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Laryngology

Hemicricoidectomy with modified rotational thyro-crico-tracheal anastomosis: a newborn in the family of crico-tracheal resection and anastomosis techniques

Emicricoidectomia con anastomosi rotazionale tiro-crico-tracheale modificata: una nuova procedura nella famiglia delle resezioni e anastomosi crico-tracheali

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SUMMARY

Objective. The aim of the present study is to describe our novel surgical technique of hemicricoidectomy and reconstruction with modified rotational thyro-crico-tracheal anastomosis for the treatment of non-squamous cell subglottic tumours. The procedure has been defined as Type E crico-tracheal resection and anastomosis (CTRA) following the University of Brescia (C)TRA classification introduced elsewhere.

Methods. A detailed anatomical step-by-step dissection was reproduced and illustrated on a cadaveric laryngo-tracheal specimen. Moreover, oncological and functional outcomes of the first 5 patients who underwent Type E CTRA at our Institution between October 2016 and September 2022 are described.

Results. Three patients underwent Type E CTRA for cricoid chondrosarcoma (CS) and 2 patients for subglottic adenoid cystic carcinoma (ACC). No post-operative complication was reported. All patients maintained intact oral intake and an intelligible voice at discharge. All but one patient with obstructive sleep apnoea hypopnea syndrome and lung comorbidity were successfully decannulated before discharge. At the last follow-up (April 2023), one patient experienced local recurrence of CS that was still amenable to conservative treatment by transoral debulking, while the remaining patients were free of disease.

Conclusions. With the proper indications, Type E CTRA is a feasible and effective conservative surgical technique for selected non-squamous cell subglottic tumours.

KEY WORDS: cricoid, trachea, crico-tracheal resection and anastomosis, chondrosarcoma, adenoid cystic carcinoma

RIASSUNTO

Obiettivo. *Scopo del presente studio è quello di descrivere una nuova tecnica chirurgica di emicricoidectomia e ricostruzione mediante anastomosi rotazionale tiro-crico-tracheale modificata per il trattamento di tumori sottoglottici non-squamocellulari. La procedura è stata denominata resezione-anastomosi crico-tracheale (CTRA) Tipo E, in base alla classificazione delle (C)TRA dell'Università degli Studi di Brescia, già descritta in precedenza altrove.*

Metodi. *Una dissezione dettagliata è stata eseguita e illustrata su un pezzo anatomico laringo-tracheale proveniente da cadavere. Inoltre, i risultati oncologici e funzionali dei primi 5 pazienti sottoposti a CTRA Tipo E presso la nostra Clinica nel periodo ottobre 2016 - settembre 2022 sono stati qui descritti.*

Risultati. *Tre pazienti sono stati sottoposti a CTRA Tipo E per condrosarcoma (CS) cricoideo e 2 per carcinoma adenoidocistico (ACC) sottoglottico. Non è stata riscontrata nessuna complicanza post-operatoria. Tutti i pazienti hanno mantenuto una normale alimentazione per bocca e una voce comprensibile già alla dimissione. Tutti i pazienti sono stati decannulati prima della dimissione, tranne una che presentava una*

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sindrome delle apnee ipopnee ostruttive notturne e importanti comorbidità polmonari. Durante il follow-up (terminato nell'aprile 2023) solo una paziente ha evidenziato una recidiva locale di CS, trattata conservativamente mediante debulking per via transorale, mentre i restanti pazienti sono tuttora liberi da malattia.

Conclusioni. *Rispettando le corrette indicazioni, la CTRA Tipo E si è dimostrata una tecnica chirurgica conservativa riproducibile ed efficace per il trattamento di selezionati tumori sottoglottici non-squamocellulari.*

PAROLE CHIAVE: *cricoide, trachea, resezione e anastomosi crico-tracheale, condrosarcoma, carcinoma adenoidocistico*

Introduction

Within the wide range of possible malignant laryngeal tumours, the subgroup of lesions limited to the cricoid cartilage represents a rare clinical finding and a well-known therapeutic challenge. Such lesions are usually of cartilaginous origin, i.e. chondrosarcoma (CS), or arise from minor salivary glands, like adenoid cystic carcinoma (ACC) [1,2]. In fact, due to their rapid growth and more aggressive biologic behaviour, subglottic squamous cell carcinoma (SCC) limited to the cricoid cartilage is a serendipitous diagnosis and, when encountered, usually requires an aggressive approach in the form of total laryngectomy (TL) for the sake of oncologic radicality [3,4].

Limiting attention to non-SCC subglottic tumours involving less than 60% of the cricoid circumference, with complete sparing of at least one crico-arytenoid unit (CAU), and without involvement of the thyroid lamina and/or hypopharyngeal and upper oesophageal mucosa, we herein demonstrate that such a clinical scenario is potentially manageable by conservative therapeutic strategies, which has been heterogeneously described in the modern literature. In fact, in between transoral laser-assisted debulking and TL, several reports describe different open partial reconstructive techniques, variously described and not widely popularised [1,5-7]. In particular, in 2017 Rovò and coworkers described a case series of 4 patients who were surgically treated for low-grade (G1) CS by total cricoidectomy and rotational thyro-tracheopexy [8]. Based on this provocative work, we modified the Rovò's procedure, making it suitable for lesions involving slightly more than half of the cricoid circumference thus allowing the preservation of an intact CAU unit, and obtaining the best possible compromise between oncological and functional outcomes.

The aim of the present study is to illustrate our standardised surgical procedure of hemicricoidectomy and reconstruction with modified rotational thyro-crico-tracheal anastomosis; in accordance with the University of Brescia (crico)-tracheal resection and anastomosis [(C)TRA] classification previously described [9], we named this procedure Type E CTRA. Moreover, oncological and functional outcomes of the first 5 patients treated in our centre with this technique are described herein.

Materials and methods

Laboratory setting

A pre-clinical study on one human laryngo-tracheal cadaveric specimen was carried out to accurately describe step-by-step the surgical procedure herein demonstrated. In detail, a 20% alcohol fixed human male head was employed. The specimen, at the time of harvesting, was sectioned at the base of the neck, maintaining 8 tracheal rings intact. The specimen was provided by Medcure®, USA, and arterial injection with a bicomponent red silicone was conducted before fixing the specimen with an alcohol solution. All the phases (specimen injection, fixation, and dissection) took place in the dissection laboratory "L.F. Rodella" at the Section of Anatomy and Physiopathology of the University of Brescia, Italy. Photos of each significant step of the Type E CTRA were taken and shown herein to demonstrate the technical details.

Surgical technique

After orotracheal intubation, the patient is placed on the operating table with the head in a hyperextended position. A cervical horizontal skin incision is performed in between the cricoid prominence and the suprasternal notch, and subplatysmal/fascial flaps are raised superiorly and inferiorly, thus exposing the superficial cervical fascia and the underlying prelaryngeal muscles. The linea alba is vertically incised and strap muscles separated to expose the underlying thyroid gland and laryngo-tracheal axis. Thyroid isthmusotomy is completed along the midline and thyroid lobes lateralized to completely expose the laryngo-tracheal junction. This manoeuvre must be carefully conducted in strict adherence to the external tracheal perichondrium, in order not to damage the recurrent laryngeal nerves (RLNs), especially on the side not affected by the tumour. Lateralisation of the thyroid lobes allows protection of the RLNs, moving them away from the tracheal axis and their point of entry behind the inferior thyroid cornua. An incision is performed through the crico-tracheal membrane, thus obtaining a circumferential laryngo-tracheal separation (Fig. 1A). At this point, after withdrawing the orotracheal tube above the vocal folds, the airway is directly intubated through the distal tracheal stump to remove the obstacle of the endolaryngeal tube during subsequent cricoid resection.

A vertical anterior section of the cricoid arch is then performed on the midline, with the possibility of slightly modifying it on the base of the anterior tumour extension. Care should be paid to avoid any injury to the crico-thyroid muscle on the healthy side with the aim of preserving the tension of the corresponding vocal fold. The crico-thyroid membrane of the hemicricoid to be resected is then incised, together with the ipsilateral cranial insertions of the crico-thyroid muscle, maintaining the section line at the level of the inferior border of the thyroid lamina on the tumour side (Fig. 1B). Finally, the inferior cornu of the thyroid cartilage is sectioned to allow full crico-thyroid separation and direct endoluminal tumour inspection (Fig. 1C). The lateral crico-arytenoid muscle is then sectioned, and the crico-arytenoid joint is disarticulated, thus freeing the posterior-superior surface of the cricoid plate (Fig. 1D). With the tumour under direct view, a posterior vertical cricoidotomy at the level of the cricoid plate is now performed, paying attention to not injure the hypopharyngeal mucosa of the post-cricoid area (Fig. 2A). This posterior cut can be modulated according to the specific tumour extension and, potentially, carried slightly off the posterior midline while preserving an intact and fully functioning contralateral CAU. No attempt

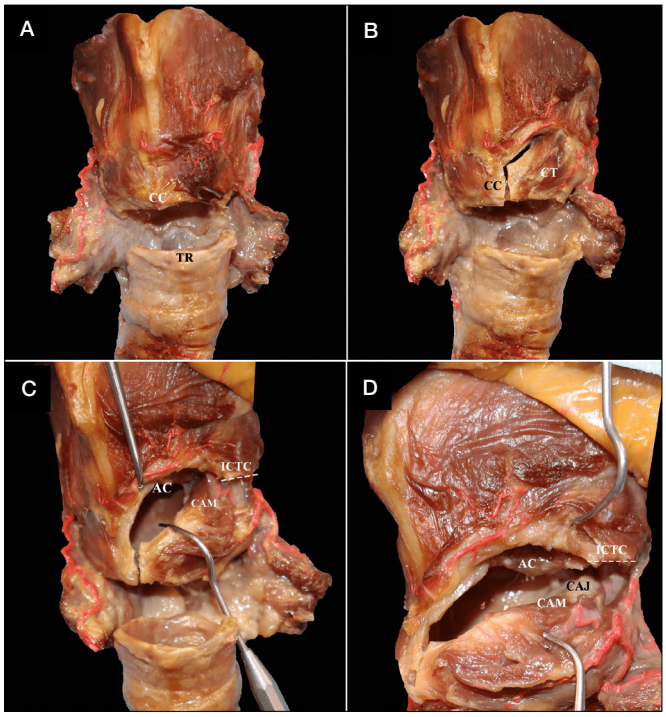

Figure 1. (**A-D**) Laryngo-tracheal separation and first steps of the hemicricoid resection.
AC: arytenoid cartilage; CAJ: crico-arytenoid joint; CAM: lateral crico-arytenoid muscle; CC: cricoid cartilage; CT: crico-thyroid muscle; ICTC: inferior cornu of the thyroid cartilage; TR: trachea.

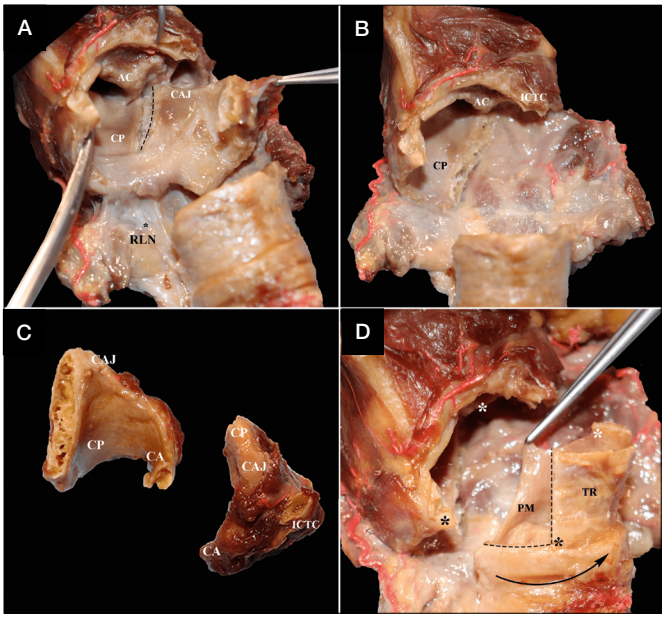

Figure 2. (**A-D**) Left hemicricoidectomy and tracheal re-shaping.
AC: arytenoid cartilage; CA: cricoid arch; CAJ: crico-arytenoid joint; CP: cricoid plate; ICTC: inferior cornu of the thyroid cartilage; PM: pars membranacea; RLN: recurrent laryngeal nerve (black asterisk in Figure 2A); TR: trachea; black asterisks in Figure 2D, planned suture between the inferior portion of the cricoid arch and reshaped trachea; white asterisks in Figure 2D, planned final position of the posterolateral edge of the superior tracheal ring supporting the above-placed arytenoid; black arrow, planned 30° tracheal rotation.

is made to preserve the ipsilateral RLN due to the complete removal of the intrinsic laryngeal muscles on the tumour side, including the posterior crico-arytenoid muscle. The specimen, composed of a hemicricoid and the corresponding inferior thyroid cornu, can now be removed and mucosal fresh frozen sections performed, if needed (Figs. 2B, C).
Subsequent airway reconstruction is accomplished by reshaping the distal tracheal stump to close the subglottic gap and sustain the disarticulated and paralysed arytenoid. At least 3 hemi-tracheal rings, equivalent to the cricoid plate cranio-caudal height, are thus removed from the tracheal stump, contralaterally to the cricoid defect (Fig. 2D). The tracheal membranous wall must be completely preserved to save tissue to cover the post-cricoid hypopharyngeal mucosa from the inside, suturing it to the remaining subglottic mucosa at the level of the preserved hemicricoid plate. To prevent excessive swelling and medialisation of the paralysed vocal fold, its inferior margin needs to be fixed with one or two 3-0 polyglactin 910 stitches to the inferior border of the ipsilateral thyroid lamina.
While planning the thyro-crico-tracheal anastomosis, an approximately 20°-30° tracheal rotation must be considered to: (a) position the posterior angle of the first cartilaginous tracheal ring just below the disarticulated arytenoid;

(b) cover the entire posterior vertical cricoid split, allowing safe suture between this and the mucosa of the tracheal membranous wall; (c) align the lateral edge of the three sectioned hemi-tracheal rings with the residual anterior hemicricoid arch and crico-tracheal membrane; (d) match the inferior edge of the thyroid lamina with the superior margin of the first tracheal ring. The modified thyro-crico-tracheal rotational anastomosis is then accomplished in a posterior to anterior direction (Figs. 3, 4A-C). The anastomosis technique involves the use of a couple of robust "stay sutures" with 2-0 polyglactin 910 stitches, positioned above and below the anastomotic line and aimed at reducing its tension. These are positioned in the antero-lateral aspect of the future anastomosis, ideally at 2 and 10 o'clock positions in an axial view of the airway. Therefore, on one side the superior stay suture will be placed submucosally in the cricoid arc, while the correspondent inferior one should be placed at least one tracheal ring below the removed lateral tracheal window. On the other side, the superior stay suture will be placed submucosally through the thyroid ala (perforated by using a burr if ossified), while the inferior matching one should be placed at the level of the second tracheal ring. Care should be taken to foresee the appropriate tracheal rotation while positioning the stay sutures. Harvesting of the anastomosis is accomplished by placing five to seven 4-0 polyglactin 910 stitches between the tracheal membranous wall and the posterior mucosa of the preserved hemicricoid plate (Fig. 3). The preparation is then completed by passing 10 to 15 2- and 3-0 polyglactin 910 sutures equally distributed along the antero-lateral circumference of the laryngeal and tracheal stumps (Fig. 4A-C). The endotracheal tube in the distal tracheal stump can be now removed and replaced by the previous orotracheal one by passing it through the anastomosis before tying the knots. Finally, patient's head is flexed, and the sutures are symmetrically tied: in first place the posterior ones, then the "stay sutures", followed by all the stitches from the posterior-lateral to the most anterior ones.

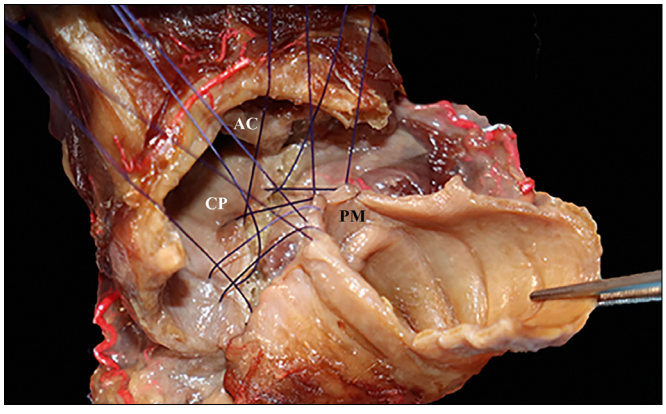

Figure 3. Crico-tracheal anastomosis, posterior portion.
AC: arytenoid cartilage; CC: cricoid cartilage; CP: cricoid plate; PM: pars membranacea; TC: thyroid cartilage; TR: trachea.

After the anastomosis has been successfully accomplished, a temporary tracheotomy is performed at least 3 tracheal rings below the anastomotic line to preserve its vascularisation. A cuffed cannula (typically a Shiley no. 6) is then positioned and inflated. During the layer-by-layer suture of the cervical wound, great care should be paid to isolate the tracheotomy from the neck by using 4 stitches, thus allowing the suction drainage(s) to maintain their vacuum. Finally, two heavy sutures are placed from chin to chest in order to maintain the patient's head in a moderately flexed position for the following 8 postoperative days.

Case series

Data concerning patients who underwent Type E CTRA between October 2016 and September 2022 for non-SCC subglottic tumours at the Department of Otorhinolaryngology – Head and Neck Surgery of the University of Brescia, Italy, were prospectively collected. In particular, a dedicated database was prospectively maintained, collecting data about patient demographics, comorbidities, previous head and neck treatment(s), details of surgical procedure, post-operative course, hospitalisation time, and final histopathological examination of the surgical specimen. Moreover, oncological and functional outcomes were assessed and confirmed for the last time in April 2023. A descriptive analysis of the collected data was completed.

Results

Five patients were included in the present study, 3 females and 2 males (Tab. I). Median age at surgery was 57 years, ranging from 48 to 67. One female was affected by obstructive sleep apnoea hypopnea syndrome (OSAHS) and restrictive lung disease due to extreme scoliosis, while the remaining patients did not have major comorbidities.

Three patients underwent upfront surgery: 2 for G1-G2 cricoid CS, and one for subglottic ACC. Two patients were referred to us for local recurrence after previous treatments. In detail, one patient (no. 2 in Tab. I) had been managed by two carbon dioxide transoral laser microsurgical (CO_2 TOLMS) procedures for a G1 cricoid CS, while the other had been previously treated for subglottic ACC by radiation therapy (65 Gy). All patients were without tracheostomy at the moment of our first evaluation with the exception of patient no. 2, who was tracheotomised prior to CO_2 TOLMS and was never decannulated due to OSAHS and restrictive lung disease.

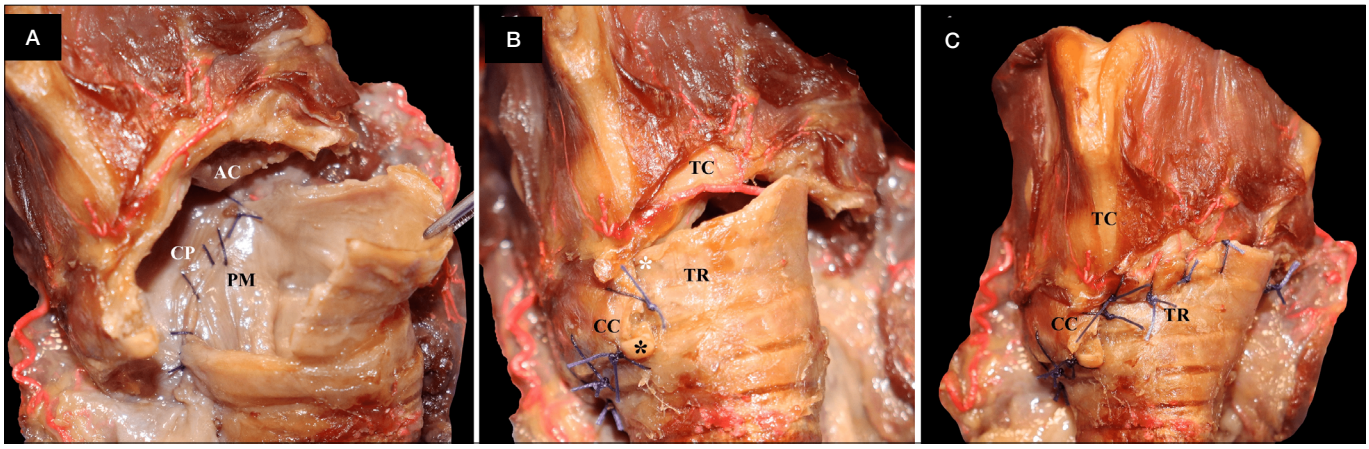

Figure 4. (**A-C**). Modified rotational thyro-crico-tracheal anastomosis.
AC: arytenoid cartilage; CC: cricoid cartilage; CP: cricoid plate; PM: pars membranacea; TC: thyroid cartilage; TR: trachea; black asterisk in Figure 4B, correspondence between the inferior portion of the cricoid arch and reshaped trachea; white asterisk in Figure 4B, final position of the superior edge of the cricoid arch and the reshaped trachea.

The postoperative course did not show early or late complications requiring surgical re-intervention. On the other hand, patient no. 2 required medical therapy for infectious pneumonia. She was also the only in which tracheostomy removal was not possible for the underlying pulmonary comorbidities and need for ventilation with continuous positive airway pressure during the night (an issue pre-existent to the surgical treatment). This patient keeps a Shiley no. 4 tracheostomic cannula plugged during her daily life and normal activity, maintaining an intelligible voice and functional swallowing without aspiration. In the other 4 patients, the tracheostomy was closed on average on the 9th post-operative day. Overall, oral feeding started after removal of the tracheostomy and nasogastric feeding tubes (the latter not before the 8th post-operative day). Median hospitalisation time was 15 days (range, 11-21).

Definitive histopathological examination showed complete tumour removal (R0) in 4 cases and R1 margins in one G2 CS along the posterior cricoidotomy line (where further contralateral extension of the resection would have impaired function of the healthy CAU). No adjuvant therapy was administered.

During follow-up, the patient affected by G2 CS with R1 margins developed a local recurrence at 36 months after surgery, which was still amenable to conservative treatment by debulking with CO_2 TOLMS. The remaining 4 patients underwent regular control visits as of April 2023 with no endoscopic and radiologic evidence of local, regional and/or distant recurrence (mean follow-up, 48 months; range, 8-78).

Discussion

The present work describes the surgical technique and preliminary results of a novel conservative procedure of hemicricoidectomy and reconstruction with modified rotational thyro-crico-tracheal anastomosis applied to the treatment of selected non-SCC cricoid tumours. The well-known complexity of organ-sparing surgical management of such lesions, due to the pivotal role played by the cricoid

Table I. Demographics, clinical, and post-operative details.

Patient no.	Age	Gender	Previous treatment(s)	Histology	Margins	Decannulation (post-op day)	Oral feeding (post-op day)	Recurrence	Additional treatments	Status
1	48	M	-	G1 CS	R0	14	15	No	-	NED, 78 mos
2	59	F	2 CO_2 TOLMS	G1 CS	R0	-	12	No	-	NED, 74 mos
3	67	F	-	G2 CS	R1	7	8	Yes, 36 mos	CO_2 TOLMS	AWD, 14 mos
4	56	M	RT	ACC	R0	9	10	No	-	NED, 33 mos
5	57	F	-	ACC	R0	7	8	No	-	NED, 8 mos

M: male; F: female; CO_2 TOLMS: transoral laser microsurgery by carbon dioxide; RT: radiotherapy; G1: well-differentiated; G2: moderately differentiated; CS: chondrosarcoma; ACC: adenoid cystic carcinoma; R0: microscopically negative margins; R1: microscopically positive margins; mos: months; NED: no evidence of disease; AWD: alive with disease.

within the upper airway, forced surgeons to find new therapeutic solutions for such an unmet need. In fact, complete or partial cricoid removal may bring about several alterations in terms of airway patency, swallowing and voice production [10,11]. For this reason, historically, the simplest choice of treatment for tumours involving the cricoid was TL, which still remains the gold standard in most subglottic SCC with cricoid cartilage infiltration [3,4]. On the other hand, in case of subglottic tumours of other histotypes, e.g. G1-2 CS or minor salivary gland neoplasms, various open conservative procedures might be taken into account. In this scenario, in fact, CO_2 TOLMS is mostly indicated for surgical debulking of endolaryngeal lesions to obtain samples for histological examination and temporarily restore the airway patency avoiding tracheostomy, while oncological radicality is often difficult (if not impossible) to achieve by such an approach [12-14].

In order to maximise oncologic radicality while preserving laryngeal functions, two main rules need to be respected: 1) the anatomical and functional integrity of at least one CAU; 2) the maintenance of a rigid structure framing the airway patency [11]. In light of these principles, airway reconstruction after cricoid resection may be carried out either by interposition of a revascularised or pedicled flap, or by direct laryngo-tracheal anastomosis.

The first reconstructive option requires complex techniques, frequently carried out by multiple-staged procedures, often deserving prolonged laryngeal stenting [7,15-17]. Another shortcoming of these types of procedures is the impossibility to completely reproduce the laminated airway structure, composed by a cartilaginous skeleton in support to a respiratory epithelium. Therefore, the most successful surgical interventions imply the use of composite flaps with the association of various grafts [16,17]. In this regard, Delaere and coworkers described tracheal auto- and allotransplantation techniques, which were also applied with good results in cases of cricoid CS [18,19]. The authors described a two-step procedure to restore the defect of a vertical hemilaryngectomy, using a composite flap. In detail, a fascial forearm free flap was used to enwrap and revascularise a tracheal graft harvested from the same patient or from a donor. In the latter scenario, the buccal mucosa of the recipient was also used to resurface the inner tracheal portion. Naturally, the completion of the procedure required several months and immunosuppressive therapy in case of allotransplantation [18,19].

On the other hand, airway reconstruction by direct anastomosis, when feasible, represents a straightforward procedure that allows maintenance of airway structure and preservation of an intact respiratory mucosa. Gaissert and coworkers [20] described a series of 25 patients with laryngo-tracheal tumours of various histotypes treated by laryngotracheoplastic procedures and reported very sound results. Dealing with cricoid G1-G2 CS, Piazza et al. [21] reported 11 cases of subtotal cricoidectomy, variably extending the resection to the cricoid arch and plate, but always maintaining a slender portion of posterior cricoid plate as support to the above placed arytenoids and in front of the posterior cricoarytenoid muscles in order not to damage the RLNs. According to the authors' classification [9], this procedure will be subsequently named as Type C CTRA.

For what concerns further extended resections, Guinchard et al. [22] reported on the use of inferior vertical hemilaryngectomy for a patient with synovial sarcoma of the arytenoid in which the resection encompassed one CAU together with the ipsilateral hemicricoid and the inferior portion of the thyroid ala. In this case, airway reconstruction was accomplished by employing the ipsilateral hemitracheal stump, sacrificing the contralateral one, and accomplishing a thyro-crico-tracheal anastomosis by placing the superior edge of the tracheal flap inside the thyroid cartilage, in order to replace the removed vocal fold [22]. The patient maintained an LT-Mold laryngeal stent [23] in place for 6 weeks, and the tracheostomy was surgically closed after 2 months, with satisfactory functional outcomes. Finally, Rovò et al. [8] described a peculiar way to support the arytenoid cartilages in case of total cricoidectomy, trying to avoid the functional sequalae proper of this type of procedure [6,24]. The authors proposed a rotational thyro-tracheoplasty, performing a 90° rotation of the distal tracheal stump to support the paralysed arytenoid cartilages by means of the cartilaginous portion of the first tracheal ring. In detail, the paper reports 3 total and 1 subtotal cricoidectomy for CS. Three of 4 patients required soft laryngeal stenting and the same underwent a second operation for single or bilateral arytenoid lateropexy. All patients were decannulated after surgery, and 3 patients were able to regain oral feeding [8].

