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Original Scientific Paper

TREATMENT OF SUBGLOTTIC STENOSIS: A SINGLE INSTITUTION EXPERIENCE

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SUMMARY – The aim of this article is to present experiences of the Department of Otorhinolaryngology and Head and Neck Surgery, Zagreb University Hospital Center with the treatment of patients with subglottic stenosis. Subglottic stenosis is a rare congenital or acquired disorder of airway patency that is part of a wider complex of disorders known as laryngotracheal stenosis with the ultimate effect in the form of respiratory insufficiency that can be life-threatening. As an acquired condition, it is most often the result of iatrogenic damage to the larynx and trachea during invasive airway management, whether it is intubation or tracheotomy. In the case of intubation as the etiologic factor, cases of prolonged intubation were most common. Retrospective analysis of patient medical histories over a ten-year period was performed and 29 patients met the inclusion criteria. All patients were monitored for at least two years after completion of treatment. Out of a total of 29 treated patients, 20 were permanently decannulated, of which 4 have paresis of one or both vocal cords. In conclusion, there is no clear treatment protocol for patients with subglottic stenosis. The optimal modality of treatment is combined endoscopic and open surgical treatment.

Key words: *Subglottic stenosis; Surgical treatment; Airway management Complications*

Introduction

Subglottic stenosis (SGS) is a rare congenital or acquired narrowing of the airway below the glottis. It is part of the stenoses that occur in the area of the larynx and trachea and can be at the level of the supraglottis, glottis, subglottis and trachea, and account for 50% of all laryngotracheal stenoses[1,2]. The most common and significant cause is prolonged endotracheal intubation[3]. Prolonged intubation causes direct injury to the back wall of the glottis, while a subglottic cuff extends the injury to the subglottis. In patients undergoing prolonged intubation, about 57% may sustain acute laryngeal injury, with an increased risk of injury with endotracheal tubes greater than 7.0, with large endotracheal tubes and narrower airways being associated with a higher frequency of SGS. This applies especially to obese patients[4,5]. The etiologic causes are trauma, neoplasms, and chronic inflammatory systemic diseases. Traumatic stenoses are most common, divided into intrinsic and extrinsic. Intrinsically caused stenoses are

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those caused by tracheotomy, prolonged intubation, or laryngopharyngeal reflux[6]. Extrinsic are, for example, a result of radiation or neck trauma. Systemic diseases that cause stenosis through chronic inflammation are diabetes mellitus, Wegener's granulomatosis, sarcoidosis, tuberculosis, and numerous autoimmune diseases[7]. Neoplasms as causes of stenosis can be papillomas, chondromas and malignant tumors. Some of the subglottic stenoses are idiopathic. Idiopathic subglottic stenosis (ISS) is an unexplained progressive obstruction of the upper airway that occurs almost exclusively in adult, Caucasian women between 30 and 50 years of age. The disease is characterized by mucosal inflammation and localized fibrosis resulting in life-threatening blockage of the upper airway[8]. Because of the higher frequency of reflux than in the general population, many studies indicate an association between laryngopharyngeal reflux and development of ISS, as well as laryngotracheal stenosis with known causes. However, the effect of pepsin on endothelial cells was studied *in vitro* using epithelial cells from healthy patients and did not show any effects on the gene or protein expression associated with endothelial proliferation, nor did the presence of pepsin induce fibroblast migration[9,10]. There are a number of studies that indicate that as a result of the COVID-19 pandemic, due to the increased number of long-term intubated patients, critically ill patients and delayed tracheostomy, in the near future there will be an unprecedented increase in iatrogenic consequences ranging from granulomas to laryngotracheal stenoses and tracheomalacia. These patients will certainly ask for frequent monitoring and timely intervention[11,12]. The most commonly used grading system for SGS is the Myer-Cotton system, which initially used the size of the endotracheal tube to classify solid, peripheral stenosis based on the percentage of cross-sectional stenosis of the trachea. Grade 1 is <50% obstruction, grade 2 is 51%-70% obstruction, grade 3 is 71%-99% obstruction, while in grade 4 there is no visible lumen[13]. Preoperative evaluation of stenosis is the key to choosing an appropriate treatment model. It aims to evaluate stenosis localization, its extension in terms of length and narrowing of the lumen, and type of tissue that caused stenosis. Diagnostic workup of subglottic stenoses includes a thorough history, i.e., intubation, tracheostomy, laryngotracheal surgery, trauma, infection, autoimmune disease, reflux, and radiation. It must also provide an answer on the degree of preservation of the function of the affected organ, such as vocal cord mobility, phonation, and swallowing. Standard preoperative evaluation of laryngotracheal stenosis includes flexible fiberoscopy, flexible bronchoscopy, and three-dimensional computed tomography scan of the larynx and trachea[14]. Depending on the underlying cause, severity, and complexity of stenosis, treatment options include endoscopic dilatation, stent implantation, CO2 laser therapy, an open surgical approach and immunotherapy[15].

