Chapter 34: Stenosis of the larynx

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Stenosis of the larynx is more frequent than tracheal stenosis; in a review of 752 cases of stridor seen at The Hospital for Sick Children, Great Ormond Street, London, laryngeal pathology accounted for 88% of the cases (Evans, 1986). The major cause of airway obstruction was as a result of congenital anomalies of the larynx and trachea. Holinger (1980) noted in his review of 219 patients with stridor, that it was caused by a congenital anomaly of the larynx or trachea in 87.2% of the patients. Congenital laryngeal anomalies are discussed in Chapter 26.

The incidence of acquired subglottic stenosis is increasing, resulting from the increased survival rate of preterm infants ventilated for bronchopulmonary dysplasia and hyaline membrane disease. The precise incidence of subglottic stenosis following intubation is difficult to establish. It is certainly less than the high figure of up to 20% reported in the late 1960s and early 1970s, the true incidence probably lying between 1 and 8% (Parkin, Stevens and Jung, 1976; Strong and Passy, 1977; Papsidero and Pashley, 1980; Ratner and Whitfield, 1983). This figure almost certainly underestimates the true incidence since, sadly, many low-birth weight infants do not survive, and minor degrees of subglottic stenosis may go undetected. Some are recognized only later as a result of persistent stridor following an upper respiratory tract infection, or as an incidental finding on intubation for general anaesthesia.

Aetiology and pathology

Many factors are involved in the creation of subglottic stenosis due to intubation; these include the material from which the tube is made, the shape and size of the tube (Marshak and Grundfast, 1981; Gould and Howard, 1985), its method of fixation and, above all, the skill and care which the intubated patient receives. Increased awareness of all these factors is extremely important if the incidence of subglottic stenosis is to be reduced further.

There are two varieties of acquired laryngeal stenosis related to intubation: soft and hard stenosis. In the soft stenosis, acute inflammatory oedema of the mucosa and submucosal connective tissue occurs (Rasche and Kuhns, 1972; Hawkins, 1978). Mucosal ulceration will then supervene, because of mucosal abrasion resulting from poor fixation of the endotracheal tube, or because of pressure if the endotracheal tube is too large. The process of ulceration will be accelerated by infection; good aseptic technique and strict hygiene will, therefore, minimize the infective complications of intubation. Chemical irritation from rubber or plastisizers used to soften plastic tubes may further aggravate the process of mucosal ulceration, as will any residue of chemicals used in the sterilization of the tubes, for example ethylene oxide (Guess and Stetson, 1970). The process of ulceration eventually exposes the perichondrium of the cricoid cartilage causing perichondritis and chondritis. This is usually associated with the production of granulation tissue and fibrosis. The stenosis associated with infection of the cricoid cartilage is of the hard variety. Hard stenosis may be further subdivided into two categories: fibrous and cartilaginous (Holinger, 1982). The fibrous stenoses can be dilated but tend to re-stenose, whereas the cartilaginous stenoses cannot be dilated.
Subglottic stenoses may also occur as a result of acute infection of the larynx (see Chapter 30) and of blunt trauma to the neck in hanging injuries. The incidence of direct laryngeal trauma as a result of road traffic accidents has declined as a consequence of legislation prohibiting the transport of children under the age of 5 years in the front passenger seat of cars, and the compulsory wearing of seat belts by older children. Iatrogenic stenosis of the larynx may also occur as a result of prolonged treatment of juvenile laryngeal papillomata and the injudicious use of the CO₂ laser. Whatever the aetiological factor, the end result is a scarred contracted laryngeal opening. Although the number of cases of acquired subglottic stenosis is increasing due to increased survival rates of preterm infants of low birth weight, the actual incidence of subglottic stenosis is falling due to the improved care of preterm babies who are intubated endotracheally. The histological nature of the cricoid cartilage of preterm babies has been noted by Hawkins (1978) to be hypercellular with a scant gel-like matrix, and it may be that it is more distensible; this would account for the fact that these tiny babies may tolerate endotracheal intubation for several weeks without gross damage to the subglottic larynx.

There is certainly no point in laying down arbitrary time scales for endotracheal intubation before a tracheostomy becomes necessary. In general, it is essential to use an endotracheal tube that is as small as possible and which allows a leak of air during positive pressure ventilation. If the air leak disappears and a smaller endotracheal tube cannot be used, then a cricoid split procedure as advocated by Cotton and Seid (1980) and Frankel et al (1984) may allow a further period of between 10 and 14 days intubation before tracheostomy is necessary due to developing perichondritis or chondritis of the cricoid. It has been suggested by Quiney et al (1986) that, even if chondritis of the cricoid is present, epithelialization of the laryngeal mucosa may occur around the endotracheal tube - an argument for prolonged undisturbed intubation!

