Post-intubation Subglottic Stenosis

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Running title:
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**Abstract:**

Subglottic and proximal tracheal stenoses are the most crippling complications of endotracheal intubation. There have been innumerable approaches to the management via endoscopic techniques or open surgical procedures, which bear testimony to the difficulty in obtaining predictably satisfactory results. Aim of our project is evaluation of the efficacy and long-term results of the combined approach (endoscopic and cricoid split) in managing postintubation subglottic stenosis in adults.

This study was done on nineteen patients of post-intubation subglottic stenosis. Thorough endoscopic diagnosis by videotelelaryngoscopy and (CT) scan was performed for all patients. The steps of the procedure include; a) Microlaryngoscopic excision of the stenotic fibrosis assisted by microcoagulation using Boucheier’s instruments, b) Splitting the anterior cricoid arch for complete excision of fibrotic tissues. C) Stenting the interior of the larynx by silicone T-tube. The patients were followed-up for two years.

The study group consisted of 19 males. The mean age of the patients was $36.7 \pm 3.7$ years with a range of 14-68 years. No patients developed stridor after extraction of the stent and succeeded to depend on their natural airway. Recurrence of the scar occurred in 37% of cases. Early tracheostomy in comatosed patients is much more better than prolonged endotracheal intubation to avoid post-intubation subglottic stenosis. Silicone tubes must be used only for prolonged endotracheal intubation. This is attributed to the inert nature of silicone that could avoid subglottic stenosis. Adult subglottic region is fully-grown and so, should stenosis occur, excision and stenting is expected to lead to marked improvement.

Keywords: Subglottic stenosis, Post-intubation.

*Post-intubation subglottic stenosis*
Introduction:

Acquired subglottic stenosis due to endotracheal intubation is the predominant cause of subglottic stenosis that requires surgery. There is a twofold challenge in treating this problem: (1) to accurately and precisely define the site(s) and nature of the obstruction, and (2) to choose an appropriate procedure for surgical correction\(^1\).

Surgical correction aims to provide an adequately enlarged lumen while preserving vocal quality and airway protection. Treatment success is predicted upon a thorough preoperative evaluation and tailoring the repair plan to address the severity and location of the individual lesion. Understanding the complex pathophysiology of subglottic stenosis along with the wide variety of available surgical options will aid the surgeon in achieving a successful outcome\(^2\).

There have been innumerable approaches to the management via endoscopic or open surgical techniques, which bear testimony to the difficulty in obtaining predictably satisfactory results\(^3\). Endoscopic management is successful in the majority of patients if they are selected properly. Abundant scarring involving the whole circumference or extending beyond one cm vertically may jeopardize the endoscopic management. Moreover, endoscopic management does not preclude the use of open surgical procedures if necessary\(^4\). Modern open surgical management includes a wide variety of surgical procedures. These can broadly be divided into two groups. First, laryngotracheal reconstruction (LTR) procedures, in which the cricoid cartilage is split and the framework is expanded with various combinations of cartilage grafts and stents; and second, cricotracheal resection (CTR) where a segmental excision of the stenotic segment is done and an end-to-end anastomosis is performed\(^5\).
Cricoid split without grafting or stenting has been criticized because splitting the cricoid during high tracheotomy had been believed to be the principal cause of subglottic stenosis for many years. This article is designed to evaluate the anterior cricoid split (ACS) approach in managing post-intubation subglottic stenosis in adults, aided by endoscopic excision of the cephalic part. We analyze the subglottic pathology, and determine the efficacy, and long-term results of the management procedure.

Pathophysiology
The most common cause of subglottic stenosis is mechanical trauma from an endotracheal tube cuff. If the cuff inflation pressure meets or exceeds the capillary perfusion pressure of the subglottic mucosa contacting it, ischemia and necrosis of the mucosa occur. The intubation time required for this complication to occur depends on both the degree of mechanical trauma and the capillary perfusion pressure of the subglottic mucosa. With ischemia and necrosis of subglottic or tracheal mucosa, the underlying soft tissue and cartilage could be exposed to bacterial contamination. Mucociliary stasis also occurs, and the subsequent accumulation of secretions also contributes to local tissue infection. If the process continues, the infection penetrates the perichondrium to reach the cartilage. The resulting chondritis destroys cartilage, and the support of the airway is lost. The process may reverse at any point, and healing begins. Scar tissue forms and contracts circumferentially in the subglottis, forming a cicatrix and thus reducing the cross-sectional area of the airway. The degree of stenosis depends on the severity of the original infection, the extent of cartilage destruction, and the amount of scarring. Symptoms typically develop in one to three months following extubation.
Patients and methods:

This study was done on nineteen patients with post-intubation subglottic stenosis for whom tracheotomy was performed. The patients were presented to otolaryngology service in Mansoura University Hospital Mansoura, Egypt for seek of tracheotomy decannulation. The study was conducted in the period of January 1997 to January 1999. Complete history taking and thorough endoscopic diagnosis by videotelelaryngoscopy revealed subglottic stenosis in all of them. Portex stylets were used as measure of airway diameter. The stylet that barely passed through the stenosis was considered the actual measure. The available stylets had three different sizes according to their diameter and length: small (2.1mm diameter and 34cm long), medium (2.9mm diameter and 38cm long), and large (3.9 diameter and 45cm long). Endotracheal tubes were used as measure of airway diameter larger than 3.9mm. Vertical dimension of the stenosis was also measured by using the portex stylets. First, the stylet was introduced through the stenotic segment until it could be just visualized beeping through the caudal end of the stenosis. This was aided by a 2.7mm 30° Hopkins telescope placed at the tracheotomy. The stylet was marked where it passed incisors. The stylet was then withdrawn to the cephalic end of the stenosis and marked again where it passed the incisors. The stylet was then withdrawn to the glottis and marked for the third time. The distance between the marks indicates the length of the stenosis and the distance between the stenosis and the glottis. Computerized tomography (CT) scan was performed for all patients to assess the laryngeal contour and diameter. Criteria for entry to the study were airway diameter of less than

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5mm (fig. 1), and at least two years of follow up after repair. Patients who had laryngoscleroma, laryngeal fractures, serious chest injuries, cardiopulmonary disease, or other systemic illnesses were excluded from the analysis. Cases having more than one cm vertical depth of stenosis in the subglottic region were also excluded from the study.

**Technique:**

A combined technique of both endoscopic and anterior cricoid split approaches was performed on all cases under general anesthesia.

Microlaryngosurgery was firstly done to excise the cephalic end of the stenotic part by using microcoagulator of Bouchier (fig. 2). Then, an anterior transverse neck incision was made at the level of the cricoid cartilage. Subplatysmal flaps were elevated superiorly to the thyroid notch and inferiorly to the suprasternal notch. The strap muscles were separated vertically in the midline and retracted. The anterior cricoid ring was divided vertically with either a knife or a saw, according to the degree of ossification. The goal was to open the lower part of the stenotic segment. To maximally preserve voice, great care was experienced in order not to extend the incision to the anterior commissure. Submucosal resection of scar tissues was attempted meticulously to avoid scar regeneration that could happen if much mucosa has been damaged. The Montgomery Long Tracheal T-Tube “INVOTEC” of outer diameter 12-14mm was inserted in the interior of the larynx (fig. 3). The whole tube was withdrawn from the tracheotomy by using a catheter passing through the endoscope, the vertical limb was set just below the vocal cords, and the horizontal limb was emerging from the tracheotomy. The T tube was left in place for 6 months.
Results:

The study group consisted of 19 males. The mean age of the patients was 36.7±3.7 years with a range of 14-68 years.

Inner diameter of stenosis in all cases was less than 5mm. It was below 2.1mm in seven, 2.1-2.8mm in five, 2.9-3.8mm in five, and 3.9-5 mm in two (table 1). Firm scar tissues were noted in 13 cases (average 5.6 months after intubation), and the remaining six cases showed voluminous grayish glistening soft tissues (average 3.3 months after intubation). Spillover occurred in three patients, who were readmitted to the theater for trimming of the upper end so as not to touch the vocal folds.

Decannulation of the T-tube stent was done without difficulty in 19/19 (100%) of cases, no one developed stridor after its extraction, and all patients succeeded to depend on their natural airway. The adequacy of airway was furtherly confirmed objectively by introducing the appropriate tube size for the age. In all cases, the tube was easily admitted into the subglottis with additional leak with normal ventilation pressure up to 25cm water. Follow-up of the patients showed recurrence of scar tissue in 7/19 patients (37%) at the end of the two-year period. Reduction of airway diameter by 2mm in the anterior part at the split site of the cricoid has occurred in three, and circumferential scarring has occurred in four. However, they did not experience stridor in the
ordinary life style.