The new surgical procedure described herein is a modification of the technique reported by Rovò et al. [8], aimed at treating the case of an hemicricoid (or slightly more than hemicricoid) resection. The final result is a procedure providing complete resection of (potentially slightly more than) half of the cricoid, while preserving a fully functional CAU and supporting the paralysed arytenoid with a solid structure, thus providing a further barrier to aspiration and an ideal condition for good swallowing and voice compensation. Different from the abovementioned procedures, Type E CTRA is characterised by a lesser amount of rotation of the distal tracheal stump (maximum 30°) from one side, and a tracheal reshape that reduces the anastomotic tension and the asymmetry of airway reconstruction from the other. These features, together with sparing

of one functional CAU, may provide major stability of the reconstructed airway and easier functional recovery. Furthermore, preservation of both arytenoids (even if one is paralysed), the entire thyroid cartilage, and the whole supraglottic and glottic structures confer superior functional outcomes compared to other procedures, such as open partial horizontal laryngectomy Types IIIa or IIIb [25]. Our initial results, with no surgical complications, 80% decannulation rate and 100% of functional swallowing, confirm the feasibility of this technique and adequately safe oncological and functional profiles. In fact, only one patient experienced a tumour relapse of a G2 CS at 36 months after a Type E CTRA, and during this period she completely maintained laryngeal functions and continued to work as a lawyer. Another patient was unable to remove the tracheostomy due to severe OSAHS and lung comorbidities, but maintained normal oral intake and an intelligible voice, as did all the other patients in the present series. Moreover, Type E CTRA has the great advantage to be a standardised single-stage procedure, with the possibility to be extended anteriorly to the cricoid arch and first hemitracheal ring inferiorly. Our case series confirmed that no laryngeal stenting or further surgical re-interventions to maintain the airway patency are usually required.

However, airway surgery in general, and this type of procedure in particular, requires very strict and watchful indications. Type E CTRA as described herein should be limited to non-SCC lesions of the subglottis, involving no more than 60% of the inner cricoid circumference, with complete sparing of one CAU, and without infiltration of the thyroid cartilage and/or the hypopharyngeal and upper oesophageal mucosa. Another theoretically possible indication, not encountered in the present series, may be represented by a single sided cricoid infiltration by well-differentiated advanced thyroid cancer.

Regarding patient selection, Type E CTRA seems less demanding than the other types of CTRA applied for management of various neoplastic and non-neoplastic airway stenoses of the crico-tracheal junction, usually performed without post-operative tracheostomy. As demonstrated by patient no. 2 of the present series, in fact, even severe pulmonary comorbidities may allow the patient to be treated radically while preserving effective voice and swallowing, using the tracheostomy just for nocturnal positive-pressure ventilation.

The small number of patients, due to the rarity of the disease and the very strict surgical indications followed by us in applying Type E CTRA, remains the major limitation of this work, together with the relatively short-term follow-up. After the desirable diffusion of such a technique, multicentric studies with a larger number of patients and longer follow-up will allow for assessment of the reproducibility of the procedure.

Conclusions

Subglottic non-SCC tumours represent a rare entity and a demanding surgical challenge, which may often require more aggressive treatments in the form of TL. The present work describes the surgical technique and initial encouraging results of a novel conservative approach of hemicricoidectomy and reconstruction with modified rotational thyro-crico-tracheal anastomosis, named Type E CTRA. With the appropriate indications and adequate surgical expertise of the airway, we believe that this type of procedure will be able to provide an additional effective and standardised option in the armamentarium of surgeons dealing with tumours of the crico-tracheal junction.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

CP, DL, DM: concept; DL, GZ, CM, FDB: data collection; CP, DL, VR: anatomical dissection; DL, MT, GZ, CP: pictures editing; CP, DL, MT: writing – original draft; FDB, CM, VR, DM: writing – review/editing.

Ethical consideration

This study was approved by the Institutional Ethics Committee (CE Spedali Civili) (protocol number 4267). The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from each participant/patient for study participation and data publication.

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