The investigation of the patient with acquired laryngeal stenosis is similar to that required for congenital laryngeal anomalies and is dealt with in Chapter 26.

**Treatment of laryngeal stenosis**

The treatment of laryngeal stenosis is one of the most controversial topics in paediatric otolaryngology. Therapeutic procedures range from repeated dilatation, prolonged laryngeal stenting with or without the use of steroids, the use of the CO₂ laser to create an airway with or without tracheostomy, to early tracheostomy and open surgical operation on the child's larynx.

**Congenital subglottic stenosis**

Congenital subglottic stenosis is on the whole less severe than acquired stenosis and, in some cases, mild congenital subglottic stenosis can be treated without performing a tracheostomy. Holinger (1982) reported a series of 24 infants with severe subglottic stenosis, six of whom were treated with the CO₂ laser so avoiding tracheostomy.

Almost half of the patients with congenital subglottic stenosis will require a tracheostomy (Cotton and Myer, 1984). Most of these patients will be decannulated within 2-5 years without requiring any operative procedure on the larynx. The process of natural
resolution makes the effect of treatment difficult to assess. This difficulty is compounded by the fact that there are two basic types of congenital subglottic stenosis, the first being the result of soft tissue abnormality, the second of abnormalities of the cricoid cartilage.

**Soft tissue abnormalities**

Submucosal fibrosis, hyperplasia of the submucous glandular tissue and frank granulation tissue usually occur as a result of intubation (Holinger, 1982). The hyperplasia of the submucous glandular tissue may be so exuberant as to present as submucous retention cysts (Mitchell et al, 1987) and these cysts respond well to deroofing with the CO$_2$ laser, cup forceps or diathermy.

**Abnormalities of the cricoid**

In the review by Morimitsu et al (1981) of congenital cricoid stenosis, 12 cases had a large anterior lamina with a very small posteriorly sited airway having an average diameter of 1.9 mm. In one case, there was a thickened posterior lamina and, in another, the cricoid cartilage itself was oval. Tucker et al (1979) also described a trapped first tracheal ring as an abnormality associated with subglottic stenosis. Thickening of the cricoid with a small posterior lumen is certainly the author's experience. The clinical importance of identifying thickening of the cricoid is fundamental, since these cases do not respond to dilatation and treatment with the CO$_2$ laser is also likely to be unsuccessful. After a period of observation of approximately one year, in the case of neonates, or until the child's weight exceeds 10 kg, an open procedure on the larynx should be considered.

An open procedure on the larynx is also necessary in acquired stenosis were there is a hard cicatrix which has formed as a result of cricoid perichondritis.

**Dilatation**

The soft tissue stenoses may respond to simple dilatation whereas dilatation is contraindicated, and may indeed be harmful, in patients with abnormalities of the cricoid cartilage.

**Steroids**

The use of steroids as an adjunct to dilatation and simple excision of scar tissue either by CO$_2$ laser or cup forceps might be expected, on theoretical grounds, to aid decannulation. Baker and Whitaker (1950) demonstrated that the administration of corticosteroids during wound healing stopped fibroplasia and the growth of granulation tissue. Successful decannulation after the intralesional injection of steroids was reported by Waggoner, Belenky and Clark (1973). Peerless, Pillsbury and Peerless (1981) showed that the inhalation of beclomethasone dipropionate was an excellent adjunct therapy for the treatment of laryngeal stenosis. Birck (1970) reported seven patients with subglottic stenosis who were successfully decannulated within 2 months of treatment which involved dilatation and systemic administration of steroids. In spite of their occasional reports of successful treatment with steroids, most practitioners have not found them to be helpful in the management of subglottic stenosis because the delayed healing process increases the patient's susceptibility to infection.
and thereby delays epithelial healing. It is the practice of the author to use systemic steroids in a dose of 0.5 mg/kg to reduce oedema after bronchoscopy in a difficult case, for example after the removal of a foreign body from the trachea of a young child.

**Endoscopic resection**

Various endoscopic methods of resection have been employed and include infant urethral resectoscopes (Downing and Johnson, 1979) and cryogenic probes (Rodgers and Talbot, 1978). It is probably true to say that the majority of paediatric otolaryngologists who specialize in the management of laryngeal stenosis would favour the use of the CO\(_2\) laser for endoscopic resection (Strong et al, 1979; Friedman, Healy and McGill, 1983; Carruth et al, 1986). The successful endoscopic management of laryngeal stenosis depends upon careful patient selection. Simpson et al (1982) reviewed 60 cases of laryngeal stenosis, 31 of whom had subglottic stenosis, and he was able to identify factors which indicated where endoscopic treatment was likely to be unsuccessful. These included cases of combined laryngeal and tracheal stenosis, particularly if the stenotic areas were wide or circumferential or if they were accompanied by significant loss of cricoid or tracheal cartilage.

