined as tracheotomy dependent or significant airway compromise following single-stage laryngotracheal reconstruction, were 3.43 if the child’s weight was less than 4 kg at the time of surgery and 2.31 if the gestational age was less than 30 weeks at the time of surgery. Length of time for intubation did not appear to have any effect on outcome.

Conclusions: Patients’ gestational age and weight at the time of surgery appear to have the most impact on successful outcome. Children weighing more than 4 kg and those with gestational age of greater than 30 weeks appear to have a greater chance at successful extubation and eventual patent airway. Duration of intubation following single-stage laryngotracheal reconstruction does not appear to affect outcome.


THE SURGICAL management of subglottic stenosis (SGS) has been evolving since posterior cricoidotomy was first described by Rethi1 in 1956. In the late 1960s, following the reintroduction of long-term intubation in children as an alternative to tracheotomy for ventilatory support, the incidence of acquired SGS has increased.2 This was found to be more severe than congenital SGS, and was twice as likely to require tracheotomy. There was a higher rate of morbidity and mortality in patients with acquired SGS than in those with congenital SGS.3

In 1974, Fearon and Cotton4 reported surgical correction of SGS by laryngotracheal reconstruction (LTR) with an interposition of autogenous cartilage anteriorly between the edges of the longitudinally divided cricoid cartilage and upper tracheal rings. This was followed by stenting of the larynx with a prosthesis for a period of weeks or months until healing occurred. Until recently, standard management of children with acquired SGS has consisted of tracheotomy and serial endoscopy to assess the size of the subglottic airway. Subglottic stenosis usually requires reconstruction when the subglottis will only accept a rigid bronchoscope of 2 or more sizes below the normal for that child’s age or weight.3 In up to 20% of children with grade I SGS (Table), growth of the airway results in decannulation without further intervention. In patients with higher grades of stenosis, LTR is required.9 In the series by Bailey3 (1988), 62% of patients needed anterior grafting (grades I and II), 30% required anterior and posterior grafting (grades III and IV), and 8% required only a posterior graft; the last group had primarily posterior stenosis and dense interarytenoid scarring. Ochi et al10 reported decannulation rates after reconstruction of 88% for patients with grades I and II SGS, 78% for grade III, and 50% for grade IV. Overall, with some children undergoing several procedures, a decannulation rate of more than 90% has been
PATIENTS AND METHODS

Twenty-eight children underwent SS-LTR at GOS since this procedure was begun at GOS in 1993. There were 9 females and 19 males. The mean and median gestational ages at birth were 32.8 and 31 weeks, respectively. The mean and median weights at the time of surgery were 7.6 and 6.25 kg, respectively. Twenty-two procedures were performed for acquired SGS, 5 for congenital SGS, and 1 for trauma of the subglottic airway. The grade of stenosis, based on the Cotton grading system of SGS, was as follows: 7 patients (25%), grade III; 12 patients (43%), grade II; 5 patients (18%), grade I; and 4 patients (14%), grade unknown.

All children had an SS-LTR as their first procedure for corrective airway surgery. The mean and median number of days after birth to the time of the first procedure were 421.75 and 235, respectively, with a range of 56 to 2460 days. Three (11%) of 28 patients had anterior and posterior grafts. The remaining 25 (89%) had anterior grafts only. Five (18%) of the 28 children had tracheotomies at the time of the first procedure. All procedures were performed by the consultant staff at GOS.

achieved. No adverse effects on laryngeal growth have been reported. The problems inherent in this management of SGS in children include the complications of a long-term tracheotomy. Adverse effects of tracheotomy on speech and language development have been documented, and the abnormal respiratory patterns and unduly effortful phonation of tracheotomy-dependent children have been shown to persist, even after successful LTR and subsequent decannulation. Rates of morbidity and mortality for tracheotomies in children are variable, with reports of morbidity up to 44% and mortality from 0.9% to 8.7%. There is also a considerable risk of behavioral difficulties in these children; the strain on the family of a child with a long-term tracheotomy should not be underestimated.

Long-term stenting of the larynx in traditional LTR is another factor associated with a significant morbidity. Swallowing difficulties and aspiration during stenting, granulation tissue delaying decannulation, and trauma to the free edge of the vocal fold mucosa with subsequent fibrosis have all been documented.

The anterior cricoid split procedure was reported by Cotton and Seid to reduce the need for tracheotomy in neonates in whom extubation is not possible because of SGS secondary to damage related to the endotracheal tube. Following the procedure, the endotracheal tube is left in place, acting as a stent, and then the child is subsequently extubated. The authors reported a success rate of 70% with this procedure. It has been emphasized that the pulmonary reserve in these neonates must be adequate to allow spontaneous respiration once the SGS is relieved so that reintubation is not required with its risk of further subglottic trauma.

