



Comparative videostroboscopic analysis after different external partial laryngectomies

Komparativna videostroboskopska analiza nakon parcijalnih laringektomija

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Abstract

Background/Aim. After external partial laryngectomies, videostroboscopy is very useful in evaluation of postoperative phonatory mechanisms showing the “slow motion” of the vibrations of the remaining laryngeal structures. The aim of this paper was to compare the videostroboscopic characteristics of the vibration and to establish the differences in the phonation mechanisms depending on the type of external partial laryngectomy performed. **Methods.** This prospective study was conducted during the period 2003–2009 at the Ear, Nose and Throat Clinic, Clinical Center of Vojvodina, Novi Sad, including 99 patients with laryngeal carcinoma, treated with open surgical approach using different types of vertical and horizontal partial laryngectomy. Videostroboscopy was used to analyse vibrations of the remaining laryngeal structures. **Results.** The dominant vibration structure after partial horizontal laryngectomy, chordectomy, frontolateral laryngectomy and three quarter laryngectomy was the remaining vocal fold, after hemilaryngectomy it was the false vocal fold and after subtotal and near total laryngectomy it was the arythenoid. In patients with supracricoid hemilaryngopharyngectomy performed, many different structures were involved in the vibration. After most of the partial laryngectomies, vibrations can be found in the reconstructed part of the defect. In both horizontal and vertical partial laryngectomies movements of the larynx during phonation were mostly medial, while in cricohyoidoglottopexies they were anterior-posterior. Most of the operated patients (72.7%) had insufficient occlusion of the neoglottis during the phonation. **Conclusion.** Videostroboscopy is a useful method in examining the phonation mechanisms of reconstructed laryngeal structures after partial laryngectomy as well as in planning postoperative voice therapy.

Key words:

laryngectomy; treatment outcome; vocal cords; stroboscopy; diagnostic technics and procedures; laryngeal neoplasms.

Apstrakt

Uvod/Cilj. Nakon eksternih parcijalnih laringektomija, videostroboskopija je veoma korisna za procenu postoperativnog mehanizma fonacije pokazivanjem usporenosti vibracija preostalih laringealnih struktura. Cilj rada bio je da se međusobno uporede videostroboskopske karakteristike vibracija preostalih struktura larinksa i utvrde razlike fonacijskih mehanizama nakon različitih parcijalnih laringektomija otvorenim spoljašnjim pristupom. **Metode.** Ispitivanje je sprovedeno kao prospektivna klinička studija u periodu od 2003. do 2009. na Klinici za bolesti uva, grla i nosa, Kliničkog centra Vojvodine u Novom Sadu, a obuhvatilo je 99 bolesnika operisanih zbog karcinoma larinksa nekom od parcijalnih laringektomija, kod kojih je načinjena videostroboskopska analiza vibracija preostalih struktura i fonacijskih mehanizama. **Rezultati.** Dominantno mesto vibracije bila je glasnica kod horizontalne supraglotične laringektomije, hordektomije, frontolateralne laringektomije i kod tročetvrtinskih operacija. Ventrikularni nabor dominantno je vibrirao kod hemilaringektomije, a aritenoid kod suptotalnih i kod skoro totalne laringektomije. Kod suprakrikoidne hemilaringofaringektomije zabeleženo je učešće u vibraciji više različitih struktura. Moguće su vibracije i u zoni rekonstrukcije defekta kod većine operativnih tehnika. Kod horizontalnih i vertikalnih laringektomija pokreti larinksa u fonaciji bili su najčešće medijalni, dok su kod krikohioideoepiglotopeksije bili anterioposteriorni. Insuficijentna okluzija neolarinksa u fonaciji bila je prisutna kod većine operisanih bolesnika. (72,7%). **Zaključak.** Videostroboskopija je korisna metoda proučavanja fonacijskih mehanizama rekonstruisanog larinksa posle parcijalnih laringektomija, kao i kod planiranja vokalne terapije.

Ključne reči:

laringektomija; lečenje, ishod; glasne žice; stroboskopija; dijagnostičke tehnike i procedure; larinks, neoplazme.

