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*Editorial*

# Evolution in the Management of Laryngotracheal Stenosis

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**Introduction:**
Laryngotracheal stenosis (LTS) can be congenital or acquired. It can be benign or malignant. The acquires LTS presents with progressive worsening dyspnea and in many cases variable degree of dysphonia[1-5].

Commonest cause of LTS being iatrogenic, secondary to ICU intubation or trache-ostomy[6-10]. The incidence of iatrogenic LTS is likely to be increasing as the survival rates following ICU intubation improve with the improvement of ICU care[11,12]. Despite the use of these high- volume low- pressure cuffs on endotracheal and tracheostomy tubes the incidence of postintubatioin airway stenosis in post- ICU patients can only be approximated between 1 and 4%[13]. In a study performed in England, it was found that an estimated annual population of 30,030 are at risk of development of tracheal stenosis, and the incidence rate of post intubation laryngotracheal stenosis was calculated as 4.6%[14].

LTS can significantly affect the quality of life (QOL) and it can sometimes be a life threatening condition by itself or as a complication of treatment offered for it. In severe grade III and grade IV stenosis patient is likely to present with aphonia and severe dyspnea and stridor necessitating emergency tarcheostomy as a life-saving procedure[6]. Tracheostomy itself can lead to stenosis at the level of either stoma, tip of the tube or at the level of its cuff.

For improvement of the QOL by alleviating dyspnea, dysphonia and allowing decanulation patients with LTS mandates management in one or other form. Treatment of airway stenosis has been tried since ancient period.

**Current techniques:** In 1953 John Conley of the New York successfully resected the second and third tracheal rings for scar with primary end- to-end anastomosis. In addition to performing the first tracheal resection in 1953, he summarized several techniques for treatment of subglottic stensosis[13]. He performed a laryngofissure, removed all scar tissue and placed a split skin graft over a Vaseline gauze over a foam rubber sponge. He also mentioned that autologous cartilage could be used to assist in reconstructing the tubular from of the trachea. He did not discuss specific cases but the ideas are in use in paediatric airway reconstruction today[16].

In 1964, Ogura and Powers had the initial experience of segmental resection of cricoid cartilage and included a series of seven cases of primary thyrotracheal anastomosis [17]. In 1974, Gerwat and Bryce described a technique to preserve the posterior cricoid plate and the recurrent laryngeal nerve for the first time; the removed only the anterior cricoid arch [18]. Pearson and his team proposed a modification of this technique in 1975. They described a transverse cut at any level below the vocal cords with preservation of a posterior shell of cricoid cartilage sparing the laryngeal nerves[19]. In this technique primary

thyrotracheal anastomosis can be performed less than 1 cm below the vocal cords. Grillo described a technique for interarytenoid scar complication complicating subglottic stenosis. Interarytenoid scar tissue is excised and the mucosal defect created is covered by pedicled flap of membranous posterior wall of distal trachea created by resecting one or two cartilaginous rings from its anterior wall[1].

In 1968, Grillo and Mulliken reported the length of trachea that could be resected for postintubation at 4.5cm (7.2 rings). He discovered that the length that could be resected in older patients was progressively shorter because of the reduced elasticity between the cartilaginous rings/ he further demonstrated that it would be possible, with additional maneuvers involving release of pulmonary ligaments and suprahyoid laryngeal release, to resects a further 2 cm[13].

In 1974, Evans and Todd in Londonreported the use of rib cartilage in laryngo-tracheoplasty, but favored a castellated laryngofissure to expand the airway over a piece of rolled silastic sheet used as a stent for 6 weeks[13].

Cotton in Cincinnati (Ohio, United States) in 1978 described in detail laryngotracheal reconstruction (LTR) with an anterior costal cartilage graft[20]. Later, in 1984 Cotton published a series of 100 case of LTR in children over a decade. He emphasized that the stenosis should be mature before undertaking open surgery[21].

In 1985, Fearon and McMillin in Toronto Ontario, Canada described cricoid resection and thyrotracheal anastomosis in primates. They demonstrated that there was no interference with normal laryngeal growth following this. Ranne et al in Kansas City (MO, United States) are credited with the first cricoid resection in patients, published in 1991. This procedure, originally described by Pearson et al,was adopted by Monnier et al in Switzerland, who subsequently published their series in 1993[13].

