Surgery for laryngotracheal stenosis: Improved results

Giulio Maurizi, MD, PhD,[a] Camilla Vanni, MD,[a] Erino Angelo Rendina, MD,[a] Anna Maria Ciccone, MD,[a] Mohsen Ibrahim, MD,[a] Claudio Andreetti, MD,[a] Federico Venuta, MD,[b] and Antonio D'Andrilli, MD[a]

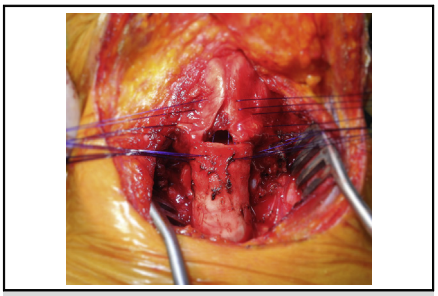
ABSTRACT

Objective: Laryngotracheal resection is still considered a challenging operation and few high-volume institutions have reported large series of patients in this setting. During the 5 years, novel surgical techniques as well as new trends in the intra- and postoperative management have been proposed. We present results of our increased experience with laryngotracheal resection for benign stenosis.

Methods: Between 1991 and May 2019, 228 consecutive patients underwent laryngotracheal resection for subglottic stenosis. One hundred eighty-three (80.3%) were postintubation, and 45 (19.7%) were idiopathic. Most of them (58.7%) underwent surgery during the past 5 years. At the time of surgery, 139 patients (61%) had received tracheostomy, laser, or laser plus stenting. The upper limit of the stenosis ranged between actual involvement of the vocal cords to 1.5 cm from the glottis.

Results: There was no perioperative mortality. Two hundred twenty-two patients underwent resection and anastomosis according to the Pearson technique; 6 patients with involvement of thyroid cartilage underwent resection and reconstruction with the laryngofissure technique. Airway resection length ranged between 1.5 and 8 cm (mean, 3.8 ± 0.8 cm) and it was >4.5 cm in 19 patients. Airway complication rate was 7.8%. Overall success of airway complication treatment was 83.3%. Definitive success was achieved in 98.7% of patients. Patients presenting with idiopathic stenosis or postcoma patients showed no increased failure rate.

Conclusions: Laryngotracheal resection for benign subglottic stenosis is safe and effective, and provides a very high rate of success. Careful intra- and postoperative management is crucial for a successful outcome. (J Thorac Cardiovasc Surg 2021;161:845-52)



Partial laryngofissure. The thyroid cartilage is incised in order to enlarge the airway.

CENTRAL MESSAGE

Laryngotracheal resection for benign subglottic stenosis is safe and effective, and provides a very high rate of success. Careful management is crucial for a successful outcome.

PERSPECTIVE

Laryngotracheal resection has proven to be the definitive curative treatment for benign subglottic stenosis. Nevertheless, it is still considered a challenging operation and few high-volume institutions have reported large series of patients in this setting. During the past 5 years, novel surgical techniques as well as new trends in airway management have been proposed.

See Commentaries on pages 853 and 854.

Since Gerwat and Brice[1] and Pearson and colleagues[2] proposed the principles for a safe laryngotracheal (LT) resection more than 40 years ago, this reconstructive operation has proven to be the definitive curative treatment for benign subglottic stenosis. Nevertheless, this operation is still considered challenging and only a few high-volume institutions have reported their experience with a large series of patients in this setting.[3-5] With respect to a simple tracheal resection, the resection and reconstruction of the LT region poses additional technical issues, mainly because the space below the vocal cords is the narrowest segment of the airway, and due to the need for resecting the anterior portion of the cricoid cartilage near the vocal cords. Main causes of

From the [a]Division of Thoracic Surgery, Sant'Andrea Hospital, Sapienza University of Rome, and [b]Division of Thoracic Surgery, Policlinico Umberto I, Sapienza University of Rome, Rome, Italy.

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Address for reprints: Giulio Maurizi, MD, PhD, Division of Thoracic Surgery, Sant'Andrea Hospital, Sapienza University of Rome, Rome, Via di Grottarossa, 1035, 00189 Rome, Italy (E-mail: giulio.maurizi@uniroma1.it).

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Abbreviations and Acronyms
FBO = fiberoptic bronchoscopy
LT = laryngotracheal
NT = nasotracheal

benign subglottic stenosis most frequently include acquired inflammatory postintubation and/or posttracheostomy disease. Idiopathic stricture, which is a more rare condition, represents the second most frequent cause. The resection of a postintubation/posttracheostomy LT stenosis may strain surgical teams that are frequently called to operate and manage patients presenting with additional difficult conditions such as local (peritracheal and anastomotic site) severe inflammatory status and postcoma neuropsychiatric disorders. On the other hand, the surgical treatment of an idiopathic stenosis presents additional challenges that need to be addressed and resolved[6]: in particular, this type of stricture tends to involve the vocal cords and to recur. During the past several years, some novel techniques have been proposed, most of which pertain in particular to the treatment of very-high-level stenosis.[7]

The perioperative management of patients undergoing LT resection has changed as well. Intraoperative airway management in addition to new surgical techniques have revolutionized the in-hospital stay and, ultimately, the outcome of the patients.[8] The increase in knowledge and in technology have also changed the way we treat patients with subglottic stenosis.[5,7,9] Herein, we present our increased experience with LT resection for benign stenosis since 2015.

