



## Cricoid Reconstructive Surgery in Treating Subglottic and Glottic Stenosis

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### ABSTRACT

**Introduction:** Glottic and subglottic stenosis, and most notably the cricoid fracture, is a common sequela of larynx trauma, which has received inadequate and ineffective treatment. This is a difficult fracture with a high recurrence rate. It affects the patient's airway and voice, forcing him to breathe through a tracheal cannula or depriving him of normal speech. These conditions badly influence his quality of life, leaving him as a burden on his family and society. This study is to evaluate the result of a glottic and subglottic reconstructive surgery through grafting. **Materials and methods:** A prospective study was conducted in a hospital in Ho Chi Minh city, Vietnam. Data were collected from a descriptive clinical trial of 9 cases that were admitted to the ENT Department of Cho Ray Hospital. These patients displayed symptoms of glottic and subglottic stenosis and were being prepared for reconstructive surgery by grafting. **Results:** Total 9 patients were included in the study (9 males and 1 female). The main cause was identified as cricoid trauma (8/9 cases), with one case having an unknown reason. Most cases have a total or near total loss of glottic/subglottic lumen. The rate for successful cannula removal for 6 cases was 77.8%. The study clearly demonstrated that glottic and subglottic reconstructive surgery through grafting is a difficult but effective operation to reconstruct the laryngeal lumen. **Conclusion:** Cricoid trauma gave rise to most of the glottic and subglottic stenosis cases, with the majority of the cases having a total or near total loss of glottic/subglottic lumen.

**Keywords:** Laryngeal stenosis, Laryngoplasty, Cricoid reconstructive, Stenosis, Vietnam

### INTRODUCTION

According to Antonio D'Andrilli, the subglottic space at the cricoid level is the narrowest part of the airway; it extends from the inferior margin of the vocal cords to the lower border of the cricoid cartilage [1]. According to the literature, laryngotracheal trauma appears with a low frequency but develops as a potentially life-threatening injury. Due to scarcity, some symptoms in the multiple-trauma patients can go unnoticed and thus untreated [2]. Laryngotracheal trauma may develop complications or even cause death if diagnosis or treatment is deferred. If patients who suffer from this disease are not treated completely and effectively, they may often develop glottic and subglottic stenosis sequelae, with the main symptom being cricoid fracture posing a high risk of recurrence. This is an important cause of airway obstruction and damage to the patient's voice. In the aftermath of the injury, a tracheal cannula may be required for breathing, affecting normal speech. The consequences of ineffective treatment are serious and entail inconveniences for the patients, their families, and society in which they live.

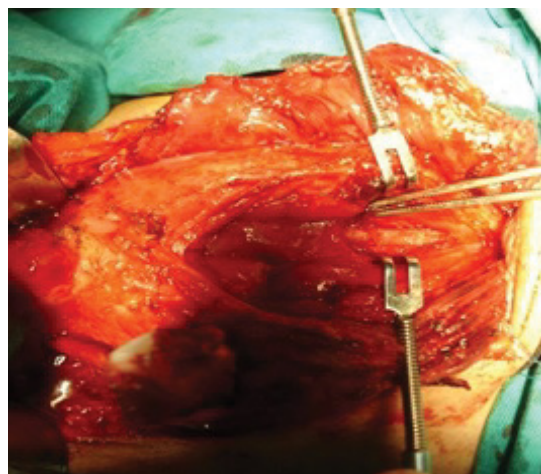
Treatment of laryngotracheal trauma consists of symptomatic management, contraction, and improvement of the laryngeal skeletal fractures. Alternatively, it involves a complete tracheal or laryngeal reconstruction [2]. Different surgical techniques have been devised to deal with this problem. However, cricoid reconstructive surgery involving

cartilage grafting is most preferred. Despite this popularity, there is little concern about the outcome, hence this study, which examines the result of a glottic and subglottic reconstructive surgery by means of grafting.