Introduction

External partial laryngectomies, horizontal and vertical ones, are a group of open approach preservative techniques for laryngeal cancer surgery. These operations are not only oncologically radical, but also provide good functional results in regard to breathing, swallowing and speech, due to the reconstruction of remaining laryngeal tissues. The ability to speech and communicate in everyday and professional life has a great influence on the quality of life of operated patients¹⁻³.

Videostroboscopy is very useful in evaluation of post-operative phonatory mechanisms showing the "slow motion" of the vibrations of the remaining laryngeal structures. The site and the mechanism of the remaining mucosa vibrations are the key factors affecting the quality of speech following partial laryngectomy^{4,5}.

The most preservative open technique for laryngeal cancer surgery is chordectomy. It includes the resection of the vocal fold, anteriorly from the anterior commissure, posteriorly to the vocal process of the arytenoid, laterally including the internal perichondrium of the thyroid lamina. Defect following resection can be left to heal without reconstruction or it is reconstructed immediately using surrounding tissue, usually mucosa of the false vocal fold. After hemilaryngectomy (lateroververtical laryngectomy), the vocal fold, up to the anterior commissure, is resected extending posteriorly to include a part of the arytenoid if necessary, together with Morgagni's ventricle and a false vocal fold with underlying thyroid cartilage⁶. The external perichondrium of thyroid lamina is usually used for reconstruction, as well as pyriform sinus mucosa and fascia of surrounding muscles, usually of sternohyoid one. Frontolateral (anteroververtical) laryngectomy is a larger resection including also resection of the anterior commissure, anterior third of the contralateral vocal fold with underlying cartilage as well. Reconstruction is similar to the one following hemilaryngectomy. In horizontal supraglottic laryngectomy, depending on the extension of the carcinoma, the epiglottis, preepiglottic space and a part of the thyroid cartilage above the glottis are resected. Reconstruction includes suturing of the remaining thyroid cartilage to the hyoid bone and/or the base of the tongue⁷. Basic surgical principle of supracricoid partial laryngectomy with cricohyoidoepiglottopexy (CHEP) is in removal of the entire thyroid cartilage with both true vocal folds, both false vocal folds, both paraglottic spaces with preservation of cricoarytenoid unit which includes cricoid cartilage, at least one arytenoid cartilage, cricoarytenoid joint, posterior and lateral cricoarytenoid muscle together with ipsilateral recurrent and superior laryngeal nerve. Reconstruction is performed by suturing the cricoid to the epiglottis and hyoid bone⁸. Near total laryngectomy is a complex surgical procedure⁹ with preservation of small part of the cricoid, one arytenoid, cricoarytenoid joint, one vocal fold and ipsilateral recurrent laryngeal nerve. These structures with overlying mucosa form a tunneled mucosal shunt between the trachea and pharynx that is controlled by remaining intrinsic laryngeal musculature with its nerve supply. This shunt forms a phonatory valve which is

insufficient for breathing and therefore requires a permanent tracheostoma. Supracricoid hemilaryngopharyngectomy (SCHLP) is indicated in cases of pyriform sinus carcinoma. Resection includes ipsilateral structures above the cricoid without the external perichondrium of the thyroid cartilage which is used for reconstruction. The superior part of the defect is reconstructed with surrounding pharyngeal and arytenoid mucosa¹⁰. Three-quarter laryngectomy is regarded as supraglottic laryngectomy extended on one side to the glottic plane. Reconstruction of a new fold on the hemilaryngectomy side is through a triangular strip of the exterior thyroid perichondrium.

Since rare comparative studies can be found in the literature, the aim of this paper was to present and compare the videostroboscopic characteristics of vibration and to establish the differences in the phonation mechanisms depending on the type of partial laryngectomy performed.

Methods

This prospective clinical study during the period 2003–2009 at the University Ear, Nose and Throat Clinic in Novi Sad, Serbia, included 99 patients with open surgery for laryngeal cancer as primary therapy. The patients with recurrent or residual disease were not included in the study. The patients underwent different types of vertical and horizontal partial laryngectomy depending on the site and spread of the tumor. After local wound healing, postoperative swallowing rehabilitation, with sufficient breathing, with or without tracheostoma, depending on the type of laryngectomy, the patients were referred to the phoniatrician. Each patient underwent videostroboscopic examination using the videostroboscopic system Storz Pulsar Model 20 140020-2002 with a SONY video screen. After recording to a compact disc, findings were analyzed, frame by frame. The unique protocol was used in videostroboscopic analysis of the next parameters: the presence of vibrations of the remaining parts of the larynx [vocal fold, false vocal fold, arytenoid, epiglottis, base of tongue, pharyngeal mucosa (present-absent)]; the presence of vibrations in the reconstructed region of the postoperative defect (present-absent); the types of the laryngeal movement during phonation (medially, anteriorly, posteriorly, antero-posteriorly); the level of approximation of the vibrating structures during phonation; level of neophonation (glottic, ventricular, chordo/ventricular, vestibular, subglottic); closure of neoglottis during the closed phase of vibration (present/absent).