MATERIALS AND METHODS

Between 1991 and May 2019, 228 consecutive patients underwent LT resection for benign subglottic stenosis (Figure 1). One hundred eighty-three (80.3%) were postintubation and 45 (19.7%) were idiopathic. Most (58.7%) underwent surgery during the past 5 years. At the time of surgery, 139 patients (61%) had received tracheostomy (n = 83), laser (n = 29), or combined laser plus stenting (n = 27). The patients who received laser underwent resection 1 to 8 months later. LT resection was generally performed after having assessed endoscopically the remission of the inflammation in the stenotic tract. In patients with tracheostomy showing local evidence of infection, systemic and local antibiotic treatment was administered until complete sterilization was achieved.

Preoperative study included fiberoptic bronchoscopy (FBO), which was performed while patients were awake under local anaesthesia with the aim to assess the status of the vocal cords (mobility and trophism); the characteristics of the stricture (severity grade and extent); and the presence of inflammation, edema, or malacia. Since 2003, our preoperative assessment has also included neck and thorax computed tomography scan with contrast medium and volume rendering to better evaluate the tracheal wall, the peritracheal structures, and tissue status.

The upper limit of the stenosis ranged between actual involvement of the vocal cords (n = 6) and 1.5 cm from the glottis. Grade of stenosis ranged between 60% and 100% of the LT lumen; according to Cotton-Meyer scale, 28.5% of these patients were classified as grade 2, 54.8% were classified as grade 3, and 16.7% were classified as grade 4.

The resection and anastomosis were performed according to the principles described by Pearson and colleagues in 1975.[2] We have reported our standard technique in previous publications.[9] The anastomosis was performed by interrupted sutures of 3-0 absorbable monofilament material; a running suture (3-0 or 4-0 polydioxanone) was employed for the posterior membranous portion in case of short segment resection (up to 2 cm) with no tension. Since 2015, when there is involvement of the vocal cords we have employed a personal variation of the standard Pearson technique (ie, partial laryngofissure) (Figure 2, *A* and *B*, and Video 1). We reported this novel technique in detail in a previous publication.[7]

Intraoperative airway ventilation was achieved with endotracheal intubation using a wire-reinforced tube. In most cases of tight stenosis, a small caliber (4-4.5 mm) orotracheal tube was passed through the stenosis or placed immediately above it. In patients with tracheostomy, the stoma was intubated directly and later removed en bloc with the stenotic segment. Since 2018, we have used laryngeal masks in selected patients. All patients underwent cross-field ventilation after the tracheal resection during the intervention.

Airway resection length ranged between 1.5 and 8 cm (mean, 3.8 ± 0.8 cm) and it was >4.5 cm in 19 patients. LT release was performed in 17 patients. LT release was suprahyoid, pericardial, or suprahyoid plus pericardial.

Immediate postoperative airway management was conducted as follows: a small uncuffed nasotracheal tube (NT) was passed over the anastomosis to protect it and to allow a safe tracheobronchial toilette. The tube was usually removed after 24 hours under FBO visualization to check anastomosis status and vocal cord function. If a laryngeal mask was intraoperatively used, no uncuffed NT tube was employed but an FBO check was

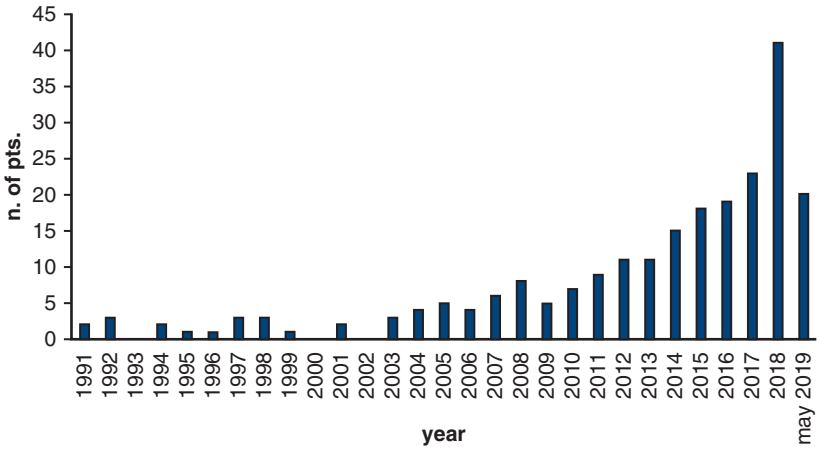


FIGURE 1. Patients (pts) distribution over the study period.