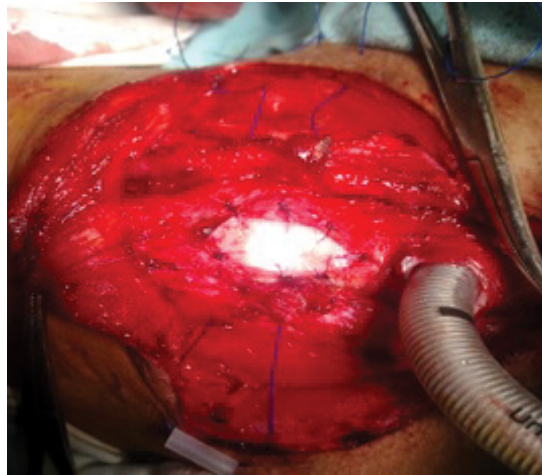
#### PATIENTS AND METHODS

A prospective study was used to examine the result of a glottic and subglottic reconstructive surgery by grafting. The study was designed as a descriptive clinical trial investigation conducted in the ENT Department of Cho Ray Hospital-one of the largest hospitals in Ho Chi Minh City. Study participants were those individuals who had been diagnosed with glottic and subglottic stenosis and undergone reconstructive surgery by cartilage or bone grafting from 2014-2016. Their admission to the study was refused if any of the following criteria were present: (a) congenital stenosis, and/or (b) airway narrowing due to external pressure or tumor.

To obtain more accurate and representative treatment evaluations, patients were divided into groups based on demographic characteristics, e.g. age and gender, causes of stenosis (cartilage damage in CT-scan area), previous treatment procedures (type and quantities), stenosis diameter with Cotton-Meyer grading system of subglottic stenosis, and surgical results. Patients' subglottic and glottic stenosis receive surgery through grafting cartilage and bond, using basic Rethiand Cotton procedures. The patients were required to be in a supine position with a pillow under their shoulders. A nasogastric tube is inserted under anesthesia with endotracheal intubation. There is a horizontal skin incision at the cricoid cartilage level in order to expose the cricoid and thyroid cartilage. The cricoid and thyroid cartilages are then incised at the middle line. The position and size of the stenosis, as well as the cartilage fracture, should be assessed before incising the lamina of cricoid cartilage at the middle line to insert the grafting materials. Subsequently, the harvest of the grafting materials such as hyoid bone, thyroid cartilage, and septum cartilage depends on the size and position of stenosis. The stage involving inserting grafting material includes measuring the size of the grafting material in the anterior and posterior larynx wall and inserting it between 2 parts of cricoid lamina in the posterior wall of the cricoid cartilage. Finally, mitomycin is applied to the reconstructive suturing of the anterior wall of the larynx with grafting material before inserting the drainage tube and suturing the skin (Figures 1 and 2).



**Figure 1** Posterior larynx wall grafting



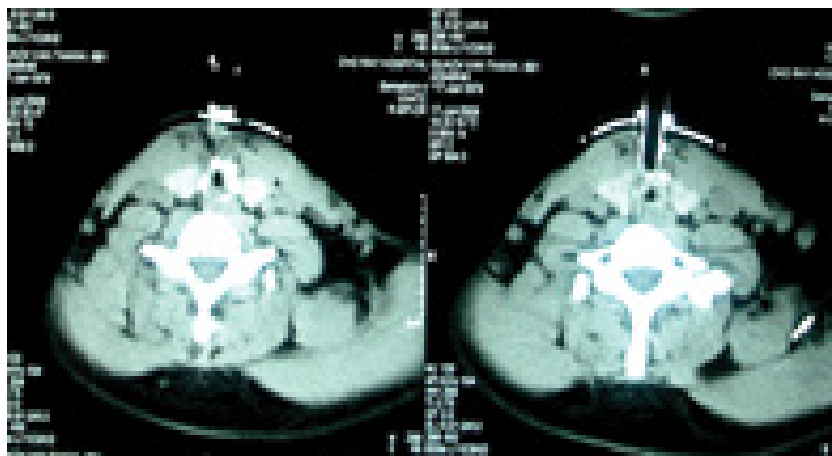
**Figure 2 Anterior larynx wall grafting**

Following cricoid reconstructive surgery, post-operative care includes: (a) using an antibiotic, anti-inflammatory, and antireflux, (b) carrying the dual tracheal cannula by the patient, (c) removing the drainage tube after 3 days, and (d) removing the nasogastric tube after 5 days.

