Laryngology

Laryngotracheal stenosis treated with multiple surgeries: experience, results and prognostic factors in 70 patients

Trattamento delle stenosi laringo-tracheali: esperienze, risultati e fattori prognostici su 70 pazienti

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SUMMARY

Laryngotracheal stenosis is a complex condition that usually requires multiple procedures to restore physiological respiration. The aim of this study was to evaluate the percentage of decannulation compared to different or multiple surgical treatments. We retrospectively reviewed the charts of 70 patients treated between 1990 and 2005 for laryngotracheal stenosis of various aetiology: iatrogenic stenosis (n = 55), post-traumatic stenosis (n = 11) or other causes (autoimmune disease, n = 3; diphtheria, n = 1). In order to maintain laryngotracheal patency, a Montgomery Safe-T tube was used in all patients as a single dilation treatment or associated with endoscopic and/or open-neck surgery. Fifty-four of the 70 patients (77.1%) were eventually decannulated; 39 of these (72.2%) underwent 3 or fewer surgical procedures, showing a significant difference compared to patients who underwent more than 3 surgeries (p = 0.00002). A total of 257 surgeries were performed. Only seven of 54 patients (13%) were decannulated after more than 5 surgical procedures. Patients over 60 years of age and with a higher grade of stenosis showed a significantly lower success rate (p = 0.0017 and p = 0.007, respectively). There was no significant correlation between the rate of decannulation and gender, aetiology, site of stenosis or surgery. Patients undergoing dilation for laryngotracheal stenosis usually require multiple procedures. The T tube plays an important role in the treatment of this pathology. However, if the tracheostomy is not removed within 3 surgical interventions, the odds of decannulating the patient decrease significantly, and additional surgeries may be of questionable therapeutic benefit.

KEY WORDS: Laryngotracheal stenosis • Montgomery Safe-T tube • CO2 laser

RIASSUNTO

Le stenosi laringo-tracheali sono condizioni complesse che richiedono generalmente ripetute e varie procedure chirurgiche prima di ottenere il ripristino di un'efficiente respirazione fisiologica. Lo scopo di questo studio è quello di valutare la percentuale di decannulazione in relazione al tipo ed al numero di interventi chirurgici eseguiti. Sono state analizzate le cartelle cliniche di 70 pazienti trattati tra il 1990 ed il 2005 per stenosi laringo-tracheale di varia eziologia: stenosi iatrogene (55 casi), stenosi post-traumatiche (11 casi), altre cause (malattie autoimmuni: 3, difterite: 1). Con lo scopo di mantenere la pervietà laringotracheale, un tubo T di Montgomery è stato utilizzato in tutti i pazienti come unico trattamento oppure in associazione con un trattamento endoscopico e/o per via esterna. Nella nostra casistica 54 pazienti su 70 (77,1%) sono stati definitivamente decannualati; 39 di questi (72,2%) sono stati sottoposti al massimo a tre interventi chirurgici mostrando una differenza statisticamente significativa rispetto ai pazienti sottoposti a più di 3 interventi (p = 0,00002). Sono stati eseguiti un totale di 257 interventi chirurgici. Soltanto 7 pazienti dei 54 decannulati (13%) hanno subito più di 5 interventi chirurgici. Pazienti con oltre 60 anni d'età e con un alto grado di stenosi presentano una più bassa percentuale di decannulazione (p = 0,0017 e 0,007 rispettivamente). Non è stata evidenziata un'associazione statisticamente significativa tra percentuale di decannulazione e sesso, eziologia, sede della stenosi e tipo di intervento chirurgico eseguito. In conclusione i pazienti sottoposti ad intervento di dilatazione di stenosi laringo-tracheale necessitano generalmente di ripetute procedure chirurgiche. Il tubo T di Montgomery gioca un ruolo importante nel trattamento di queste condizioni. L'analisi della nostra casistica suggerisce che, qualora non si riuscisse a chiudere il tracheostoma entro 3 interventi chirurgici, le probabilità di decannulare il paziente diminuiscono significativamente e l'esecuzione di ulteriori interventi potrebbe rappresentare un accanimento terapeutico.