Patients and Methods

Between 2010 and 2020, 29 patients with SGS were surgically treated at the Department of Otorhinolaryngology and Head and Neck Surgery. There were 12 female and 17 male patients, with an average age of 19 to 72 years. All were followed up for 2 years after the procedure. 9 patients had idiopathic stenosis and 20 patients acquired stenosis. Preoperatively, 18 patients underwent tracheotomy, 3 with idiopathic and 15 with acquired stenosis. In acquired stenosis, the most common cause of the stenosis was a consequence of prolonged intubation, in 14 patients and a tracheotomy in 3 patients. In one case, external trauma was the cause, and in two, thyroid cancer with penetration into the trachea, which required surgical resection. According to the Myer-Cotton classification, there were 9 patients with grade 1, 5 patients with grade 2, 8 patients with grade 3 and 7 with grade 4. Preoperatively, all patients underwent diagnostic endoscopy, including flexible and rigid directoscopy, radiological workup, which included multislice computed tomography and, on three occasions, nuclear magnetic resonance (Figs. 1-3).

Surgical treatment

In endoscopic laser resections, CO2 laser was used in the ultrapulse mode with a fluence of 150 mJ/cm^2 at a frequency of 10 Hz. In patients who were treated surgically, resection of the stenosed part of the trachea and an 'end-to-end' anastomosis was performed. With an external transcervical approach, the prelaryngeal musculature is shown and then detached from the hyoid bone, which facilitates mobility of the larynx (Fig. 4). This prevents additional unwanted tension on

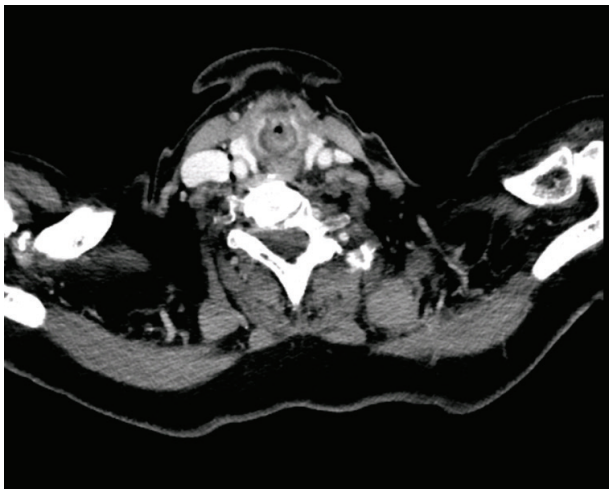

Fig. 1. Preoperative computed tomography scan of stenosis.

Fig. 2. Postoperative computed tomography scan with patent trachea.

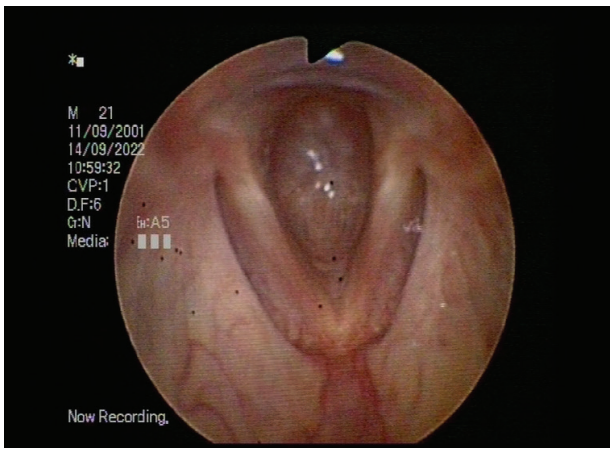

Fig. 3. Fiberoptic finding of subglottic stenosis.