The study was conducted after Ethics Committees approval and with each patient consent.

Results

Among 99 patients, there were 90 male and 9 female patients, the age range 40–80 years (80% of the patients being in the age group 50–70 years), 92 (93%) of the patients were cigarette smokers, while alcohol consumption was present in 85 (86%) patients. The next types of partial laryngectomy were performed: horizontal supraglottic laryngec-

tomy in 16 (16%), chordectomy in 22 (22%), hemilaryngectomy in 28 (28.5%), frontolateral laryngectomy in 19 (19.5%), CHEP in 5 (5%), three-quarter laryngectomy in 1 (1%), SCHLP in 4 (4%) and near-total laryngectomy in 4 (4%) patients.

Videostroboscopic examination postoperatively revealed that the dominant place of vibrations, out of all 99 patients, was the vocal fold – 75 (75.8%): in all 16 (100%) patients after partial horizontal supraglottic laryngectomy, in 20/22 (90.9%) patients after chordectomy, in 15/19 (78.9%) patients after frontolateral laryngectomy, in 3/4 (75%) after near total laryngectomy, in 2/4 (50%) after SCHLP and 1/1 (100%) patient after three-quarter laryngectomy performed. Vibration of the false vocal fold was found in 41 patients (41.4%); after hemilaryngectomy in 25/28 (89.3%), after frontolateral laryngectomy in 12 (63.2%), after chordectomy in 12 (54.5%), while after other types of the laryngectomy performed it was found only in single cases. Vibration of the arytenoid was registered in 39 (39.4%) of the patients; in 15 (53.6%) of the patients after hemilaryngectomy in all patients with CHEP and near total laryngectomy and in 2 patients after SCHLP. Vibration of the epiglottis was present in 11 (11.1%) patients; 4 patients after hemilaryngectomy, 3/5 after CHEP and in single cases after other operations. (Table 1).

Medial movement of the remaining larynx during phonation was seen in 64 (64.6%) patients. It was the dominant direction of the movement during phonation after hemilaryngectomy, frontolateral laryngectomy, partial horizontal supraglottic laryngectomy, chordectomy and three-quarter laryngectomy. Some of the types of anterior or anterior-posterior movements were found in 22 (22.2%) patients; all the patients after CHEP, in 8 patients after hemilaryngectomy, in 5 patients after chordectomy and in single cases after other types of laryngectomy. In the group of patients with the same type of surgery, different types of movement could be detected as seen in table 2. (Table 2).

In 43 (43.43%) of the patients, the most satisfactory type of approximation – the glottic one, was found. In 22 (22.2%) it was ventricular, in 19 (19.19%) vestibular, in 16 (16.2%) chordo-ventricular and in 4 (4%) subglottic level of approximation was found. Glottic approximation was present in all the patients after partial horizontal supraglottic laryngectomy, while all the patients after CHEP had vestibular approximation. After hemilaryngectomy, all levels of approximation were present. After chordectomy, 11 (50%) patients had glottic, and other half had other different levels of approximation. After frontolateral laryngectomy, glottic ap-

Table 1
Vibrating structures in patients depending on the type of external partial laryngectomy performed

Types of partial laryngectomy	Number (%) of patient			
	Vocal fold	False vocal fold	Epiglottis	Arythenoid
Hemilaryngectomy	18 (64.3)	25 (89.3)	4 (14.3)	15 (53.6)
Frontolateral	15 (78.9)	12 (63.2)	1 (5.3)	8 (42.1)
PHSL	16 (100.0)	0 (0.0)	0 (0.0)	1 (6.3)
CHEP	0 (0.0)	0 (0.0)	3(60.0)	5 (100.0)
Three-quarter	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Near-total	3 (75.0)	0 (0.0)	0 (0.0)	4 (100.0)
Chordectomy	20 (90.9)	12 (54.5)	1 (4.5)	4 (18.2)
SCHLP	2 (50.0)	2 (50.0)	2 (50.0)	2 (50.0)
Total	75 (75.8)	41 (41.4)	11 (11.1)	39 (39.4)

PHSL – Partial horizontal supraglottic laryngectomy; CHEP – cricothyroidoepiglottopexy;
SCHLP – supracricoid hemilaryngopharyngectomy.