Table 1: Preoperative subglottic airway diameter

<table>
<thead>
<tr>
<th>Airway diameter</th>
<th>&lt;2.1mm</th>
<th>2.1-2.8mm</th>
<th>2.9-3.8mm</th>
<th>3.9-5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Discussion

Prolonged endotracheal intubation, with possible injury of subglottic mucosa, may lead to subglottic stenosis. This study included 19 adult male patients with post-intubation subglottic stenosis, presented to ENT department with tracheotomy. Thorough ENT examination including videotelelaryngoscopy, measuring portex stylets, and CT confirmed the presence of subglottic stenosis with an airway diameter of less than 5mm in all of them.

Microlaryngosurgery was firstly done to excise the cephalic end of the stenotic part by using microcoagulator of Bouchier. This helps avoid splitting the thyroid cartilage and anterior commissure that may result in web formation of anterior commissure and subsequent dysphonia.

Although recurrence of scarring occurred in more than one third of the cases (37%) in the two-year period of follow-up, it seems a logical sequence of surgery on diffuse fibrous tissues. We expected that the submucosal excision techniques as well as the use of inert silicone stent help preserve a wider area of intact mucous membrane and limit the amount of subsequent fibrosis.

The Montgomery T tube (a performed hollow silicone tube) has the advantage of being both a
stent and a tracheotomy tube. It is made of silicone, thus causing little tissue reaction, and is sufficiently soft so as not to injure the lining structure of the larynx. It is self-secured, relatively easy to place and remove under general anesthesia, and allows normal respiration and speech. During surgery the upper end of the tube was adjusted by microlaryngoscopy to avoid postoperative spillover. The tube was left in place for six months. The Montgomery T tube, however, has the risk of obstruction, especially when the inner diameter is small. This risk has been limited in our series, being all adults, as we used the size 12-14mm. Proper suctioning help minimize the risk of obstruction caused by accumulation of mucoid and viscid secretions. The patient’s family and care givers need to be aware of the possible risk of obstruction and should be well-trained and equipped for emergent removal of the tube and replacement with a tracheotomy tube should obstruction occur.

In 1980, Cotton⁶ published the anterior cricoid split procedure as an alternative to tracheotomy in the neonate who could not be successfully extubated. In 1988, 67 patients who had undergone this procedure were reported and 47 (70%) had been successfully extubated⁷. Currently this operation is performed to avoid a tracheotomy in the majority of children with early subglottic stenosis who fail extubation. Our results showed 100% decannulation rate, this might be attributed to the larger dimensions of airway in the adult larynx.

In 1989 Cotton et al¹⁰ published an update of the Cinncinati experience of LTR. Grade 1 (up to 50% obstruction) patients mostly did not require tracheotomies so decannulation rates were not given. 129 procedures were performed on 98 patients with grade 2 (51%-70% obstruction) and 97% were ultimately decannulated. Ninety-four procedures had been carried out on 80 patients with grade 3 (70%-99% obstruction) and ultimately 91% were decannulated. Twenty-eight procedures had been carried out on 25 patients with grade 4 (no detectable lumen) and ultimately

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72% were decannulated. In 1992 Ochi et al\textsuperscript{11} through a 10-year review published decannulation rates of 88% for grade 1, 89% for grade 2, 78% for grade 3, and 50% for grade 4 subglottic stenoses.

With the introduction of CTR\textsuperscript{5}, it is natural to compare outcomes with the previous surgical techniques. In the comparison of different surgical techniques for airway reconstruction, the use of decannulation rate as a principal outcome measure has several limitations. First, most grade 1, some grade 2, and even a few of grade 3 patients did not have a tracheotomy to begin with. Second, patients may require a tracheotomy for reasons other than subglottic stenosis. This is not uncommon. Surgery may successfully correct the subglottic problem but the patient may remain tracheotomy dependent due to different causes like tracheomalacia, supraglottic collapse or suprastomal collapse and granulation. In this situation the surgery for subglottic stenosis may really be successful although the patient is a decannulation failure. Despite this, decannulation rates for patients with severe grade III and grade IV subglottic stenoses remain broad and easily understandable measure of success. Furthermore, in the published literature it is usually the only outcome measure available.
Conclusion:

1. Early tracheotomy in comatose patients is much better than prolonged endotracheal intubation to avoid post-intubation subglottic stenosis.

2. Silicone tubes must be used only for prolonged endotracheal intubation. This is attributed to the inert nature of silicone that could avoid subglottic stenosis.

3. Adult subglottic region is fully-grown and so, should stenosis occur, excision and stenting is expected to lead to marked improvement.

4. A longer follow-up period is recommended to assess the long-term outcome of the special procedure.
5. The low rate of recurrence in our adult series may be attributed to the low rate of scar reformation with submucosal excision technique,

References:


