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Functional Outcome of Supracricoid Laryngectomy: The Role of Anatomical Factors

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Abstract

Background: Supracricoid laryngectomies (SL) were introduced to radically treat laryngeal tumors while respecting laryngeal function. Despite SL standardized technique allows good functional, only few authors analyzed the influence of different anatomical structures on the functional outcome of cricohyoidopexy (CHP) and cricohyoidoepiglottopexy (CHEP) with preservation of one (A) or both (AA) arytenoids.

Materials and Methods: Thirty-eight (36M, 2F; mean age: 60.9 years) patients were submitted to SL for laryngeal carcinoma. The surgical treatment performed was: 6 (15.8%) CHEP+AA, 20 (52.6%) CHEP+A, 4 (10.6%) CHP+AA, and 8 (21%) CHP+A. Postoperative swallowing, phonation, and breathing functions were examined.

Results: No significant local complication was notice postoperatively. All patients were decannulated; (average time to decannulation was 30.36+4.09 days). Nasogastric tube was removed after 16+2.30 days. All patients could clear their pharynx out of any food remnant with up to 3 swallowing acts one month postoperatively. GIRBAS total score ranged from 1.2 to 3 (mean: 1.79). CHEP patients showed better swallowing, phonation and breathing results with respect to CHP. Double arytenoid preservation was associated with better pharyngeal clear out, voice quality and shorter decannulation time with respect to single arytenoid maintenance.

Discussion: our experience confirms the oncological and functional reliability of SL. Despite the good functional outcome offered by SL in general, our experience shows significant better performances in case of epiglottis maintenance (CHEP vs CHP) and both arytenoids preservation (AA vs A). The anatomical surgical details of our SL technique are reported.

Keywords: Supracricoid Laryngectomy; Functional Outcome; Surgical Technique; Laryngeal Cancer; Anatomy

Introduction

Supracricoid laryngectomies (SL) were introduced to radically treat laryngeal tumors (LT) while respecting laryngeal function [1-8]. The basic principle of these techniques is to spare at least one cricoarytenoid unit, necessary for the functional recovery of the residual larynx. The first attempts to preserve laryngeal function after treatment of LT were described in 1896 by Foderl [2], who proposed a laryngectomy that spared the epiglottis and the arytenoids followed by a reconstruction of the upper respiratory tract by suturing the epiglottis and the arytenoids to the first tracheal ring. In 1954, Hoffmann Saguez [3] introduced the term ''subtotal or re-constructive laryngectomy''. In 1959, Majer, Rieder [4] proposed a similar technique, which spared the cricoid cartilage. In 1970, Serafini [5] described the "total laryngectomy maintaining the natural respiration", which was inspired by Foderl's technique and later developed by Rizzotto's "tracheohyoidopexy" [6]. In 1971, Labayle and Bismuth [7] proposed the technique of cricohyoidopexy (CHP), while in 1974; Piquet, Desaulty and Decroix [8] described the cricohyoidoepiglottopexy (CHEP). SL with CHEP and CHP has been widely popular over the last decades, especially in Europe, thanks to their good oncological results. Despite SL standardized technique allows good functional results in terms of swallowing, tracheostomy-occluded breathing function and voice quality, only few authors analyzed the influence of different anatomical structures on SL functional outcome. In this paper, we report the functional outcome of our SL and consider the comparative influence of different anatomical factors on such results.

Patients and Methods

Thirty-eight (36M, 2F) consecutive patients were submitted to SL (CHEP or CHP) for laryngeal carcinoma between January 2012 and December 2014 at the Department of Otolaryngology-Head and Neck Surgery of "Carlo Poma" Civil Hospital, Italy. Patients' mean age was 60.9 years (age range 51-78 years) (Table 1). For 30 patients, SL was the primary treatment, while 8 patients (21%) had been treated previously for laryngeal carcinoma:

Table 1: Patients submitted to supracricoid laryngectomy. CHP = cricohyoidopexy; CHEP = cricohyoidoepiglottopexy; (AA) = preservation of both functioning cricoaritenoid units; (A-) = preservation of one functioning cricoaritenoid unit; * = preoperative radiotherapy; ° = postoperative radiotherapy.