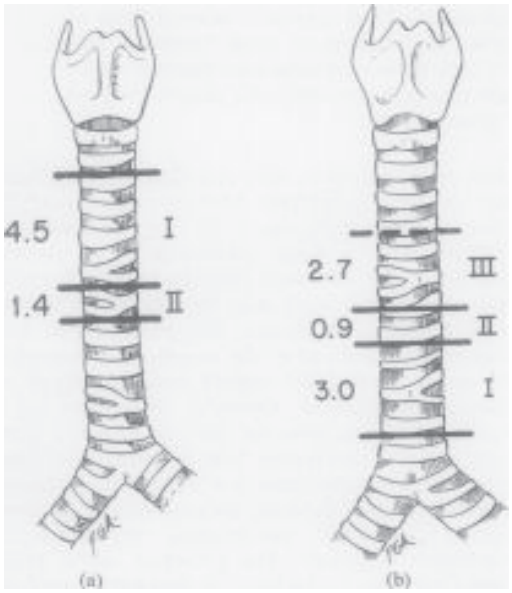


**Fig.-1:** *Diagram of lengths of trachea which may be resected and yet permit primary anastomosis. (a) 4.5 cm can be removed through an anterior approach and approxi• mation done with 1,000 g of tension, utilizing cervical fiexion. Intrathoracic dissection allowed further removal of 1 ·4 cm. (b) With the cervical spine in a neutral position, transthoracic hilar dissection and division of the pulmonary ligament allowed 3 cm to be removed and anastomosis done. Intrapericardial dissection added 0·9 cm and division of the left main bronchus with reimplantation of the bronchus intermedius permitted an additional 2·7 cm to be removed. If cervical flexion is utilized, a significantly greater amount than 3 cm may be removed.*

Ref: Grillo, H. C. (1973). Thorax, 28: 667-679

Robin Cotton's group in Cincinnati, when considering an open procedure for subglottic stenosis, primary perform anterior and posterior augmentations. In only 15% of

cases, usually those that have failed augmentation surgery, do they consider cricotracheal resection[13].

One other technique, originally described by Herberhold et al, was the use of preserved tracheal allograft. These held the promise of being able to treat long- segment tracheal stenosis in children and adults without the need for immunosuppressant. These grafts consisted of chemically treated cadaveric tracheas to remove donor cells and antigenicity. The simplicity of the technique was the ability to tailor the size and shape of the tissue to suit the patient's requirements[13].

**Endoscopic procedures:**

Although the gold standard treatment for benign LTS is surgery, significant comorbidities, limited surgical experience and involvement of nonsurgical specialists frequently prohibit tracheal resection or tracheoplasty[22-25]. Endoscopic management of LTS is chronic in nature with lower morbidity while open procedures are more definitive in nature with higher rates of morbidity and mortality[26].

Many of the cases of LTS can be managed safely and effectively by endoscopic procedures like Laser, coblation, dilatation, steroids, etc. with or without stenting for various duration.

Failure of repeated endoscopic procedures may dictate open surgical procedure and Failure of surgical procedure may necessitate endoscopic procedures with or without stenting.

The first airway stent was a metal alloy stent described by William Hankins of St Louis, USA, in 1952[27(S58)].

However, there were problems related to repeated obstruction and migration of this stent, this led to the development of the T-tube, which was invented in 1962 by Montgomery, a Physician at Harvard Medical School and the Department of Otolaryngology of Massachusetts General Hospital. He first applied T-tube for tracheal stenosis[28]. The external limb prevented migration of the endoluminal tube. Initially the T-tube was made of acrylic material which was too rigid to intubate and severely affected the expectoration function of tracheal cilia. In1986, Boston Medical Products developed the "safe T-tube" and later used an implantable silicone material[29]. 1n 1974, Montgomery reported use of silicone T- tube in 94 cases of LTS[30]. The main advantages of the T-tube include preservation of normal respiration and phonation, minimal cough, minimal tissue reaction to silicone and elimination of risk of stent migration[31].

In the 1990's, Dumon produced the first dedicated endobronchial straight silicone stent[32]. The Gianturco metal stent is an uncovered stainless steel mesh stent and was first described in 1986[33]. Current metal stents tend to be made from steel or nitinol (a titanium and nickel alloy with a memory) wire mesh.

Endoscopic treatment gained popularity over the last few decades. Initial treatments mainly involved dilatation and insertion of silicone stent[32]. Due to the disadvantages of straight silicone stent as rigid bronchoscopy for insertion, migration, development of granulation tissue or sputum retention and blockage in late 1980's, the use of modified vascular metal stents was attempted in the airway[34,35]. But the rate of complications was unacceptable[36]. Subsequently in 1990's there was innovation of self-expandable metallic stent (SEMS). SEMS are easy to position even with a flexible bronchoscope and are less prone to migrate[35]. However, it also showed complication like blockage, granulation tissue formation[37-39], stent

fracture[40], difficulty in removal when needed[37,41,42]. The use of SEMS in benign airway disease was the object of boxed warning from USFDA in 2005[43]. So, a fully covered self-expandable metallic stents (FC-SEMS) have been developed in effort to combine the advantages of self-expandable metallic stent and complete polymer coverage. Studies on FC-SEMC showed complications like stent migration (30% or more), granulation tissue formation (35%) and sputum retention and 50-55% stents had to be removed due to complications[37,44].