Single-stage LTR (SS-LTR) has been a logical development of the anterior cricoid split. It developed independently in a number of centers in the late 1980s. The term has been used to describe both LTR as the primary surgery performed on a stridulous or intubated patient, avoiding tracheotomy, and LTR combined with surgical closure of a preexisting tracheotomy by a cartilage grafting technique. The 2 procedures resemble each other in that postoperatively, instead of prolonged endolaryngeal stenting, a nasotracheal tube is left in situ for a short period, usually 7 to 10 days, and the child is traditionally sedated, paralyzed, and ventilated in the pediatric intensive care unit. Although many practices paralyze and sedate their children, at the Hospital for Sick Children, Great Ormond Street, London, England (GOS), we traditionally limit sedation and rarely paralyze. Once subglottic edema has settled, signified by a low-pressure leak around the indwelling tube, the child is extubated.

Cotton et al reported in 1995 the Cincinnati experience of SS-LTR. One hundred sixteen children underwent SS-LTR with endotracheal tube stenting. One hundred seven of these 116 children underwent reconstruction of the laryngotracheal complex; 77 of whom had tracheotomies preoperatively and 30 of whom had no tracheotomy preoperatively. Sixty-three percent of all patients had Cotton grade I or II SGS. Eighty-seven percent of these patients left the hospital with an adequate airway without a tracheotomy. Although observations were made regarding failures and successes, no definitive comments were made regarding patient selection except for guidelines for adequate pulmonary function prior to the SS-LTR. In an effort to define guidelines for successful SS-LTR, we reviewed all cases of SS-LTR performed at GOS.

The mean and median duration of intubation following SS-LTR were both 6.5 days, with a range of 2 to 14 days. Complications following extubation were as follows: no complications, 16 patients (57%); stridor but not requiring reintubation, 5 patients (18%); and stridor requiring reintubation, 7 patients (25%).

Final outcomes of the first procedure for the 28 children were as follows. Fourteen (50%) had an excellent result with no resulting stridor, 8 (29%) had good results with mild stridor but no airway compromise, and
6 (21%) were tracheotomy dependent. Follow-up ranged from 14 to 1470 days.

Eleven (39%) of the 28 children required a second procedure: 1 (4%) required a revision SS-LTR for persistent stridor; 6 (21%) required tracheotomy; and 4 (14%) required laser excision of granulation tissue around the graft site.

Following the second procedure, the one child requiring a revision SS-LTR had an excellent airway with no residual stridor at 330 days’ follow-up. Outcomes of the 6 who required tracheotomies were as follows: 2 succumbed to disease other than airway; 1 underwent revision SS-LTR, resulting in a good airway with mild stridor but no airway compromise (follow-up, 60 days postoperatively); 1 was tracheotomy dependent; 1 had revision SS-LTR with excellent results and no residual stridor at 180 days follow-up; and 1 underwent 2-staged LTR with excellent results.

Of the 4 second procedures that required laser excision of granulation tissue, 3 had excellent results and 1 required a tracheotomy and died of disease unrelated to airway.

Twenty-four (86%) of the 28 patients left the hospital without requiring a tracheotomy. Of the 4 remaining patients, 1 (4%) remained tracheotomy dependent and 3 (11%) died of diseases unrelated to airway.

Statistical analysis was undertaken to identify factors that may predict successful outcomes. For the purpose of statistical analysis, successes were reported as children who underwent surgery and were not tracheotomy dependent and had no significant airway compromise following surgery. For weight less than 4 kg at the time of surgery, the relative risk of failure was 3.43 ($\text{P} = .14$). If gestational age was less than 30 weeks, the relative risk of failure was 2.31 ($\text{P} = .37$). There was no relative risk to intubation less than 7 days after the procedure. However, for children who weighed less than 4 kg, there was a statistically higher incidence of extubation complications, ie, bleeding, reintubation, or subcutaneous emphysema ($\text{P} = .045$). The relative risk of extubation complications was 2.88 ($\text{P} = .20$) for children who had a gestational age less than 30 weeks. There was no significant relative risk to extubation complications in children who were intubated less than 7 days ($\text{P} > .99$). No statistical significance was identified with respect to the sex of the child and successful outcome.

### Comment

Single-stage laryngotracheal reconstruction remains an excellent treatment modality for repair of the SGS in children. We have tried to define guidelines for selecting children for successful repair of SGs using the single-staged approach. Because our numbers are relatively small, statistical power was limited; however, based on relative risks, it appears that children weighing more than 4 kg and those with a gestational age greater than 30 weeks have a greater chance at successful extubation and eventual airway patency. It also appears that children weighing less than 4 kg have more complications surrounding extubation. This may be due to the other underlying disease states that are often present in these neonates or purely to their inherently small size. Finally, although not statistically significant, duration of intubation following surgery had no bearing on extubation complications or on final outcome.

### References