PAROLE CHIAVE: *Stenosi laringotracheali • Tubo a T di Montgomery • Laser CO2*

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Introduction

Laryngotracheal stenosis (LTS) is a non-specific term implying the presence of airway compromise involving the larynx, trachea or both. This is usually the result of scar formation with associated morbidity depending on the location, extent and thickness of the tissue. LTS is one of the most complex problems in the field of head and neck surgery and is a genuine challenge for otolaryngologist-head and neck surgeons. LTS may result from various insults to the upper airway, including direct trauma, post-surgical complications, prolonged endotracheal intubation, tracheostomy, congenital lesions or tumours. Although numerous studies describe various treatment modalities, there is no standard approach to LTS and repetitive procedures may often be required to restore physiological respiration. The goals of any treatment modality are to maintain a patent airway, glottic competence for airway protection against aspiration and acceptable voice quality. Two surgical approaches are possible: endoscopic and/or external. Endoscopic treatment includes laryngeal microsurgery, laser-assisted excision, traditional dilation and endoscopic stent insertion, while external surgical treatment comprises a wide range of techniques such as tracheal resection and anastomosis or laryngotracheal reconstruction [1]. In order to maintain laryngotracheal patency, a Montgomery Safe-T tube may be used as single dilation treatment or in association with endoscopic and/or open-neck surgery. The tracheal T tube, introduced by Montgomery in 1965 [2], has the advantage of being both a stent and tracheostomy tube (Fig. 1). It is usually inserted in the operating theatre under general anaesthesia.

The aim of this retrospective study was to evaluate the rate of decannulation compared to different and/or multiple surgical treatments, and to assess variables that reduce the possibility of decannulation so that proper pre-operative evaluation can be made.

Materials and methods

We retrospectively reviewed the medical charts of 70 patients with laryngotracheal stenoses treated at the Department of Otorhinolaryngology, Audiology and Phoniatrics, "Sapienza" University of Rome from 1990 to 2005. Most surgeries were performed by only two surgeons (MdV, AG). There were 39 males (55.7%) and 31 females (44.3%) with an age range of 16-77 years (mean 52.6 years). Approval for the study was obtained by the Institutional Review Board of the University. Data collected for each patient included age, gender, aetiology, site and degree of stenosis, diagnostic and therapeutic procedures, and number of surgeries performed. The cause of airway stenosis was iatrogenic in 55 cases and post-traumatic in 11 cases; 4 patients presented autoimmune diseases or diphtheria (Table I). In the iatrogenic stenosis group, we included patients previously submitted to supracricoid laryngectomy (28 cases) and those with post-intubation injury (23 cases), laryngeal papillomatosis (2 cases) or post-radiotherapy stenosis (2 cases). In most of the 11 patients with post-traumatic LTS, the stenosis was a consequence of automobile or, in particular, bicycle accidents (9 cases); in one case it was due to manual strangulation injury and to blunt trauma in another.

The degree of stenosis was graded using the Myer-Cotton classification in which grade 1 indicates up to 50% obstruction; grade 2, 51-70%; grade 3, 71-99% and grade 4, no detectable lumen.

All patients undergoing elective surgery underwent pre-operative work-up, including a fibre optic endoscopic evaluation and a computed tomography of the neck. All patients underwent tracheostomy in our institute or elsewhere. The stenosis was located above the tracheostomy in all cases. Patients who had undergone other surgical procedures for LTS elsewhere were excluded from the study.

T tube insertion was performed in the operating theatre under general anaesthesia. Medical gauze was inserted in the upper intraluminal opening of the T tube, drawn out through the external opening and a knot was tied. The patient was ventilated through the stoma while the end of the medical gauze coming out of the upper opening of the T tube was inserted into the trachea through the tracheotomy stoma. The operator clamped the end of the gauze with forceps

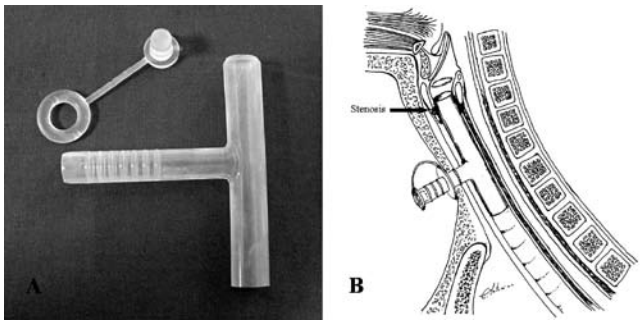

Fig. 1. a) Montgomery tracheal T tube (Safe-T tube) with ring washer and plug; b) An example of a Safe-T tube shown in the correct position with a ring washer advanced to the external skin. In this case, subglottic stenosis was present.

Table I. Aetiologies of laryngotracheal stenosis.

Aetiology	No. patients
Iatrogenic stenosis	
Subtotal laryngectomy	28
Post-intubation injury	23
Laryngeal papillomatosis	2
Post-radiotherapy	2
Post-traumatic stenosis	11
Other causes	
Autoimmune diseases	3
Diphtheria	1
Total	70

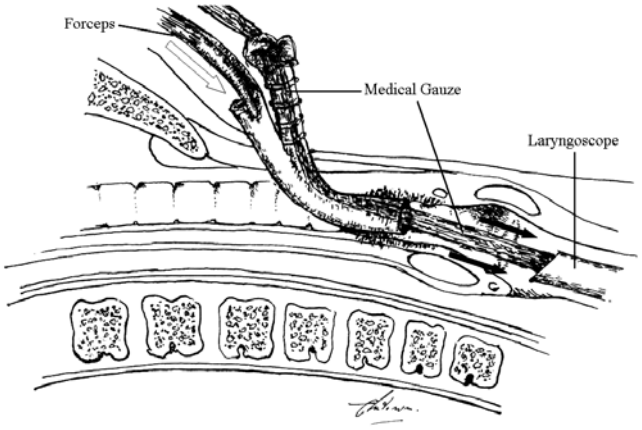

Fig. 2. Safe-T tube insertion (performed surgically). Medical gauze was inserted into the T tube and a knot was tied at the external opening. The gauze in the tube was pulled out with the laryngoscope (full arrows) until the inferior intraluminal end of the T tube disappeared into the trachea. Forceps were used to pull the inferior intraluminal end of the tube (empty arrow).

using standard direct suspension microlaryngoscopy. After extubation, the gauze was pulled out through the mouth until the inferior intraluminal end of the T tube disappeared into the trachea (Fig. 2). Forceps were used to pull the inferior intraluminal end, thus the inferior portion of the tube was put into place and the medical gauze was removed. The tube was left in place for at least 6 months and a fibre optic endoscopic evaluation was performed prior to tube replacement with a tracheal cannula left in place for approximately 4 additional weeks. Decannulation, which was our ultimate goal, was performed after careful evaluation of airway patency by endoscopic observation and spirometry. We considered patients as decannulated when they presented with a closed tracheostomy and did not require additional surgery to restore airway patency for at least six months.

As a first approach, we performed endoscopic treatment with traditional dilation, laryngeal microsurgery or, more frequently, CO2 laser-assisted excision and endoscopic Safe-T tube placement. When external cartilaginous support was considered inadequate, laryngotracheoplasty with or without costal or septal cartilage graft was performed and, generally, a Safe-T tube was used as a stent. In some cases, a laryngofissure was carried out and a laryngeal keel was placed to treat anterior glottic stenosis.

All variables were analyzed by bivariate analyses to determine whether they were associated with rate of decannulation. A p value lower than 0.05 was considered significant. Data analysis was performed using the SAS statistical package.

Results

Stenosis involved the neolarynx in 28 patients previously submitted to supracricoid partial laryngectomy, the glottis in 5 patients, the glottis and subglottis in 4 patients, the subglottis and trachea in 15 patients, and the glottis, subglottis and trachea in 18 patients. In our 15 years of experience, we performed a total of 257 surgeries (mean 3.7, range 1-22) (Table II) on 70 patients treated for LTS of various aetiology. In order to maintain laryngotracheal patency, a Montgomery Safe-T tube was used, at least once, in all patients as single dilation treatment or was associated with endoscopic and/or open-neck surgery. There were no deaths following surgery. During the same surgical session most patients underwent more than one procedure (CO2 laser endoscopy and Safe-T tube implantation or open-neck surgery and Safe-T tube implantation). The 70 patients were submitted to a total of 129 T tube implantations or re-implantations, 196 endoscopic treatments and 24 open-neck surgeries associated or not with T tube implantation (total: 349, mean 5, range 1-29). A total of 134 of the 196 endoscopic treatments consisted of CO2 laser-assisted excision, 51 laryngeal microsurgeries and 11 traditional dilatations. Sixteen of the 70 patients underwent 24 open-neck surgeries. We performed laryngotracheoplasty in 20 cases and laryngofissure with laryngeal keel placement in 4 cases. Eleven patients underwent open-neck surgery once (9 patients underwent laryngotracheoplasty, while 2 patients underwent laryngofissure and laryngeal keel placement), 2 patients twice (2 laryngotracheoplasties) and 3 patients three times (1 patient underwent 3 laryngotracheoplasties and 2 patients underwent 2 laryngotracheoplasties and 1 laryngofissure with laryngeal keel placement). Granulomas at the proximal or distal end of the T tube were observed in 7 patients. In all these patients laser coagulation and tube re-implantation were performed. Eight patients had secretion retention with partial stent obstruction requiring cleaning of the tube through its external end. No other significant complications such as dislocation of the tube, airway oedema or inhalation pneumonia were observed. According to the Meyer-Cotton classification, we staged 18 stenoses as grade 2 (25.7%), 36 patients as grade 3 (51.4%) and 16 as grade 4 (22.9%). None were considered as grade 1. There was no statistically significant correlation between the type of surgery performed (open-neck surgery, endoscopic CO2 laser treatment, laryngeal microsurgery or laryngeal dilation) and grade of stenosis ($p > 0.05$ in all cases). Mean length of the stenosis was 2.9 cm (range 1.5-5.3).

Table II. Surgical procedures performed in 70 patients.

	No. patients
T tube implantation alone	28
Endoscopic surgery alone	119
Open-neck surgery alone	9
T tube implantation and endoscopic surgery	86
T tube implantation and open-neck surgery	15
Total	257

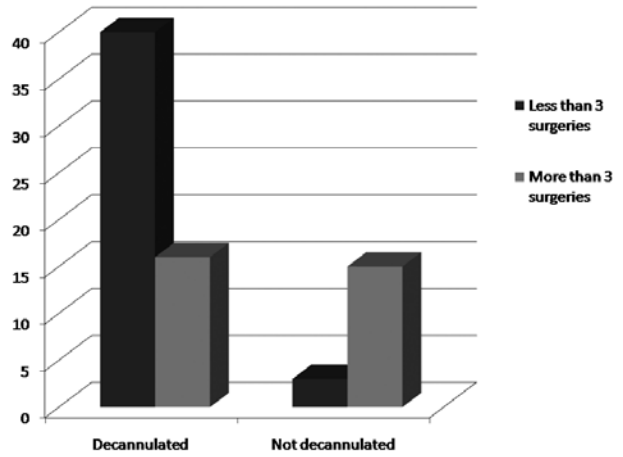

Fig. 3. Bivariate analysis: decannulation vs. number of surgeries (p = 0.00002).

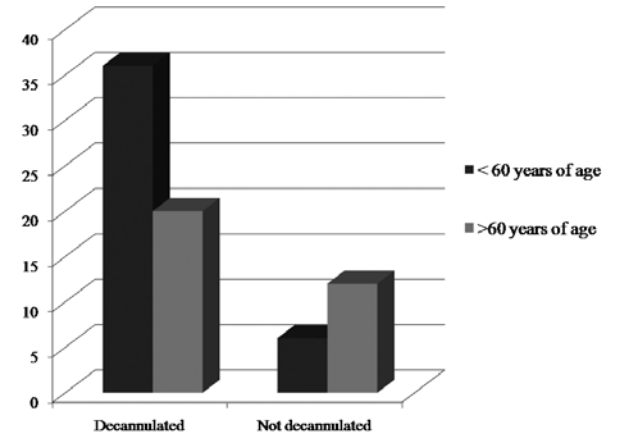

Fig. 4. Bivariate analysis: decannulation vs. age (p = 0.0017).

Of the 70 patients analyzed, 54 (77.1%) were ultimately decannulated, 39 of these (77.2%) underwent 3 or fewer surgical procedures showing a significant difference compared to patients who underwent more than 3 surgeries (p = 0.00002) (Fig. 3). Only 7 of 54 (13%) patients who had the tracheotomy removed underwent more than 5 surgical procedures. Patients over 60 years of age showed a significantly lower success rate (p = 0.0017) compared to younger patients (Fig. 4). Seventeen of 18 patients with grade 2 stenosis (94%), 29 of 36 with grade 3 (80.5%) and 8 of 16 with grade 4 (50%) were ultimately decannulated. A higher degree of stenosis was statistically correlated with a lower rate of decannulation rate (p = 0.007) (Fig. 5). Twelve of 17 decannulated patients with grade 2 stenosis (70.6%), 22/29 with grade 3 (75.9%) and 5/8 with grade 4 (62.5%) underwent 3 or fewer surgical procedures. There was no significant correlation between decannulation and gender (p = 0.53), aetiology (p = 0.9) or site of stenosis (p = 0.3). A chi-square test showed no statistically significant differences between patients who underwent open-neck surgery compared to those submitted to endoscopic surgery in terms of decannulation (p = 0.81).

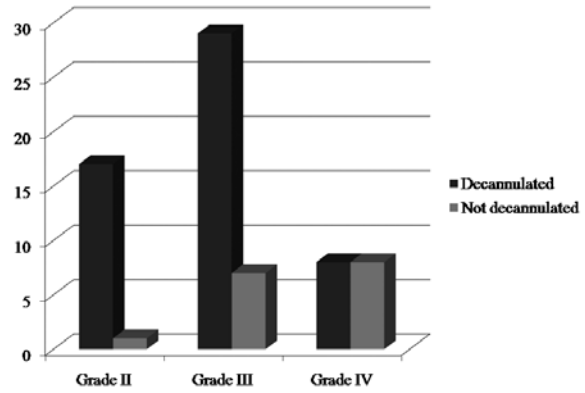

Fig. 5. Bivariate analysis: decannulation vs. grade of stenosis (p = 0.007).

Discussion

Laryngotracheal stenosis remains a challenging condition for otolaryngologist-head and neck surgeons. Decannulating a tracheotomy-dependent patient represents an enormous personal satisfaction for the surgeon, but there is a great sense of failure and frustration when the tracheotomy tube cannot be removed after an extensive surgical procedure. Multiple surgeries may be necessary to restore airway patency and different surgical techniques can be used. The causes of stenosis may be numerous and multiple areas of the airway can be involved.

Most of the LTS cases in our series were the sequelae of partial laryngectomy (28 cases) and, in particular, of supracricoid laryngectomy, performed at our institute or elsewhere. This technique was introduced in our department in 1984. In 2005, we published our experience on 253 consecutive patients with selected glottic and supraglottic carcinomas in which supracricoid partial laryngectomy was performed as an alternative for vertical partial laryngectomy and total laryngectomy, with good oncological and functional results [3]. The high number of LTS after subtotal partial laryngectomy in our series is due to our vast experience in this type of surgical technique.

LTS is currently one of the most frequent complications associated with prolonged nasal/orotracheal intubation and tracheotomy, such as in intensive care units [4]. Tracheal stenosis mostly occurs at the cuff of the tube. The reported incidence of tracheal stenosis following tracheotomy and laryngotracheal intubation ranges from 0.6% to 21% and 6% to 21%, respectively [5]. The endotracheal tube causes erosion and mucosal necrosis within hours. If the tube is not withdrawn within a week, full thickness injury exposes cartilage and perichondritis develops. Subsequently, reepithelialization of the edges of the ulcera-

tion begins. Healing is usually complete within 4 weeks and fibrosis and metaplastic squamous epithelium mark the site of the previous ulcer. If the degree of ulceration is unusually severe or if the healing process is delayed by a secondary infection, tissue damage increases and laryngotracheal stenosis may result. In our study, 23 patients presented LTS secondary to prolonged intubation that involved the glottis, subglottis and/or trachea. The cuff of the tube can cause stenosis in the trachea and/or subglottic region, while the endotracheal tube can cause pressure injury to the glottis that can result in severe commissural scarring.

Our series included 11 patients with LTS caused by acute laryngotracheal injury of various aetiology. Laryngeal injuries are uncommon, but however are serious and life-threatening, possibly resulting in LTS. The widespread use of safety devices in automobiles has led to a remarkable decrease in the number of blunt trauma cases in recent years.

Despite being histologically benign, the tendency for laryngeal papillomatosis to proliferate and recur creates substantial morbidity. Airway stenosis may be a consequence of laryngeal papillomatosis and/or multiple surgeries which are often necessary in the treatment of these conditions. Two patients were referred to our department after previous treatments for their recurrent respiratory papillomatosis, and were ultimately decannulated after 3 and 9 surgical procedures.

The typical patient with radiation-induced complications initially develops symptoms of hoarseness and breathiness. Most patients become symptomatic within the first 3 months after radiotherapy. However, there are case reports of patients presenting symptoms 25, 44 and even 50 years after radiotherapy due to fibrosis [6]. Two patients in our series reported a laryngotracheal stenosis at 1 and 3 months after radiotherapy.

Our series, similar to others, is very heterogeneous considering the causes and characteristics of the stenosis. This heterogeneity explains why, despite the availability of various treatment options, none have been completely satisfactory and often patients are subjected to multiple surgeries to restore airway patency. Two basic treatment modalities prevail: external and endoscopic. In reality, tracheal resection and anastomosis is considered the treatment of choice for tracheal stenosis [7]. However, when the glottis and/or the subglottis are also involved this surgical approach may not be applicable; moreover, it may not be feasible due to the extent of the stenosis, underlying disease and general health of the patient [8]. Laryngotracheoplasty techniques are widely-used procedures which include many different variations to address specific aspects of the narrowed airway. These techniques have been developed from the anterior cricoid split procedure, first described in 1980 as an alternative to tracheotomy in children [9]. Currently, many procedures are available and consist essentially of splitting followed by reconstruction using cartilage or bone. Cartilage grafts are considered to be highly superior to those of bone due to the lower rate of resorption and the ease in shaping it [8]. In patients for whom it was necessary to use a cartilage graft, we used costal or septal cartilage graft.

Endoscopic treatment includes laryngeal microsurgery, laser-assisted excision, traditional dilation and endoscopic stent insertion. These minimally invasive treatments may avoid the need for open cervicomediastinal surgery in most patients, but the effects of dilatation, laryngeal microsurgery and laser effects can be of short duration and repeated treatments may be required [10]. Currently, topical application of mitomycin C is often used as adjuvant therapy to the endoscopic management of LTS with contradictory results [11]. Occasionally, prolonged splinting achieves successful tracheal stabilization and thus allows definitive removal of the stent [12]. Long-term stenting might therefore yield good therapeutic results, but the indications and technical details remain undetermined since insufficient clinical data are available. On the other hand, in those cases where patient decannulation was not possible, airway stenting can be considered a valid long-term palliative alternative.

The choice of ideal treatment should be based on the characteristics of each patient after evaluating all the advantages and disadvantages of the procedures. In our series, we retrospectively analyzed 70 patients with LTS of different aetiology treated with multiple surgeries. In all cases we used, at least once, a Montgomery Safe-T tube as single dilation treatment associated with endoscopic or open-neck surgery. We included 3 young patients in this study, one aged 16 years and two aged 18 years. Although successful use of the Montgomery T tube has been reported in the paediatric population, it is probably not an appropriate choice in younger children since it can cause granulation tissue formation at the upper intraluminal end, and may become easily blocked due to its small lumen size. In adolescents, such as those considered in this study, where adequate distance between the true cords and the subglottis is present, the T tube can also be useful.

The Safe-T tube, first described by Montgomery in 1964, is made of non-irritating medical grade silicone, does not harden with prolonged contact with body temperature and secretions and is generally well-tolerated by patients even for a long period of time. It can be used for long-term stenting of the larynx and trachea for up to 7 years, or, if periodically replaced, for up to 15 years [2]. As recommended by several authors, we keep the stent in place for at least 6 months. The optimal period of stenting should be evaluated on an individual basis, since it is related mostly to the severity of the lesion and to the patient's general conditions. These silicone prostheses can be considered foreign bodies and may be responsible for infections and granulation tissue formation. This granulation is an integral part of the

wound healing process, but may result in contracture of the wound and thereby decrease the lumen size. Bacterial infection and consequent inflammation increase the risk of granulation formation. Antibiotic therapy can prevent granulation tissue formation, but additional surgeries may often be necessary to restore airway patency. If the formation of a biofilm around the tube is suspected, making antibiotic therapy unnecessary, its replacement can be considered [13]. Although the risk of stent obstruction by dried secretions is quite high, the Montgomery Safe-T tube allows easy clearance through its external end. In our department we use an insertion technique similar to that described by Sichel in 1998 [14] as reported in the Materials and Methods. This technique gives increased control of the airway via the laryngoscope, and direct visualization of the stenosis and trachea makes positioning of the T tube possible in a very short time. The length and diameter of the T tube were selected on the basis of the length of the stenosis and airway dimensions. The T tube should completely cover the stenotic tract and fit snuggly into the airway, but not too tightly to avoid causing excessive pressure on the tracheal wall mucosa. In patients with stenosis superior to the subglottis, transglottic positioning of the proximal intraluminal end of the tube has been used [15]. These patients may have a high risk of inhalation or foreign body sensation, and subsequent interventions may be required to shorten the proximal end of the tube in the days following implantation until it reaches optimal length.

We obtained decannulation in 77.1% of cases (54/70 patients). Our results are similar to most of those published in literature [16]. However, some authors report better results showing only a 2.5% failure rate [17]. These studies show the data of patients with simple subglottic LTS submitted to laryngotracheal resection and reconstruction, while our series includes patients with glottis/subglottic stenosis for which treatment is more difficult. The analysis of our series showed that in 72.2% of cases (39/54 patients), decannulation was obtained in 3 or fewer surgical procedures, showing a significant difference compared to patients who underwent more than 3 surgeries ($p = 0.00002$). The likelihood of decannulation was significantly associated with patient age, as already reported [18], whereas there was no statistically significant association with the other variables considered. Previous studies have shown that low-grade stenosis and a stenosis inferior to 50% of total tracheal extension also seem to be decisive for a better prognosis [19]. The Myer-Cotton grading system [20] is currently the most widely used classification in evaluating LTS severity. In our series, the grade of stenosis was determined with certainty by reviewingmedical charts. None of our patients had grade 1 stenosis. Our study also shows that the probability of decannulation was closely related to the grade of stenosis (Fig. 5), but the rate of decannulation in patients who underwent more than 3 surgeries was very low regardless the degree of stenosis.

After analyzing the results of this study, we modified the approach to our patients by clearly informing them that if decannulation was not obtained within the first 3 surgeries, the chances of closing the tracheotomy would decrease significantly and additional surgeries would be of questionable benefit. In these cases, a Montgomery Safe-T tube can be used as a valid therapeutic alternative for long-term palliation. However, although only 7 of 54 patients (13%) were decannulated after more than 5 surgical procedures, we believe that in particularly motivated patients who are clearly informed, it is possible to make further attempts, especially in young patients with good general health.

Conclusions

Appropriate management of LTS requires a high degree of expertise in endoscopic and open-neck surgery. The numerous treatment modalities available for both approaches render patient selection and treatment difficult. For tracheal stenosis, tracheal resection and anastomosis is widely considered the treatment of choice. However, this surgical approach is not feasible when the glottis and subglottis are involved or in patients with poor general condition. Patients undergoing dilation for LTS usually require multiple procedures. The T tube plays an important role in the treatment of this pathology. However, if the tracheotomy is not removed within 3 surgical interventions, the odds of decannulating the patient decrease significantly and additional surgeries, especially in older patients and in those with higher grade stenosis, may not be beneficial.

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