**LASER and Cryotherapy:** In 1962 C Kumar N Patel introduced the carbon dioxide gas Laser. In 1972, in Boston, USA, Jako and Strongwere the first to pioneer the use of CO2 laser in otolaryngology, head and neck surgery[45]. Jaco collaborated to develop the endoscopic attachment to a CO2 laser and performed the first in vivo experiment on the canine larynx in 1969[45]. In 1971, Bredemeir attached the micromanipulating arm to the CO2 laser to the operating microscope providing binocular vision and depth of field. Laser delidary system was further developed by Ossoff and Karlan allowing delivary of CO2 laser under direct visualization through the bronchoscope[46]. Laser allows ablation and cutting with minimum bleeding in comparison to cold steel instruments. Addition of scanner to CO2 laser allows more precise action. CO2 laser works in straight line which is minimized by the development of fibre delivery system for it by Omniguide (Cambridge, Massachusetts, USA). This Omniguidefibre system does not have any aiming beam. Lumenis Surgical (USA) recently launched a CO2 laser fibre with aiming beam.

The KTP laser and diode laser due to their fiber delivery system are easier to be used in distal trachea and bronchi. Their tissue penetration is significantly deeper and chances of granulation tissue, scar formation and consequently restenosis is higher. Nd:YAG laser irradiation and stenting have been traditionally used as a first step in the treatment of benign tracheal stenosis[47].

More recently cryo-spray therapy has shown promising results[48].

Recent study revealed that holmium laser treatment combined with cryotherapy by flexible bronchoscopy appears to be a safe and feasible treatment for post-intubation SGS in children. This includes SGS with lengths e" 1cm. Furthermore, this therapeutic technique can be considered a viable alternative option when performed by a practitioner with appropriate training and supervision[49]. The use of spray cryotherapy alone or in conjunction with balloon dilation is a promising and effective therapeutic approach to treating glottic and subglottic narrowing. Laryngoscope, 2010[50].

**Mitomycin-C:** Mitomycin-C (MMC), as a systemic chemotherapeutic agent, is available since 1960's [4]. It was first reported in the Otolaryngology literature for the treatment of tracheal scaring after tracheal reconstruction in a case series[51]. MMC produces free oxygen radicals causing breakage of DNA strands. It also induces apoptosis of fibroblasts. Mitomycin is the drug most commonly used. Various concentrations were advocated (0.1 up to 10 mg/mL). However, the concentration is usually 0.4 mg/mL and is applied topically on a cottonoidpledget. The length of application varies from two to three repeat applications of 2 min each to a single application of 5 min[52]. It is applied topically on cottonoidpledget. A Recent 10-year review showed that the use of mitomycin-C did not result in longer intervals between procedures[53]. Due to lack of clear evidence of improved outcome and continuing uncertainty about long term authors have stopped its use[4].

**Steroid:** As inflammation progresses granulation tissue is gradually replaced by fibrous tissue. Inflammatory tissue in the airway responds to intralesion steroid injection. More mature fibrous tissue responds. Satisfactory results with intralesion steroid injection have also been found in another study[52]. A randomized clinical trial has shown that low dose oral steroid therapy (Prednisolone 15 mg/day) can be beneficial in the management of postintubation tracheal stenosis[54]. Intralesion steroid injection has also been used successfully for management of resistant strictures of the gastrointestinal tract[55].

**Radiofrequency Coblation:** Bipolar radiofrequency plasma ablation (Coblation) has been used in various orthopedic and otolaryngologic procedures on a regular basis during the recent years. The technique produces a localized, high-energy plasma field that ablates tissue and seals blood vessels simultaneously. It operates at temperatures of 40–70 °C, which is significantly lower than the 400–600 °C temperatures of monopolar cautery and $CO_2$ laser, and therefore may reduce collateral tissue damage[56]. The radiofrequency plasma ablation device also reduces, if not completely eliminates the risk of airway fire.

Radiofrequency The results of study on paediatric LTS suggests that radiofrequency plasma ablation may be an effective endoscopic tool for the treatment of pediatric airway stenosis. All patients experienced good results without major complications, perioperative, or post-operative sequellae[57].

A retrospective analysis of adults cases underwent coblation resection for airway stenosis from 2007 to 2012 was performed. All patients reported significant improvement in their symptoms following treatment. All patients were alive at the time of writing of the article and none have required open resection. A retrospective case note analysis of all cases of airway stenosis in adults from 2007 to 2012 was performed. The authors commentedthat radiofrequency coblation as an attractive alternative technique for the treatment of idiopathic or acquired airway stenosis in adults[58].

Submucosal coblation can be considered, sparing the mucosa, as an alternative treatment in patients with subglottic stenosis due to suspected submucosal hypertrophy[59].

**Conclusion:**

Treatment of LTS includes various modalities like laser, coblation, cryosurgery, repeated endoscopic dilatation, stenting, T-tube, laryngotracheal reconstruction, segmental resection and end-to-end anastomosis. Ideal modality of treatment depends on the merit of the individual case: patient factors (age and particularly the comorbidities), facilities available in the center, site of involvement, nature of the stenosis, length of the involved segment, surgeon's choice and patient's preference. Every individual modality has its advantages and disadvantages. Thorough discussion and counselling should be made regarding pros and cons of each procedures that may be suitable for the patient. Relatively conservative approaches can be tried as the first line of treatment in many cases as every modality has a proportion of successful cases and these does not preclude the possibility of future surgical procedure in cases of failure. Further studies on tissue engineering hope to open a new dimension in the treatment of laryngotracheal stenosis.

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