After being discharged from the hospital, patients must follow up their treatment every 2-week in the first month and every month for 2-months. They also need to be hospitalized to remove the stent and follow their progress up 1-week after a period of 2-3 months. The flexible laryngo-tracheal endoscopic examination can be used to evaluate the surgical results. This can be carried out following the removal of the stent, and every week in the first month, every month for a period of 3-months, and every 3-month for the first year.

### RESULTS

The average (and standard deviation) of ages for both sexes was 35-36 years old, with an above-average concentration of subjects in the middle-aged group of 31-40 years old (55.6%), followed by 20-30 years old (22.2%), and 41-50 years old (22.2%). The distribution of subglottic and glottic stenosis cases in the sample is predominant in the male patients with a ratio of 8:1. Most cases were caused by neck trauma that had been overlooked or treated inappropriately; the fracture of the cricoid cartilage damage for 5 cases accounted for 55.6% (Figure 3 and Table 1).

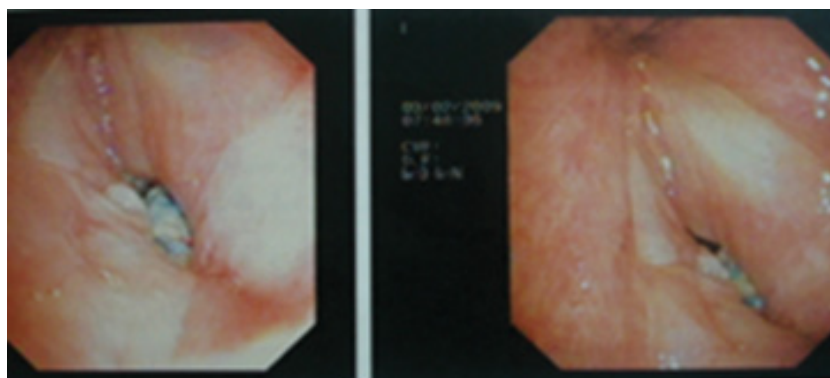


**Figure 3 CT-scan laryngeal stenosis**

**Table 1 Demographic characteristics of the included patients (N=9)**

| Characteristics  | Number of cases | Percentage |
|--|-----------------|------------|
| <b>Age (Years)</b>   |                 |            |
| 20-30  | 2               | 22.2%      |
| 31-40  | 5               | 55.6%      |
| 41-50  | 2               | 22.2%      |
| <b>Gender</b>  |                 |            |
| Male   | 8               | 88.9%      |
| Female   | 1               | 11.1%      |
| <b>Cartilage damage in CT-scan</b>   |                 |            |
| Cricoid cartilage fracture   | 5               | 55.6%      |
| Cricoid and thyroid cartilage fracture   | 2               | 22.2%      |
| Cricoid thyroid and tracheal cartilage fracture                                  | 1               | 11.1%      |
| Cricoid thyroid cartilage deterioration in autoimmune disease                    | 1               | 11.1%      |
| <b>Previous treatment procedures</b>   |                 |            |
| Aboulker tube  | 4               | 44.5%      |
| T stent  | 1               | 11.1%      |
| Endoscopic dilatation  | 3               | 33.3%      |
| No previous procedure  | 4               | 44.5%      |
| <b>Number of previous treatments</b>   |                 |            |
| None   | 4               | 44.5%      |
| 1  | 2               | 22.2%      |
| 2  | 3               | 33.3%      |
| <b>Stenosis diameter with Cotton-Meyer grading system of subglottic stenosis</b> |                 |            |
| Grade (Cotton and Myer) 51-70% (II)  | 5               | 55.6%      |
| Grade (Cotton and Myer) 71-99% (III)   | 3               | 33.3%      |
| No detectable lumen (IV)   | 1               | 11.1%      |
| <b>Grafting position</b>   |                 |            |
| Anterior grafting  | 4               | 44.5%      |
| Anterior and posterior grafting  | 5               | 55.6%      |
| <b>Outcomes</b>  |                 |            |
| Decannulation  | 7               | 77.8%      |
| Endoscopic removing of granulation tissue  | 3               | 33.3%      |
| Restenosis   | 2               | 22.2%      |

In our study, 55.5% of the patients (5 cases) had an unsuccessful record of treatments. There were patients who had undergone double treatments with a total percentage approximate to 100%, including Aboulker's stent insertion without cartilage grafting, T-tube surgery, and treatment by endoscopic dilatation as in 4, 3 and 1 cases, respectively (Figure 4).