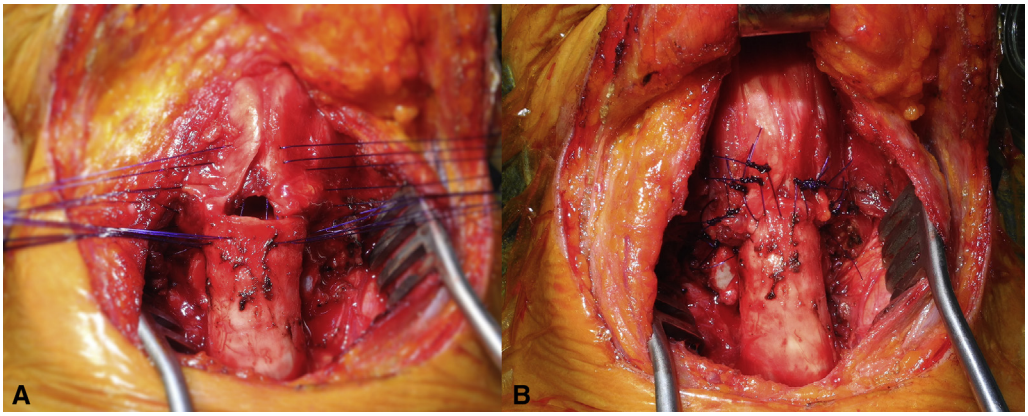


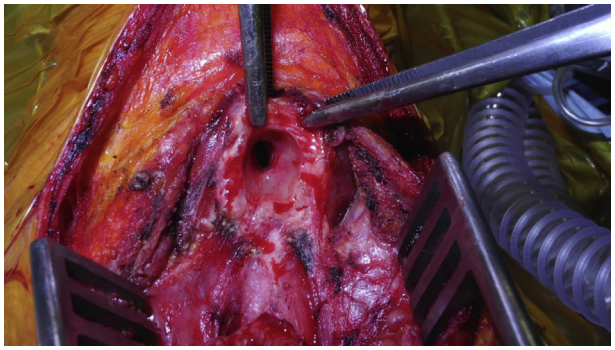
FIGURE 2. Partial laryngofissure: This technique includes a longitudinal partial incision of the thyroid cartilage on the midline for an extent of 1 to 1.5 cm, the lateral retraction of its margins to increase the airway space and, finally, the direct anastomosis of the lower trachea to the retracted ends of the incised thyroid cartilage. A, Intraoperative picture showing the thyroid cartilage incised on the midline; the stiches are passed but still untied. B, The completed anastomosis between the lower trachea and the incised and enlarged thyroid cartilage.

done before removing the mask. During the following hospital stay, FBO were done on postoperative day 1 and on the day of discharge.

After discharge, follow-up controls by FBO were scheduled at month 1, month 3, and every subsequent 3 months for the first year, every 6 months during the second year, and once a year for the remaining time. Postoperative noninvasive follow-up was performed with contrast-enhanced computed tomography scan in patients who presented with sequelae persisting at long-term.

Early (postoperative within 1 month) and definitive (long-term) results were classified according to 3 different categories. Results were considered excellent in case of success with no sequelae, good voice, and breath and good if sequelae did not jeopardize the success of the reconstructive operation. The good category was divided into 2 subcategories: grade A if voice and/or breathing showed some changes that did not influence the quality of life, and grade B if abnormal voice, narrowed anastomosis, and shortness of breath on exercise were found, but not enough to hinder normal activities. Lastly, results were considered not satisfactory in case of failure (eg, restenosis, dehiscence, or other conditions requiring permanent tracheostomy or persistence of the airway stent, or dysphonia). The evaluation was performed by the surgical team according to objective (instrumental) and perceptive (patient report) findings. Voice quality was assessed using a perceptive method according to the GBRAS and then, when available, to the GIBRAS method.

All surviving patients were available for follow-up. Last date of follow-up was October 2019. The study was approved by the institutional review board and conducted in accordance with the Declaration of Helsinki. All patients provided written informed consent for the surgical intervention and for the inclusion of their personal data in a scientific database.



VIDEO 1. The partial laryngofissure technique. Video available at: https://www.jtcvs.org/article/S0022-5223(20)33363-8/fulltext.

Statistical Analysis

Data were collected and stored in an Excel database (Microsoft Corp, Redmond, Wash). All statistical analysis was performed using IBM-SPSS Statistics version 21.0.0.0 software (IBM-SPSS Inc, Armonk, NY). Quantitative variables are expressed as mean ± standard deviation or median with interquartile range, whereas nominal variables were expressed binarily as presence (1) or absence (0) of the event. Comparison of categorical variables was performed with the χ^2 test using Fischer exact test or Yates correction when appropriate. Significance was defined as a P value of less than .05.

RESULTS

One hundred thirty-one patients were men and 97 were women. The mean age was 44.8 ± 15.5 years (range, 14-77 years). Fifty-nine patients (25.9%) were postcoma patients with neuropsychiatric disorders (severe mental disorders resulting from prolonged unconsciousness, including psychiatric problems and other cognitive disorders, especially patients with head injury sequelae). Two hundred twenty-two patients underwent resection and anastomosis according to the Pearson technique; 6 patients (2.7%) with involvement of thyroid cartilage and vocal cords underwent resection and reconstruction using a variation of the standard Pearson technique (ie, partial laryngofissure). Airway resection length ranged between 1.5 and 8 cm (median, 3.5 cm; interquartile range, 1.5-4 cm). A resection ≥4.5 cm was performed in 19 patients (8.3%). LT release was used in 17 patients (7.4%); it was suprahyoid in 13, pericardial in 1, and suprahyoid plus pericardial in 3. Hilar release was performed by a lateral minithoracotomy.