If abundant scar tissue was present involving at least 1 cm of larynx or trachea vertically, the scar tissue was circumferential or the posterior commissure was involved and the arytenoids were fixed, then an unsuccessful outcome was likely.

If bacterial infection of the trachea associated with perichondritis occurred prior to treatment, an unsuccessful outcome was noted in 87.5% of the cases.

If there adverse factors are noted, then an open operation upon the larynx is advised and if there has been evidence of perichondritis with significant cartilage loss, it is essential to wait for at least 6 months to one year before attempting an open operation. This interval allows the active inflammatory process to resolve and increases the chance of a successful outcome of a procedure which may involve free grafts of cartilage where infection is likely to prejudice the success of the operation.

**Open operations**

Many surgical procedures for the correction of subglottic stenosis have been described; in the main they involve the use of autogenous grafts, hyoid bone (Abedi and Frable, 1983), sternohyoid myo-osseous flaps (Close, Lozano and Schaeffer, 1983) and nasal septal cartilage (Toohill, Martinelli and Janowak, 1976). The techniques of laryngotracheoplasty (Evans and Todd, 1974) and laryngotracheal reconstruction using free costal cartilage grafts (Cotton, 1978) are the most popular and will be discussed in some detail (Cotton and Evans, 1981).

**Laryngotracheoplasty**

This technique is used in congenital subglottic stenosis where the cricoid cartilage is abnormally thick; it may also be used in cases of laryngeal webs where there is often an associated anomaly of the cricoid cartilage. In this procedure, a midline incision is made through the thyroid cartilage and cricothyroid membrane, a castellated incision then being fashioned through the cricoid cartilage and involved tracheal rings. The larynx is opened from
above and the vocal cords separated at the anterior commissure under direct vision. Once the larynx is opened, a submucosal dissection and removal of the scar tissue is made using scissors designed for microscopic surgery. As much laryngeal mucosa as possible is saved to line the stenotic segment. If the cricoid is abnormally thick, cartilage may be pared or cored from its internal surface to increase the lumen. An internal stent consisting of a 'swiss-roll' of Silastic sheeting is inserted and the cartilaginous laryngeal and tracheal pegs are sutured in their displaced position. The Silastic roll is secured by a transfixion suture which is brought out over the strap muscles and buried subcutaneously. The Silastic roll is removed endoscopically 6 weeks later.

**Laryngotracheal reconstruction**

This procedure is indicated where there has been loss of cartilage due to perichondritis and chondritis in acquired stenosis. If the stenosis is confined to the anterior part of the larynx and upper trachea, then it is only necessary to insert the cartilage graft anteriorly. A standard laryngofissure incision is made and a free graft of costal cartilage is inserted. The cartilage graft is taken from the costal margin and trimmed until it exactly fits the defect, the perichondrial surface is placed internally and the graft is sutured in position using 5/0 polypropylene sutures.

If the scarring involves the posterior part of the glottis with interarytenoid fixation, the posterior lamina of the cricoid is divided and a smaller graft of costal cartilage inserted, as described by Rethi (1956). If combined anterior and posterior stenoses are present or if the stenosis is complete, combined anterior and posterior grafts may be used.

**Stenting**

The author prefers to stent the larynx and upper trachea in most cases, the best material probably being a Silastic swiss-roll because it has the advantage of being self-adjusting. Rigid stents, such as the Montgomery Silastic laryngeal stent, the Montgomery T tube or the Aboulker Teflon stent (Aboulker et al, 1966), do not have this advantaged and, if the selected stent is too big, it may cause further damage to the laryngeal and tracheal mucosa. The Silastic stent is usually retained for 6 weeks, but in severe cases it may be retained for 6 months and in one of the author's cases the stent was retained for 2 years before successful decannulation (Evans, Batch and Leitch, 1986).

The management of laryngeal stenosis in infants and young children should be conservative, since in the majority of cases the stenosis will improve with laryngeal growth. The utmost gentleness must be employed in the inspection and endoscopic treatment of the infant larynx. Open surgical procedures are only to be recommended when it has been established by careful endoscopic assessment that the laryngeal lumen has not increased in size. The surgeon should be prepared to graft the larynx or to perform laryngotracheoplasty and often the appropriate procedure can only be determined when the cricoid cartilage is exposed at operation. Currently, the efficacy of operations on the larynx has been established and it has been shown that there is a reasonable prospect of achieving decannulation in the majority of cases. One can at least give the parents of these children a reasonably accurate prognosis, and the hope that their child can be restored to normality and to a state that is no longer dependent on tracheostomy.