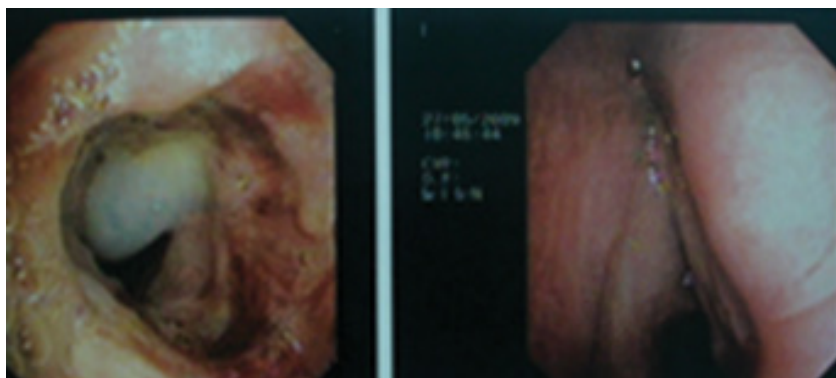
**Figure 4 Pre-operative laryngoscopy**

According to the stenosis diameter, as per Cotton-Meyer grading system of subglottic stenosis, 8 cases (of 9) of the

glottic and subglottic stenosis can be divided into 2 sub-groups: the Cotton grade II and III with a higher percentage in the former group (55.6%) than the latter one (33.3%). The grafting position involved anterior grafting and included 4 cases (44.5%), almost identical to the 5 cases that included anterior and posterior grafting (55.6%).

This study reviewed 9 cases of glottic and subglottic reconstructive surgery by grafting. Significantly, the results show that of 9 cases, 7 (77.8%) involved decannulation. Approximately one-third of these patients were able to breathe normally through their nose. Three cases, however, involved endoscopic removing of the granulation tissue after decannulation. However, there were 2 cases of restenosis in which the patients had to carry the cannula.

The initial results of glottic and subglottic stenosis surgical reconstruction with cricoid cartilage grafting are satisfactory, enabling 77.8% of the patients to resume their daily routine (Figures 5 and 6). This is a complicated procedure that requires further study.



**Figure 5 Laryngoscopy after removing the Aboulker stent**



**Figure 6 Laryngoscopy after removing the Aboulker stent after 6 months**

## DISCUSSION

The majority of the patients in this study were male (with one female only), and their average age was  $35 \pm 6$  (20-47 years), with most of them in the 31-40 age group. This indicates that the patients affected by laryngotracheal trauma were mainly in the working age population.

The principal cause of glottic and subglottic stenosis is larynx trauma; it is also attributed to the fracture of the cricoid cartilage either overlooked or ineffectively treated. The cricoid cartilage is the main cartilage to ensure the inner diameter of the larynx. This structure known as lamina is the small surface anterior and the large surface posterior, located over the neck spine. In a closed injury, the contact between the neck and a hard object causes trauma, resulting in the cricoid cartilage being pressed between the posterior area of the spine neck and the anterior part of the hard object.

Treating glottic and subglottic stenosis is difficult and challenging. Aboulker's stent insertion for laryngectomy has been carried out extensively for many years, with very limited success. Chevalier, et al., have been pioneers in larynx

reconstructive surgery since 1935. Over 3 decades on, the larynx reconstruction with posterior grafting was first performed by Rethi in 1971. This was followed by Cotton and Seid's study on rib cartilage grafting in the anterior wall of the larynx.

In our study, 7 patients (of 9) had previous surgeries, including 4 cases of recurrence following Aboulker's stent insertion without cartilage grafting, one case of recurrence after T-tube surgery, and 3 cases of ineffective treatment with endoscopic dilatation; 4 cases had not received any prior treatment.

The cause of the glottic and subglottic stenosis in most cases (8/9 in this study) is a post-injury fracture of the cricoid cartilage, suggesting that cartilage may break into pieces during the surgery. In fact, the larynx lumen and the subglottic area are so narrow that the inflammation around the cartilage and the scar inside the larynx make access to the cricoid cartilage very difficult. These circumstances make matters extremely complicated, often requiring a skillful approach from the trachea. In addition, the identification and incision of the cricoid cartilage lamina to insert the grafting materials poses many challenges, further complicated by fibrosis and scars. Basically, there were 3 problems: the lamina of the cricoid cartilage is broken at the middle line; the 2 edges overlap and create a solid one; the thick mass that narrows the larynx. The success rate for anterior, according to Denise V. Guendert, is 100%; this rate for the posterior cricoid cartilage grafting and re-surgery is 83% and 70%, respectively [3]. The overall rate of decannulation declared by Laccourreye, et al., is 89% [4].

This study has glottic and subglottic stenosis due to cricoid and thyroid cartilage deterioration in autoimmune diseases. The cricoid and thyroid cartilage deterioration had caused total stenosis of glottic and subglottic areas. We used the hyoid bone and septum cartilage to reconstruct the anterior and posterior of the cricoid cartilage. However, because the cartilage was nearly completely deteriorated, the reconstruction was difficult and resulted in a recurrence. The patient was not able to remove the cannula; however, the airway looked wider than what it was before the surgery, and the patient was able to tell when the cannula was blocked. Today, the cartilage grafting technique is a very common preservative treatment for severe deterioration lesions. For example, 68 of 107 cases (63.55%) described by Cotton have used the cartilage grafting technique in combination with a short-term stent insertion [5]. Airway's reconstruction with grafting has had an erratic history. Earlier authors, such as Narodick Fonkalsrud (focusing on periosteum), Meyer (studying cheek mucosa), Grafoord Dang Trung Hieu (concentrating on skin and cartilage), and Conley Work (investigating auricular cartilage), have managed to gradually improve this technique [6-9]. They found that cartilage and bone were the best 2 reconstructive materials. They also found that these materials can best sustain the conditions of an implanted environment when they were nourished by periosteum and perichondrium or pedicle.

Traditionally, patients have undergone Rethi procedure, which involves an incision in the anterior and posterior walls of the cricoid cartilage and the subsequent removal of all scars and long-term stent insertions. This technique is identified in subglottic stenosis or glottic stenosis with Cotton grade I, II and III. Today the technique has been improved by Grahne Fearon and Cotton, who have suggested the temporary widening of the larynx subglottic area by removing the anterior, posterior and the 2 sides of the cricoid cartilage before inserting the stent [5,10].

According to Fearon, Cotton used a modified procedure to treat 41 children with severe glottic and subglottic stenosis (Cotton III, IV narrowed by 90%-100%) [11]. The procedure involved splitting the anterior and posterior of the cricoid cartilage with short-term stent insertions (6-weeks); this technique was successful in more than 90% of the cases. Anterior and posterior cartilage grafting, using the Rethi and Cotton procedures, encompassed 5 cases. The patients suffered from severe glottic and subglottic stenosis-the Cotton grades III and IV. As a result, there were 2 cases for which decannulation was not possible; one included an autoimmune inflammatory disease and another was an enhanced post-operative case with the Cotton grade changed from IV to I. In 4 cases with anterior cartilage grafting, the patients were able to remove the cannula.

This present study focused on 9 cases of glottic and subglottic reconstructive surgery using grafting. Seven of these cases, that is 77.8%, involved decannulation; 3 cases involved removing the post-operative granulation tissue (33.3%), and 2 cases failed to yield the results expected (22.2%).