At surgery, 206 patients (90.3%) were intubated with a small orotracheal tube. Beginning in 2018, a laryngeal mask was used in 22 patients (9.7%). No postoperative (in-hospital and at 30 days) mortality occurred.

Early success rate was achieved in 92.8% of patients. Results were excellent in 81.1% of cases and good (grade: A) in 11.7%. Overall complication rate was 9.6%. Airway complication rate was 7.8% (Table 1). Restenosis was treated in all 14 patients with endoscopic procedures (7 laser, 3 laser plus stent, and 4 mechanical dilation). Stents were removed in all except 1 patient. The success rate of the endoscopic treatment of restenosis was 92.8%. Two patients with anastomotic dehiscence required temporary tracheostomy closed after 6 months and 1 year, respectively, with no sequelae. One patient presenting with postoperative dehiscence and 1 patient presenting with postoperative glottis edema received permanent tracheostomy. Overall success rate of airway complication treatment was 83.3%. Early failure rate in patients who underwent surgery for idiopathic stenosis was 4.4% (n = 2 with restenosis), whereas in the subgroup of patients presenting with neuropsychiatric disorder it was 6.1% (n = 3) (P = not significant). Mean postoperative length of stay was 7.9 ± 2.7 days (median, 7 days; range, 3-21 days).

At a mean follow-up of 65.5 ± 47 months, (median, 57 months; range, 5-302 months) definitive success was achieved in 225 patients (98.7%). Among these, 190 patients (83.3%) showed an excellent result. In 35 patients (15.4%), the long-term result was considered good (grade: A in 28 [12.3%] patients and grade: B in 7 [3.1%] patients). Results considered not satisfactory (ie, failure) were determined in 3 patients (1.3%). Four patients died from other diseases.

Patients presenting with idiopathic stenosis or postcoma patients with neuropsychiatric disorders showed no increased failure rate; definitive success rate in the group of patients with idiopathic stenosis (n = 45) was 100%, whereas in the group of postcoma patients (n = 59) definitive success rate was 96.3%.

When comparing results of our more recent, increased experience period (from April 2015 to May 2019) with data from our previous period (up to March 2015) (Table 2) we confirm a high success rate (99% vs 98.3%; P = .61) and reduced postoperative hospital stay (6.9 ± 3.1 vs 9 ± 1.8 days; P = .001) despite an older mean age of patients (50.1 ± 17.3 years vs 39 ± 10.9 years; P = .001). Definitive excellent outcome rate as well as the rate of patients undergoing LT resection for idiopathic stenosis both increased, but not significantly (86.5% vs 79.8% [P = .17] and 24.4% vs 14.6 [P = .06], respectively).

TABLE 1. Complications

Complication	n (%)
Restenosis	14 (6.1)
Dehiscence	3 (1.3)
Glottis edema requiring tracheostomy	1 (0.4)
Wound infection	3 (1.3)
Atrial fibrillation	1 (0.4)
Total	22 (9.6)

TABLE 2. Comparison between our previous published series (up to March 2015) and our latest experience (April 2015-May 2019)

Characteristic	Up to March 2015	April 2015-May 2019	P value
No. of patients	109 (100)	119 (100)	
Age (y)	39 ± 10.9	50.1 ± 17.3	.001
Idiopathic stenosis	16 (14.6)	29 (24.4)	.06
Postcoma patients	28 (25.7)	31 (26)	.9
Resection ≥4.5 cm	14 (12.8)	5 (4.2)	.01
Involvement of the vocal cords	1 (0.4)	5 (4.2)	.12
Laryngeal mask	0 (0)	22 (18.5)	.001
Early (within 1 mo) excellent result	85 (78)	100 (84)	.24
Airway complication	10 (9.2)	8 (6.7)	.49
Postoperative length of stay (d)	9 ± 1.8	6.9 ± 3.1	.001
Follow-up (mo)	52.9 ± 31.4	25.5 ± 16	.001
Definitive success	108 (99)	117 (98.3)	.61
Definitive excellent result	87 (79.8)	103 (86.5)	.17
Failure	1 (1)	2 (1.7)	.61

Values are presented as mean ± standard deviation or n (%).

DISCUSSION

LT resection plays a crucial role in the treatment of subglottic benign stenosis. All authors who have published their experience in this setting have reported data suggesting that this reconstructive operation of the airway can ensure the definitive curative treatment for the disease.[3-6,10] Subglottic airway strictures as a consequence of an ischemic injury of the tracheal mucosa after intubation or tracheostomy[11] have represented a challenging issue without any adequate solution for patients for a long time, until Pearson and colleagues[2] described the principles for a safe resection of the LT axis. A rarer cause of the stricture is idiopathic disease. This second condition represents an even more challenging situation[12] because of the not infrequent actual involvement of the vocal cords, and the need for a careful and complete resection of the airway where fibrotic tissue is present, to minimize the fearful risk of recurrence after surgery.