the anastomosis. After locating the site of stenosis, a circumferential dissection and resection is performed (Fig. 5). When establishing tracheal anastomosis patency, synthetic absorbable sutures and a simple single suture technique are used, whereby the knot is placed extraluminally (4-0 Vicryl). It is important to emphasize that all sutures are placed around the anastomosis without being tied. Then, 4 supporting sutures (2-0 Vicryl), equally and symmetrically placed on the upper and lower tracheal segment are pulled and the anastomosis is formed, after which the sutures are tied (Fig. 6). At the end of the operation, if the patient has not been tracheotomized, he is extubated and treatment continues in the intensive care unit. In cases, if necessary, it is recommended to place tracheostomy a few

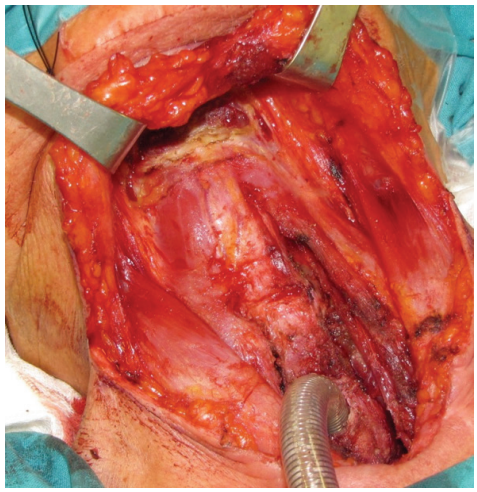

Fig. 4. Intraoperative view of a stenosed trachea.

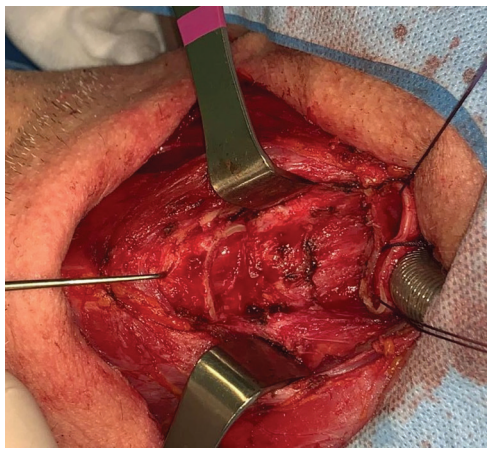

Fig. 5. Tracheal defect after resection.

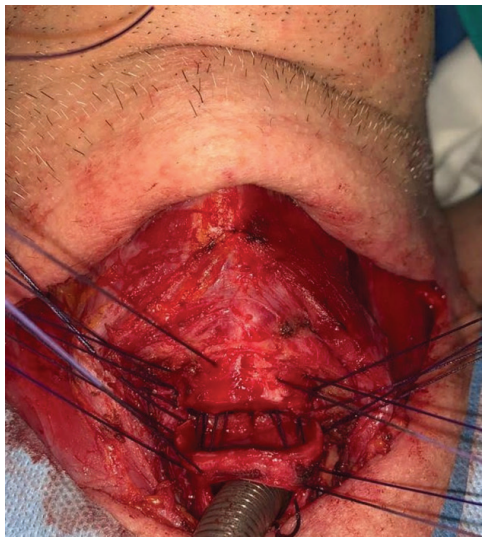

Fig. 6. Performance of tracheal anastomosis.

centimeters below the anastomosis and after 1-2 days, when the anastomosis becomes intact, the tube can be removed leaving the patient to breathe spontaneously.

Results

Out of 29 patients, 8 (28%) were treated with CO2 laser endoscopically (idiopathic 5 and acquired 3), a combination of endoscopic and open approach was performed in 12 (42%) patients (idiopathic 2 and acquired 10), and an open approach only was performed in 9 patients. Cricotracheal anastomosis was performed in 3 patients and tracheotracheal anastomosis in 9 patients. An open surgical approach only and end to end anastomosis was performed in 9 (31%) patients, of which 1 with idiopathic and 8 with acquired stenosis. In 2 cases, we performed cricotracheal and in other cases tracheotracheal anastomosis. Of 20 patients who underwent endoscopic CO2 laser resection, repeated laser procedures were performed, ranging from 1 to 4 treatments, in 12 (60%) patients. Of the 18 patients who were tracheotomized, 11 (61%) were decannulated. Of the 3 tracheotomized patients with idiopathic stenosis, only one patient was decannulated, and it was the one who underwent a combined approach, laser resection following the end to end anastomosis. Out of 15 patients with acquired stenosis and tracheotomy, 10 patients were decannulated. Of these, three patients were treated with CO2 laser initially, followed by surgical resection of the stenosis, and 7 patients underwent open resection and end to end anastomosis only. There were no deaths or other life-threatening complications. In 4 patients, we had paralysis of the vocal cords as a result of treatment, exclusively in open surgery cases.

Discussion

Optimal treatment of subglottic stenoses is still not agreed upon and there is no widely accepted single protocol. Also, it is noticeable that different specialists participate in the treatment of this condition (pulmonologists, otorhinolaryngologists, thoracic surgeons) and that certain institutions have their own protocols. Surgical treatment of laryngotracheal stenoses can be divided into the following three basic categories: open surgery, endoscopic surgery, and reconstructive methods using augmentation and grafting[16]. The oldest but still widely used procedure for rapid airway securing in a patient with airway obstruction is tracheotomy. Although it ensures adequate ventilation, it is a common cause of laryngotracheal stenosis and should be avoided whenever possible. Patients with tracheal stenosis often undergo more than one surgical procedure. Therefore, it is not unusual to convert the type of approach when the first method fails. The open approach involves resection of the stenosis and end-to-end anastomosis. Depending on the localization of the stenosis, we distinguish tracheotracheal, cricotracheal, and thyrotracheal anastomosis. The open approach allows better visibility but is also associated with a more significant number and more severe complications[17]. In the second half of the twentieth century, with the use of CO2 lasers, endoscopic surgery for tracheal stenosis began to develop. Although reserved for mild subglottic, tracheal stenoses and those that do not affect the cricoid cartilage, this surgery enables faster recovery, fewer complications, shorter hospitalization, and lower treatment costs. In addition to the CO2 laser, a microdebrider can be used in endoscopic tracheal stenosis surgery. In case of suspected vascular or vascularized lesions, it is more advisable to use a laser. Other types of lasers are also used, such as KTP laser and Nd:YAG laser. Electrocautery, radiofrequency, and coblation with mechanical dilation using bougies, tracheal tubes, or an expansion balloon catheter are also a consideration[18-20]. Monnier *et al.* suggested that endoscopic CO2 laser resection with or without dilation be used in grade I, some grade II,

and mild grade III SGS with lengths less than 1.5 cm, and open surgery should be considered for grades II, III, and IV SGS or stenosis greater than 1.5 cm[21]. A systematic review of 15 studies published between 2001 and 2018 including a total of 862 patients with ISS ranging from 40% to 100% laryngotracheal stenosis evaluated the success of endoscopic procedures in ISS. The frequency of tracheostomy after the intervention was 0-27%. Study patients underwent a mean of 3.7 procedures. The authors conclude that endoscopic laser procedures in SGS show a high percentage of recurrence, greater number of interventions, and that a combination of different surgical procedures guarantees better result[22]. Yamamoto *et al.* identified 24 eligible retrospective studies reporting on pooled success rates of laryngotracheal resection and anastomosis (12 articles) and laryngoplasty with or without grafting (7 articles) of 95% and 76%, respectively, using a random-effects model. Success rates of endoscopic dilatation and laser resection (6 articles) varied between 40% and 82%, respectively. In conclusion, they report that the success rate of laryngotracheal reconstruction is significantly higher than that of laryngoplasty or endoscopic intervention; however, endoscopic intervention is worth trying for lesions smaller than 1 cm without framework destruction[23]. In the cohort study by Gelbard *et al.*, of 810 patients with ISS who underwent 1 of the 3 most common surgical treatments, 23% of patients underwent a recurrent surgical procedure during the 3-year study period, but recurrence differed by modality (cricotracheal resection, 1%; endoscopic resection with adjuvant medical therapy, 12%; and endoscopic dilation, 28%). Overall, 185 (22.8%) patients had a recurrent surgical procedure during the 3-year study. Among successfully treated patients, those who underwent cricotracheal resection reported the highest quality of life but the greatest perioperative risk and worst long-term voice outcomes[25]. In the systematic review by Lewis *et al.*, which included 39 articles and 834 pooled patients with a purpose to determine if open surgical treatment options for laryngotracheal stenosis are more successful than endoscopic procedures, they found that patients who had an open procedure (resection with anastomosis or reconstruction with expansion grafting) had significantly different outcomes rates; 32% *versus* 38% received additional surgery and 89% *versus* 83% were decannulated, respectively. For patients who had endoscopic repair, 44% received additional surgery, and 63% were decannulated. They conclude that patients with adult laryngotracheal stenosis who undergo laryngotracheal resection with anastomosis receive less surgery compared to those who undergo endoscopic treatment or laryngotracheal reconstruction with augmentation/grafting. Patients with idiopathic stenosis are less likely to receive further surgery compared to those from trauma or intubation/tracheostomy, but have the lowest rate of decannulation[26]. In idiopathic stenosis, the lowest recurrence rate (40%) was determined in the study by Bertelsen *et al.*, who used rigid dilation with corticosteroid injections[27].

Conclusion

The causes of subglottic stenosis can be different, from trauma, inflammation to idiopathic. Understanding the mechanism of injury and contribution of comorbid illnesses is critical to system-based preventive strategies and patient-centered treatment. There is no single protocol for dealing with this condition, which can be life-threatening. Endoscopic and open surgical procedures are currently optimal treatment modalities with varying success rates, depending on the cause of stenosis and institution experience. In addition to these methods, the use of topical drugs, including corticosteroids, also has its place in treatment protocols.

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Sažetak

LIJEČENJE SUBGLOTIČNE STENOZE: ISKUSTVO JEDNOG CENTRA

D. Prgomet, D. Leović, I. Šimić, I. Gugić-Radojković, H. Feljan i *I. Blivajs*

Cilj ovoga rada je prikazati iskustva Klinike za bolesti uha, nosa i grla i kirurgiju glave i vrata Kliničkog bolničkog centra Zagreb u liječenju bolesnika sa subglotičnom stenozom. Subglotična stenoza je rijedak prirođen ili stečeni poremećaj prohodnosti dišnog puta koji je dio šireg kompleksa poremećaja poznatog kao laringotrahealna stenoza s krajnjm učinkom u vidu respiracijske insuficijencije koja može biti opasna za život. Kao stečeno stanje najčešće je posljedica jatrogenog oštećenja grkljana i traheje prilikom invazivnog osiguranja dišnog puta, bilo da se radi o intubaciji ili traheotomiji. U slučaju intubacije kao etiološkog čimbenika najčešće se radi o slučajevima produljene intubacije. Učinjena je retrospektivna analiza povijesti bolesti bolesnika u desetogodišnjem razdoblju te je 29 bolesnika ispunjavalo kriterije uključenja u studiju. Svi bolesnici praćeni su najmanje dvije godine nakon završenog liječenja. Svi bolesnici liječeni su kirurški, endoskospki, otvorenom metodom ili kombinirano. Od ukupno 29 liječenih bolesnika 20 ih je trajno dekanilirano, od kojih 4 ima parezu jedne ili obje glasiljke. Zaključno, ne postoji jasan protokol liječenja bolesnika sa subglotičnom stenozom. Optimalan modalitet liječenja je kombinirano endoskopsko lasersko i otvoreno kirurško liječenje.

Ključne riječi: *Subglotična stenoza; Kirurško liječenje; Komplikacije zbrinjavanja dišnog puta*