This discussion concentrated on the indications and techniques of surgery. The choice of grafting materials was considered carefully [5,12]. For cases with lamina cricoid cartilage grafting, we used the hyoid bone. This provides a useful and convenient grafting material for the larynx, not least because of its adjacent location, appropriate size, and the limited disturbance of the larynx function when cutting the trunk of the hyoid bone. In cases with anterior

cricoid grafting and trachea, we chose the thyroid wing cartilage or nasal septum cartilage. We used the thyroid wing cartilage because it suits our needs, and its adjacent location allows easy utilization during surgery. In the case of thyroid cartilage injury, we took the cartilage from the nasal septum. Harvesting cartilage from the nasal septum is easy and does not interfere with the function of the nose.

Rethi reports improvements in the use of “pincer” for reconstructing the lamina cricoid cartilage and suturing the sides of the cartilage. When cutting the 2 sides of the lamina cricoid cartilage, it is necessary to cut straight along the anterior-posterior direction and avoid oblique cutting. Two flat cuts prepare the edge of the graft and help to clamp it fixed in the middle. The size of the graft should be accurately measured; it is in the shape of a two-pointed rhombus, and the larynx lumen’s horizontal dimension after grafting is equivalent to the lower airway.

Aboulker tube shaping is also necessary to measure the length and the diameter [13]. The length of the tube should be equal to the length of the scar, and the diameter of the tube should be equal to its tracheal counterpart. We chose silicon to make the tube (using pleural catheter). The tube’s superior border can be at the level of the epiglottic cartilage if the trauma is above the vocal cord, or under the vocal cord if the vocal cord is functioning normally. The inferior border depends on the location of the lesion above the tracheal opening.

No complications such as bleeding, pneumothorax or fraying of the sutures occurred. Following dilatation, 3 cases of granulomatosis occurred, for which we conducted the laryngo-tracheal endoscopy and applied mitomycin, delivering satisfactory results. Many authors argue that mitomycin constrains the occurrence of the inflammatory granule tissue. However, no research hitherto has demonstrated scientifically the effect of mitomycin, which merits further research. We did not evaluate the post-operative nerve paralysis because all the cases had deformities, vocal cord movement restrictions or total stenosis before surgery. Many authors believe that the cannula should not be left too long, lest it causes infection and stimulates the formation of the inflammatory granule tissue. François’s study, for example, involved the cannulation time and the formation of the inflammatory granule tissue as well as a superinfection of *Staphylococcus aureus* or *Pseudomonas aeruginosa* [14]. *Pseudomonas* increases the risk of inflammatory granule tissue formation.

In his study, Myer used a modified procedure, which involved anterior and posterior cricoid cartilage grafting with a short-term stent insertion (six weeks) [15]. This technique has been successful in over 90% of cases. Recently, a study described achievements in using this treatment technique for patients with severe subglottic stenosis or combined with glottic or tracheal stenosis. In Vietnam, Dang Hieu Trung reported that 19 (of 22) (86.3%) cases of traumatic scarring were successfully treated [16]. All cases with severe glottic and subglottic stenosis, Cotton grade III and IV, opt for this surgical procedure as the first choice for the patient’s safety. All of these factors have a direct influence on the success rate or failure of the surgery. Technically, we differ with Grahne and Cotton who use a piece of cartilage to hold one side of the perichondrium [5,17]. The cartilage surface is placed in the direction of the tube, and the tube can reach up to 4 cm in length from the glottis to the trachea. This strategy has been successful in the majority of the cases (10 out of 11, i.e. 90.91%), with only one failure due to the cartilage deterioration. Our success rate of 77.8% decannulation largely corresponds to Cotton’s success rate of 82.24% for 88/107 patients, involving anterior and posterior grafting [5]. This result has contributed to the development of glottic and subglottic stenosis surgical reconstruction.

## CONCLUSION

These data indicate that cricoid trauma gave rise to most of the glottic and subglottic stenosis cases, with the majority of the cases having a total or near total loss of glottic/subglottic lumen. Our findings also suggest that many patients had tried other treatments before, which produced unsatisfactory outcomes. The study report shows that the cartilage grafting technique is a very effective and successful method in treating subglottic and glottic stenosis. These data also illustrate the importance of the choice of the grafting material, as it can have a significant impact on the effectiveness of the therapy.

## DECLARATIONS

### Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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