Wang and colleagues[13] reported results from a large series of consecutive patients undergoing surgery for idiopathic stenosis at Massachusetts General Hospital across 43 years. They reported good-to-excellent results in 96% of patients after single-stage reconstructive surgery. Recurrence of the stenosis occurred in 20 patients, in 14 patients it

was related to reactivation of the disease, and in 6 patients it was related to technical problems. They concluded that stents, postoperative edema, mitomycin use, and vocal cord involvement are risk factors for recurrence.

To address the last issue, the current author recently described partial laryngofissure, a novel technique for the safe treatment of very-high-level idiopathic stenosis.[7] The employment of this new technique since 2015 represents a new, feasible, and successful resource in the technical armamentarium available for the resection of stenosis with actual involvement of the vocal cords. When compared with other proposed techniques,[14,15] partial laryngofissure applied by the current authors resulted in adequate and durable enlargement of the laryngeal space (with particular reference to the lateral axis) without the need to perform a complete laryngeal split, thus simplifying the procedure.

During the past 5 years, authors publishing in this setting have also introduced some interesting variations to the current intra- and postoperative management of the airway.[8] Beginning in 2018, we modified our management, including the use of a laryngeal mask for the intraoperative ventilation of the airway during surgery. As a consequence, even the immediate postoperative airway management has changed. Patients undergoing resection under laryngeal mask were not intubated at the end of surgery and did not receive a NT intubation for 24 hours, as in the past. This could have contributed to the reduced postoperative hospital stay observed in our more recent experience (from May 2015 to April 2019) if compared with data from our previous published series.[5]

The recent introduction of these novel methods with the benefit of increased experience and skills (more than half of all patients included in the current series underwent operation during the past 5 years) are the main reasons that led us to report the results of this updated complete series of patients.

The characteristics of the patients have also changed a little bit over time. For example, there was a higher rate of idiopathic stenosis and a higher mean age than in the past (ie, before April 2015). The rate of postcoma patients presenting with neuropsychiatric disorders and undergoing LT resection (now 59 patients) did not change significantly over time, with no difference between the 2 study periods. Nevertheless, data arising from our analysis show and confirm a very high rate of final success, with an even higher rate of definitive excellent results (Figure 3). Our increased experience suggests that the treatment of the early airway complications might play a role as important as, or even more important than, the routinely careful intra- and postoperative management. A high rate of success in resolving the airway complication can guarantee that patients obtain more than satisfactory and long-lasting results.[16]

Many patients undergoing surgery at our institutions have received preoperative procedures like tracheostomy or endoscopic treatments, sometimes repeatedly. A possible explanation is that our division is a tertiary referral center and the patients included in this series came from different centers and underwent preoperative procedures (eg, dilation, laser, stenting, or tracheostomy) based on variable indications and protocols. The conviction of the current author is that, when feasible and the patient is suitable for

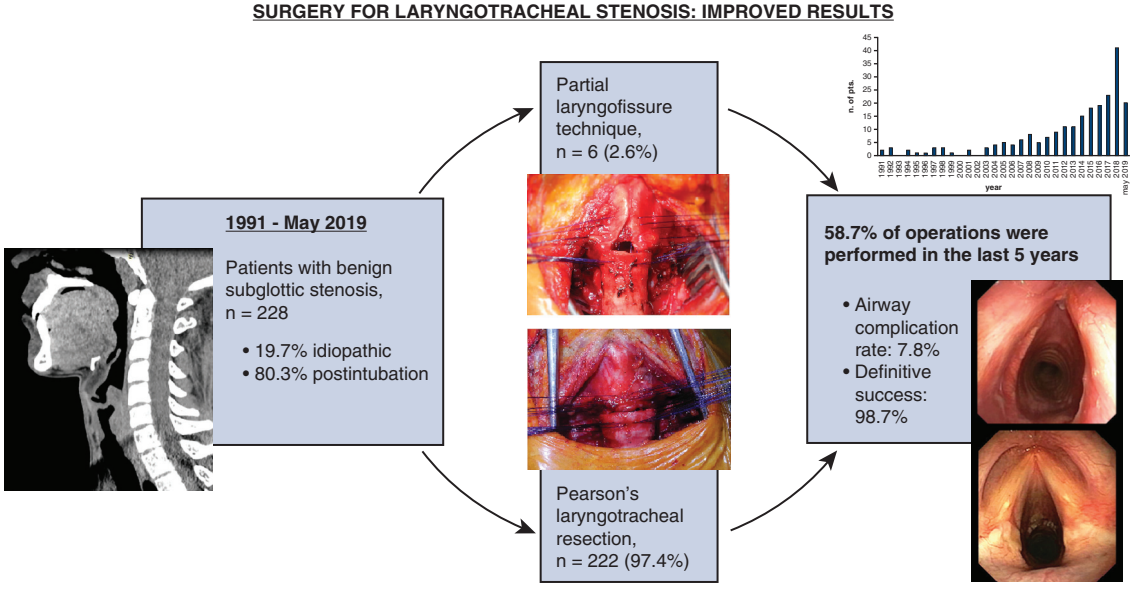


FIGURE 3. Laryngotracheal subglottic stenosis: patients, treatment, and outcome.

a safe resection, a definitive curative treatment of the LT structure by surgery is the best choice, with no further dilation or repeated attempts to solve the problem after the first unsuccessful conservative/endoscopic treatment. Another different aspect of this series from the past is the classification of the results. For this study, we have abandoned the satisfactory category and introduced 2 subcategories within the good category (ie, A and B). This is because over time we saw very few patients who qualified for the satisfactory category. Otherwise, the sets "good" and "satisfactory" differed in very few aspects. In our opinion, this change simplifies the reading of the data, avoiding confusion.

A further consideration is about patients considered at risk of complication and/or failure after resection (eg, patients with idiopathic stenosis or postcoma patients with neuropsychiatric disorders). No difference was found in terms of early or definitive failure when comparing the results of these 2 subgroups of patients with those of the whole population.

Increased experience with patients undergoing resection over the past several years has helped us modify some aspects of our surgical techniques, including the use of partial running suture or laryngofissure, and to introduce new tools for airway ventilation, including the use of laryngeal mask.

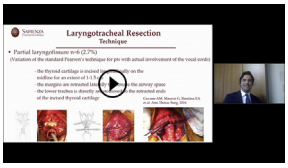
Aside from general contraindications for general anesthesia, the only absolute contraindication for LT resection is the need for mechanical ventilation, which is rare. Other local and/or systemic inflammatory or infectious condition may only require postponement of the operation. In those cases, endoscopic treatment was initially preferred to allow the patient's general and local (eg, inflammation at the anastomotic site) condition to improve. At the beginning of our experience, resection was generally postponed until complete resolution of inflammation at the operative site. More recently, we have found that in some cases complete resolution of local inflammation is not mandatory; the only necessary condition is healthy tissue without residual inflammation in the airway section and areas of subsequent anastomotic reconstruction. About 7% of patients assessed during the study period were denied surgery. Patients receiving initial endoscopic treatment and final operation after stenosis recurrence were not included in this rate.

CONCLUSIONS

Outcomes for patients undergoing LT resection might further improve during the next few years. Recently, some studies published by the field of translational medicine have made suggestions on how to prevent stenosis and achieve a successful operation.[17] The future is forthcoming.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://aats.blob.core.windows.net/media/20AM/Presentations/Improved%20Results%20of%20Surgery%20for%20Lary.mp4.



Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

The authors thank the women and men of their institution who tirelessly make patient care possible every day, even during this difficult pandemic time.

References

1. Gerwat J, Bryce DP. The management of subglottic stenosis by resection and direct anastomosis. *Laryngoscope*. 1974;84:940-7.
2. Pearson FG, Cooper JD, Nelems JM, Van Nostrand AW. Primary tracheal anastomosis after resection of the cricoid cartilage with preservation of recurrent laryngeal nerves. *J Thorac Cardiovasc Surg*. 1975;70:806.
3. Grillo HC, Donahue DM, Mathisen DJ, Wain JC, Wright CD. Postintubation tracheal stenosis: treatment and results. *J Thorac Cardiovasc Surg*. 1995;109:486-93.
4. Couraud L, Jougon J, Velly JF. Surgical treatment of nontumoral stenosis of the upper airway. *Ann Thorac Surg*. 1995;60:250-60.
5. D'Andrilli A, Maurizi G, Andreetti C, Ciccone AM, Ibrahim M, Poggi C, et al. Long term results of laryngo-tracheal resection for benign stenosis from a series of 109 consecutive patients. *Eur J Cardiothorac Surg*. 2016;50:105-9.
6. Grillo HC, Mark EJ, Mathisen DJ, Wain JC. Idiopathic laryngotracheal stenosis and its management. *Ann Thorac Surg*. 1993;56:80-7.
7. Ciccone AM, Vanni C, Maurizi G, D'Andrilli A, Korasidis S, Ibrahim M, et al. A novel technique for laryngotracheal reconstruction for idiopathic subglottic stenosis. *Ann Thorac Surg*. 2016;102:e469-71.
8. Schweiger T, de Faria Soares Rodrigues I, Roesner I, Schneider-Stickler B, Evermann M, Denk-Linnert DM, et al. Laryngeal mask as the primary airway device during laryngotracheal surgery: data from 108 patients. *Ann Thorac Surg*. 2020;110:251-7.
9. D'Andrilli A, Ciccone AM, Venuta F, Ibrahim M, Andreetti C, Massullo D, et al. Long term results of laryngo-tracheal resection for benign stenosis. *Eur J Cardiothorac Surg*. 2008;33:440-3.
10. Wright CD, Li S, Geller AD, Lanuti M, Gaissert HA, Muniappan A, et al. Postintubation tracheal stenosis: management and results 1993 to 2017. *Ann Thorac Surg*. 2019;108:1471-7.
11. Cooper JD. Tracheal injuries complicating prolonged intubation and tracheostomy. *Thorac Surg Clin*. 2018;28:139-44.
12. Dedo HH, Catten MD. Idiopathic progressive subglottic stenosis: findings and treatment in 52 patients. *Annal Otol Rhinol Laryngol*. 2001;110:305-11.
13. Wang H, Wright CD, Wain JC, Ott HC, Mathisen DJ. Idiopathic subglottic stenosis: factors affecting outcome after single-stage repair. *Ann Thorac Surg*. 2015;100:1804-11.
14. Terra RM, Minamoto H, Carneiro F, Pego-Fernandes PM, Jatene FB. Laryngeal split and rib cartilage interpositional grafting: treatment option for glottic/subglottic stenosis in adults. *J Thorac Cardiovasc Surg*. 2009;137:818-23.
15. Hoetzenecker K, Schweiger T, Roesner I, Leonhard M, Marta G, Denk-Linnert DM, et al. A modified technique of laryngotracheal reconstruction without the need for prolonged postoperative stenting. *J Thorac Cardiovasc Surg*. 2016;152:1008-17.

16. Wright CD, Grillo HC, Wain JC, Wong RD, Donahue DM, Gaissert HA, et al. Anastomotic complications after tracheal resection: prognostic factors and management. *J Thorac Cardiovasc Surg*. 2004;128:731-9.
17. Hoetzenecker K, Chan HHL, Frommlet F, Schweiger T, Keshavjee S, Waddell TK, et al. 3D models in the diagnosis of subglottic airway stenosis. *Ann Thorac Surg*. 2019;107:1860-5.

Key Words: subglottic stenosis, laryngotracheal resection, idiopathic stenosis

Discussion

Presenter: Dr Giulio Maurizi

Dr Joel D. Cooper *(Philadelphia, Pa)*. I thank the Association for the chance to participate in this historic session. I also want to congratulate the authors on their excellent results in a large series dealing with a very difficult problem. First, I would like to send my best wishes to the authors, some of whom are close personal friends, and to the entire country of Italy for the terrible tribulation and losses they have sustained, and express my great admiration, which I think is shared by the entire world, for the dedication, sacrifice, and commitment shown by the medical community and allied staff in fighting this pandemic. I wish you all a speedy return to some degree of normality.

Regarding the operative results, 2 quick questions. You mentioned that there was no perioperative mortality. Was there any 30- or 90-day mortality relating to the operation?

Dr Giulio Maurizi *(Rome, Italy)*. Thank you for your comments and questions. It is a great honor to have the opportunity to present this paper to the American Association for Thoracic Surgery, and it is a great honor to have you as discussant.

When we are talking about mortality, we refer to in-hospital mortality. Moreover, no patients died after day 30 and during the follow-up except for 4 patients who died due to other disease.

Dr Cooper. Thank you. These are indeed excellent results. The second question relates to recurrent nerve palsy, which is always a big concern when dealing with the subglottic airway. Did you have a significant incidence of either temporary or permanent recurrent nerve palsies in these patients?

Dr Maurizi. Thank you. We reported excellent result (early and definitive) in this series in more than 80% of patients. Except for patients who experienced airway complications and failure, the others showed minor sequelae like changes that did not jeopardize the success of the operation. Among these patients, 2 patients who underwent surgery in the past study period presented with abnormal voice and reduced mobility of 1 of the vocal cords, which progressively improved in 1 case spontaneously, and in the other case, after 2 months of steroid therapy. Maybe the Pearson technique principles for recurrent nerve preservation helped us.

Dr Cooper. That indeed makes it a very outstanding series, because that's among the very important aspects of your report. As far as the operation is concerned, you employ the suprahyoid release, as described by Montgomery, rather conservatively. I must say that in recent years, I've started using it more liberally. Once you've done it a couple of times, it takes no time at all, and it's not associated with any particular problem. It makes the anastomosis easier, and safer by reducing tension in many patients and we have used it maybe as much as 15% to 20% of the time, sometimes even doing it before we've done the actual resection if we anticipate a problem with tension.

You also mentioned the importance of intraoperative and postoperative care. I also wanted to emphasize—and get your thoughts on—temporizing. I believe that among the most important things you can do to ensure a good result is to not rush the repair. These patients have often experienced trauma, serious medical issues, and prolonged hospital stays, and if possible it is best to allow them to recover as completely as possible before embarking on the airway resection. Among the most practical ways of maintaining a satisfactory airway is to stent the narrowed segment with the use of a silicone T-tube, especially if the patient already has a tracheostomy tube in place. The T-tube doesn't migrate or cause further damage that otherwise can result from repeated dilatation, laser treatments, or the use of an expandable metallic stent. Do you have any comments on that?

Dr Maurizi. That is a very important point and a good suggestion. We had 190 patients presenting with postintubation stenosis and 83 patients underwent tracheostomy elsewhere before surgical resection. Tracheostomy is among the options before resection, like a T-tube, to temporize. To clarify, tracheostomy may have been done for the stenosis, or may have been the cause of the subglottic stenosis. Because in 25 of these patients tracheostomy was performed as an emergency procedure due to critical subglottic stenosis, we might conclude that in the majority of the remaining patients a too-high tracheostomy is performed because prolonged intubation was likely to be the cause of a laryngotracheal stenosis.

Dr Cooper. How often did these patients have a tracheostomy tube in place at the time of surgery?

Dr Maurizi. They experimented tracheostomy elsewhere before resection. This can be misleading: Tracheostomy could have been the cause of the stenosis or could

have been a treatment to bypass the problem before resection. Sometimes, patients had tracheostomy at surgery, but it's very difficult to tell if a previous tracheostomy was cause or treatment.

Dr Cooper. I understand that it is a difficult problem. If a patients has a tracheostomy tube in place to provide a safe airway, he or she will be much more willing to postpone the airway resection because they have their voice, can breathe fairly normally, and have much less of a daily maintenance problem. When the airway resection is scheduled, you can often remove the T-tube a few weeks before the surgery and let the whole neck heal up so you don't have an open wound at the time of the resection. Furthermore, the site of the previous tracheostomy stoma can sometimes be preserved, reducing the length of the resection required.

You mentioned that at the end of the operation you put in an uncuffed nasotracheal tube, which you leave in for a day or so. What we've done is after the anastomosis is completed but before we've closed the subcutaneous tissue and skin, we ask the anesthetist to start waking up the patient and replace the endotracheal tube with a laryngeal mask (which you referred to). We then insert a bronchoscope through the mask, clean out the airway, and park the bronchoscope above the vocal cords. When the patient is awake and can phonate, we test the vocal cord function and inspect the anastomosis. If the anastomosis is fine, we don't do anything further; we just close the subcutaneous tissue and skin. If we have any concern (maybe 10% of the time), we'll put in a small, #4 uncuffed minitrach tube through a stab incision in the trachea just below the suture line. We then close the rest of the wound and leave the minitrach in place for a few days.

Regarding prevention, in recent years we have been seeing an increasing number of postintubation subglottic strictures, whereas previously the most common cause of stenosis in the subglottic region was so-called idiopathic subglottic stenosis.

I believe there are at least 2 preventable causes of these postintubation strictures. One results from a high tracheostomy site positioned, perhaps inadvertently, too close to the cricoid. As you mentioned, this can result in damage to the cricoid, with a resulting infection and a subglottic stricture that can be, in fact, even complete obliteration not noticed until the tracheostomy tube is being removed and they fail the extubation.

Another cause may result from endotracheal intubation in very urgent circumstances (in the field or in the emergency ward), when the patient is rushed to the operating room, or to the computed tomography scanner, and no one notices that the cuff is in the subglottic region. You can see it in retrospect in these patients on their chest radiograph or computed tomography scan, but it isn't noticed at first. If the cuff remains at the level of the cricoid for just a few days, permanent damage may result in the type of subglottic stenosis you have described. I wish they had radioopaque cuffs so that the malpositioning of the T-tube could be more easily recognized. I'm wondering if you have experienced these 2 potentially preventable causes in your series?

Dr Maurizi. The cause of the stenosis, the etiology of a postintubation stenosis remains the main problem with benign subglottic stenosis. Moreover, the problem is not only the cuff, but also the decubitus of the endotracheal tube. So, the combination of these factors (the decubitus of the endotracheal tube, the cuff under the glottis, and a too high tracheostomy) remains a very big problem, causing a very high number of stenoses.

The decubitus of the tube can often cause a lot of fibrosis in the posterior portion of the cricoid: This is an additional problem in particular when performing resection and you have to pay attention. Sometimes you have to remove fibrotic tissue from the cricoid plate. I think the etiology is a combination of different problems. Postintubation airway disease is a big theme, in which we can find tracheostomy, the decubitus of the endotracheal tube, and the cuff as the origin of the problem.

Dr Cooper. Congratulations again. It's a wonderful series. It's not just of importance to a relatively small number of surgeons who have a particular interest in this type of problem, but also to a larger number of interventional pulmonologists to whom such patients may be initially referred. By demonstrating the good results that you have obtained, those who persist in trying to treat these strictures with methods such as expandable wired stents, multiple lasering, and dilatations, without realizing what is possible from a surgical standpoint, can create more damage and make a much more complicated situation out of it. What advice do you have for interventional pulmonologists or other critical care doctors who might initially discover a subglottic stenosis?

Dr Maurizi. I completely agree. Conservative treatment is a very good option for patients, but sometimes repeated endotracheal treatments (eg, laser and mechanical dilatation) can make the resection more difficult. So my advice is: When the stenosis is suitable for resection with good or excellent results, it's very important to consider resection as not the first option, but rather the second option. No many endoscopic treatments and so on. If we have a problem with healing and other airway problems, we usually perform endoscopic treatment within our division (in-house), not with outside pulmonology or other interference from outside our institution. This could be an advantage for the surgeon and for the patient.