Patient	Age (Years)	Tumor Site	pTNM	Surgical Procedure
1	55	Glottis-Supraglottis	T2N2bM0	CHP (A-)*°
2	53	Glottis	T1b	CHEP (AA)
3	64	Glottis	T2N0M0	CHEP (A-)
4	68	Glottis	T2N0M0	CHEP (A-)
5	56	Glottis	T2N0M0	CHEP (A-)
6	65	Glottis-Supraglottis	T2N0M0	CHP (AA)
7	58	Glottis	T2N0M0	CHEP (A-)
8	69	Glottis-Supraglottis	T2N2bM0	CHP (A-)°
9	69	Glottis-Supraglottis	T3N1M0	CHP (AA)*
10	54	Glottis	T2N0M0	CHEP (A-)
11	51	Glottis	T2N0M0	CHEP (A-)
12	63	Glottis	T2N0M0	CHEP (A-)
13	69	Glottis-Supraglottis	T2N1M0	CHP (A-)
14	58	Glottis	T2N0M0	CHEP (AA)
15	78	Glottis	T2N0M0	CHEP (AA)
16	62	Glottis	T2N0M0	CHEP (A-)
17	65	Glottis	T2N0M0	CHEP (A-)
18	57	Glottis-Supraglottis	T4aN2aM0	CHP (A-)°
19	56	Glottis	T3N0M0	CHEP (A-)*
20	65	Glottis-Supraglottis	T2N2bM0	CHP (A-)*°
21	58	Glottis	T1b	CHEP (AA)
22	69	Glottis	T2N0M0	CHEP (A-)
23	64	Glottis	T2N0M0	CHEP (A-)
24	68	Glottis	T2N0M0	CHEP (A-)
25	56	Glottis-Supraglottis	T2N0M0	CHP (AA)
26	51	Glottis	T2N0M0	CHEP (A-)
27	58	Glottis-Supraglottis	T2N2bM0	CHP (A-)°
28	78	Glottis	T2N0M0	CHEP (A-)
29	62	Glottis-Supraglottis	T3N1M0	CHP (AA)*
30	65	Glottis	T2N0M0	CHEP (A-)
31	57	Glottis-Supraglottis	T2N1M0	CHP (A-)
32	56	Glottis	T2N0M0	CHEP (A-)
33	69	Glottis	T2N0M0	CHEP (AA)
34	54	Glottis	T2N0M0	CHEP (AA)
35	55	Glottis	T2N0M0	CHEP (A-)
36	53	Glottis	T2N0M0	CHEP (A-)
37	63	Glottis-Supraglottis	T4aN2aM0	CHP (A-)°
38	69	Glottis	T3N0M0	CHEP (A-)*

2 (5.2%) with cordectomy and 6 (15.8%) with radiotherapy. Tumor staging was carried out according to UICC 7th Edition [9]. All patients were M0.

Preoperative Assessment

All patients were submitted to flexible videolaryngoscopy, laryngoscopy with biopsy under general anesthesia, laryngeal/

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neck computed tomography (CT) or magnetic resonance imaging (MRI), thorax-CT and nutritional evaluation, performed by clinical dieticians, who scheduled postoperative enteral nutrition with a nasogastric feeding tube (12 F diameter).

Indications for CHEP were: (a) T1b involving both true vocal cords or one vocal cord with radiological suspicion of thyroid cartilage invasion of the anterior commissure; (b) Glottic T2 with extension to the false vocal fold, to the base of the epiglottis or anterior surface of the arytenoid and/or with impairment of cordal mobility; (c) Selected cases of T3 glottic carcinoma, without invasion of paraglottic space.

Indications for CHP were: (a) Supraglottic-glottic T2 tumors; (b) Supraglottic-glottic T3 carcinoma with pre-epiglottic/ paraglottic space invasion and/or impairment of vocal fold mobility without involvement of cricoarytenoid articulations; (c) Selected cases of T4 carcinoma with invasion of the thyroid cartilage anteriorly without involvement of cricoarytenoid articulations and subglottis.

Contraindications for CHEP or CHP were: posterior commissure involvement; extensive posterior invasion of paraglottic space; arytenoid fixation (cordal fixation without arytenoid mobility impairment was not considered a contraindication); cricoid/subglottis (10mm from free vocal cord edge); lateral and posterior extralaryngeal spread; low performance status (Karnofsky's index < 80%); uncooperative patients; age older than 80 years [10-11]. All patients signed a written informed consent.

Surgery

The surgical treatment performed was: 26 (68.4%) CHEP and 12 (31.6%) CHP. Among CHEP, in 6 (15.8%) cases both functioning cricoarytenoid units were preserved, while in 20 (52.6%) subjects only one cricoarytenoid unit was maintained. Among CHP, in 4 (10.6%) cases both cricoarytenoid units were preserved, while in 8 (21%) patients only one cricoarytenoid unit was maintained. All patients received perioperative antibiotic prophylaxis with ampicillin/sulbactam 3g twice/day. The pathological TNM-staging of the CHEP and CHP cases are illustrated in Table 1. Attitudes to the treatment of the cN0 neck have varied in relation to on the location purely glottic or glotto-supraglottic cancer and the size of the primary tumor. A total of 36 patients (94.7%) underwent some type of neck dissection (ND): ipsilateral to the tumor in 22 (57.9%) patients and bilateral in 14 (36.8%) cases. Postoperative histopathological examination showed squamous cell carcinoma in all cases. Histopathological grading was: well differentiated in 14 (36.9%) cases, medium differentiated in 14 (36.9%), low differentiated in 8 (21%) and undifferentiated in 2 (5.2%) case. Overall nodal metastases were detected in 12 out of the 36 patients submitted ND (33.3%); in 4 patients, metastases were bilateral. All patients were R0. Adjuvant radiotherapy was planned when the pathology report showed two or more positive lymph nodes or extracapsular spread. Three patients were submitted to postoperative radiotherapy for nodal involvement. The total dose ranged from 45 to 60 Gy.

Postoperative functional assessment

On the 7th-8th postoperative day, patients started an oral diet under logopedic control. The tracheostomy tube was removed when patients were able to breathe and feed autonomously. Functional assessment was performed as follows: (a) Swallowing assessment was carried out with colored water jelly (percent of inhalation and number of swallowing acts necessary to clear the pharynx out 30 days after surgery); the nasogastric feeding tube was removed when satisfactory (at least 70%) swallowing of both solids and liquids was achieved [12]; (b) Phonation was assessed by GIRBAS Scale [13]; (c) Breathing function was assessed by measuring the time necessary to obtain tracheostomy-occluded satisfactory respiratory function (decannulation) and complete tracheostomy closure. Complete tracheostomy closure was obtained by spontaneous healing after placement of compressive gauze on the stoma. Our patients were divided into four groups according to the SL procedure: preservation of the epiglottis with one (CHEP+A) or both arytenoids (CHEP+AA) rather than removal of the epiglottis with preservation of one (CHP+A) or both arytenoids (CHP+AA). The differences of functional results among the different groups were analyzed to assess the impact of the two main anatomical variables (epiglottis and one/two arytenoids) on SL functional results.

Statistics

Statistical analyses were performed using the Statistical Package for Social Sciences Software (SPSS 10.0 for Windows; SPSS, Inc., Chicago, IL) and STATA 7 (Stata Corp., College Station, TX). Parametric (Student's t-test) test and non-parametric (Mann-Whitney U test for nonpaired data) tests were used to compare different values. The criteria for statistical significance were set at a value of p 0.05 (two tailed).

Results

No significant local complication (i.e. surgical field infection, neck bleeding, etc) was notice postoperatively. During the follow up (mean follow-up 17 months; range: 32-9 months), 2 (5.3%) cases (pT3N0) of local recurrence were noticed in patients previously submitted to radiotherapy, who were therefore treated with "salvage" total laryngectomy. No recurrence in the neck has been noticed so far.

Functional results

Functional results in terms of swallowing (days required to attain a satisfactory swallowing function to remove the nasogastric feeding tube and number of swallowing acts necessary to clear the pharynx out one month after surgery), phonation, and breathing (days required to allow decannulation and complete tracheostomy closure) are reported in Table 2. As to breathing, all patients were decannulated. The average time to decannulation was 30.36±4.09 days after surgery. The nasogastric tube remained in place for an average of 16±2.30 days. Two patients developed postoperative aspiration pneumonia, which resolved with temporary suspension of oral feeding. By the end of the first postoperative month, all patients could clear their pharynx out of any food remnant with up to 3 swallowing acts. No total laryngectomy was required for persistent aspiration. GIRBAS total score ranged from 1.2 to 3 (mean: 1.79).

When considering the functional results in relation to

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Table 2: Functional results in patients submitted to supracricoid laryngectomies (mean ± standard deviation). CHP = cricohyoidopexy; CHEP = cricohyoidoepiglottopexy; AA = preservation of both functioning cricoarytenoid units; A = preservation of one functioning cricoarytenoid unit; NGT = Nasogastric Feeding Tube.

		CHEP (n=26)		CHP (n=12)	
		AA (n=6)	A (n=20)	AA (n=4)	A (n=8)
Swallowing	NGT removal (days)	14.33 (±1.36)	15.68 (±2.77)	16.50 (±0.57)	17.25 (±1.16)
	Number of acts to clear the pharynx	1.66 (±0.51)	2.31 (±0.65)	2.50 (±0.57)	2.75 (±0.46)
Phonation	GIRBAS Score	1.23 (±0.05)	1.53 (±0.15)	2.50 (±0.57)	2.72 (±0.20)
Breathing	Decannulation (days)	25.66 (±1.36)	29.52 (±3.11)	31.50 (±0.57)	35.25 (±3.49)
	Tracheostomy closure (days)	61.66 (±19.11)	74.84 (±26.45)	79.50 (±12.12)	99.50 (±29.30)

epiglottis preservation/removal, several differences can be noticed between SL subgroups (CHEP vs CHP). As to swallowing, CHEP patients showed better (p=0.024) pharyngeal clear out and swallowing recovery with respect to CHP subjects (Table 2), even though no statistically significant difference was noticed in terms of days required for feeding tube removal (p=0.068). As to phonation, CHEP subjects showed better voice quality on GIRBAS Scale (p<0.001) in comparison to CHP patients. CHEP subjects also showed a shorter decannulation time (p<0.001) and time required for tracheostomy complete closure (p=0.046) with respect to CHP patients.

When considering the functional results related to preservation of one or both arytenoids (CHEP+A vs CHEP+AA; CHP+A vs CHP+AA), better performances were noticed in AA groups with respect to the corresponding A groups. In particular, CHEP+AA group showed better (p=0.041) pharyngeal clear out (Table 2), superior voice quality on GIRBAS Scale (p<0.001), and shorter decannulation time (p=0.009) with respect to CHEP+A patients. No significant difference was noticed between the two groups in terms of days required for feeding tube removal and complete tracheostomy closure. As to CHP subgroups, CHP+AA patients showed better voice quality (p<0.001) with respect to CHP+A subjects. No significant difference was noticed between the two subgroups for the other assessed items. When comparing AA patients (CHEP+AA plus CHP+AA) with A groups (CHEP+A plus CHP+A), shorter decannulation time was noticed in AA subjects (p=0.038). No other significant difference was noticed between the two subgroups for the other items.

Finally, when considering the four subgroups separately, CHEP+AA patients showed statistically significant better performances in terms of swallowing, voice quality, and decannulation time with respect to other 3 subgroups (CHEP+A, CHP+AA and CHP+A). We did not notice any significant influence of age or sex on the examined clinical performances. Patients submitted to preoperative radiotherapy showed a significant increase of the time required for feeding tube removal (p=0.005) and tracheostomy complete closure (p=0.002) regardless of the SL operation performed. A significant increase in GIRBAS Score and decannulation/tracheostomy closure time was noticed in patients submitted to postoperative radiotherapy.

Discussion

Supracricoid partial laryngectomies with CHP and CHEP for glottic or supraglottic squamous cell carcinomas were introduced by Labayle and Bismuth [7], Majer and Rieder [4], and Piquet et al. [8] in the 1970s [1]. These new surgical procedures were developed to achieve the same local control as total laryngectomy, but avoiding a permanent tracheostomy by creation of a neolarynx thanks to the preservation of at least one functioning cricoarytenoid unit. Our results confirm the oncologic reliability of SL already reported in the literature, [1-4,7,8,10-21] also in treatment of selected locally advanced carcinomas of the larynx.

From a functional viewpoint, our results confirm the efficacy of SL in creating a functioning neolarynx allowing swallowing, voice generation, and tracheostomy-occluded breathing [1-4,7,8,10-21]. Despite the good functional outcome offered by SL in general, our experience shows significant better performances in case of epiglottis preservation (CHEP vs CHP). In particular, the residual epiglottis seems to permit a shorter decannulation time, which may be due to the contribution of the epiglottis, as a solid cartilaginous structure, to the patency of laryngeal lumen. CHEP patients also displayed an improved voice quality with respect to CHP subjects, confirming a positive role of the epiglottis framework in voice generation/modulation in SL neolarynx. Our experience also shows better swallowing function in case of epiglottis preservation, probably thanks to the airway protection guaranteed by the residual epiglottis. These findings are partially different from those obtained by Alicandri-Ciufelli et al. [20].who showed similar swallowing results after different partial laryngectomies.

In addition to the role of the epiglottis, our experience shows the functional importance of serviceable cricoarytenoid units in SL [19-21]. However, the role of both arytenoids maintenance with respect to single arytenoid preservation seems less significant that epiglottis maintenance for the functional results of SL. In fact, even though CHEP+AA subjects showed better pharyngeal clear out and voice quality with respect to CHEP+A patients, no significant difference was noticed between the two groups in terms of days required for feeding tube removal and complete tracheostomy closure. Similarly, voice quality was the only significant difference between CHP+AA patients and CHP+A subjects. These findings are in agreement with those obtained by Alicandri-Ciufelli et al. [20], while they are different from the ones reported by Akbas et al, who underline the significant difference of single vs. both arytenoids preservation on decannulation time [21].

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In conclusion, our study confirms the importance of the association between epiglottis and working cricoarytenoid units preservation to optimize neolarynx function: patients submitted to CHEP with preservation of both arytenoids display better functional performances in terms of swallowing, voice quality and decannulation time with respect to subjects submitted to other SL procedures. Such results may be due to a more efficient sphincter function offered by a two-arytenoid mobile system with respect to a single-arytenoid neolarynx. The surgical technical details allowing the preservation of a functioning cricoarytenoid unit are represented by preservation of the arytenoid (adequately connected to the cricoid by the cricoarytenoid articulation), the inferior laryngeal nerve (enabling arytenoid motion), and the interior branch of the superior laryngeal nerve (allowing sensitivity of the arytenoid and pyriform sinus mucosa) [6].

According to our experience, in order to optimize the functional performances of the neolarynx after SL, some surgical technical principles should be respected: (1) Preservation of the internal branch of the superior laryngeal nerve; (2) Preservation of the suprahyoid portion of the epiglottis (CHEP) when oncologically possible, in order to attain better functional results; (3) Sectioning (rather than dissecting) with scissors the thyroid inferior cornu at its base to avoid any injury to the recurrent laryngeal nerve, located underneath the cricothyroid articulation; (4) Attention should be paid when sectioning the vocal process or part of the disease-free arytenoid to avoid trauma to the cricoarytenoid joint and avoid arytenoid luxation; (5) Suturing a pyriform sinus mucosal flap over bare cricoid surface when an arytenoid has been removed for oncologic reasons; (6) Pexy is performed with three separate 0 vicryl sutures passing around the cricoid cartilage and hyoid bone; special care must be taken to trespass the residual epiglottis (if present) with the median suture vertically in a submucosal plane to avoid epiglottis posterior dislocations (potentially obstructing the neolaryngeal lumen). The central suture should also include an abundant (at least 3 cm) portion of tongue base, while the lateral pexy should be performed with a minimum amount of tissue to avoid trapping the lingual artery and hypoglossal nerve; (7) During ND, it is mandatory to preserve the hypoglossal nerve to enable tongue movement and swallowing recovery. In agreement with the literature [15,20], our SL functional results are negatively influenced by pre-/post-operative radiotherapy, probably because of the mucosal edema/fibrosis affecting neolarynx patency and motility.

Conclusion

Supracricoid laryngectomies are oncologically safe and functionally efficacious procedures. They must be included in the armamentarium of any surgeon who treats laryngeal cancer, as it allows organ preservation, thus improving the patient's quality of life, even in selected patients with locally advanced disease. Key points for a successful outcome are: accurate preoperative staging of the disease, knowledge of indications and contraindications, and accurate surgical technique, with special attention to the technical details that can affect functional outcome. Our experience shows the more normal anatomical structures are preserved (epiglottis and arytenoids), the better postoperative functional results will be. Additional studies with more extended samples may be useful to further optimize SL functional outcome.

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