Table 2
Movement of the remaining laryngeal structures in patients during phonation

Types of partial laryngectomy	Number (%) of patient						
	A	B	C	D	E	F	G
Hemilaryngectomy	5 (17.9)	0 (0.0)	3 (10.7)	7 (25.0)	8 (28.6)	2 (7.1)	1 (3.6)
Frontolateral	2 (10.5)	0 (0.0)	0 (0.0)	8 (42.1)	7 (36.8)	0 (0.0)	2 (10.5)
PHSL	1 (6.3)	0 (0.0)	0 (0.0)	4 (25.0)	3 (18.8)	0 (0.0)	0 (0.0)
CHEP	1 (20.0)	0 (0.0)	4 (80.0)	1 (20.0)	0 (0.0)	1 (20.0)	0 (0.0)
Three-quarter	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)
Near-total	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Chordectomy	1 (4.5)	0 (0.0)	4 (18.2)	13 (59.1)	11 (50.0)	0 (0.0)	1 (4.5)
SCHLP	0 (0.0)	0 (0.0)	1 (25.0)	1 (25.0)	0 (0.0)	1 (25.0)	0 (0.0)
Total	10 (10.1)	0 (0.0)	12 (12.1)	34 (34.3)	30 (30.3)	4 (4.0)	4 (4.0)

Movement of laryngeal structures: A – anterior, B – posterior, C – anteroposterior, D – right-medial, E – left-medial, F – from right to the left side, G – from left to the right side; PHSL – partial horizontal supraglottic laryngectomy; CHEP – cricothyroidoepiglottopexy; SCHLP – supracricoid hemilaryngopharyngectomy.

Vibrations in the region of reconstruction were found in 51 (54.8%) patients; in 17 (68%) after hemilaryngectomy, in 14 (77%) after frontolateral laryngectomy and in rare single cases after other laryngectomies.

proximation was found in the same number of patients – 8 (42%) as the ventricular one. After SCHEP, one half of the patients had vestibular and the other half had chordoventricular approximation.

In 27 (27.3%) operated patients, inspite the postoperative defect, satisfactory neolaryngeal occlusion was established. Other 72 (72.7%) had insufficient occlusion. The highest percentage of the patients with insufficient occlusion was found in the patients after hemilaryngectomy – 26 (92.9%), after chordectomy in 17 (77.3%), after frontolateral laryngectomy in 11 (57.9%), after horizontal partial supraglottic laryngectomy in 9 (56.3%), in 4/5 patients after CHEP, in 3/4 patients after SCHLP and in one patient after near total laryngectomy.

Discussion

Analysis showed that the dominant place of vibration is the true vocal fold after partial horizontal supraglottic laryngectomy, chordectomy, frontolateral laryngectomy and three-quarter laryngectomy. False vocal fold dominantly vibrates after hemilaryngectomy, while the arytenoid is the dominant vibrating structure after subtotal and near total laryngectomy. In partial pharyngolaryngectomies all the remaining structures equally participate in vibration. This study shows that the false vocal fold is the important substitutional source of phonation, especially after hemilaryngectomy. Due to its size, the false vocal fold can compensate the large postoperative defect after hemilaryngectomy and allow sufficient phonation and swallowing¹¹. Granqvist i Lindestad, as cited by Kendall et al.¹², 2005, using ultra fast photography found covibrations of the false vocal folds in healthy individuals, with different vibration frequency comparing to that of the true vocal folds. It is to assume that in pathological conditions, when the true vocal fold vibrations are absent, these vibrations became the dominant vibrating mechanism. Vibrations in the zone of defect reconstruction, with irregular form, were recorded after all types of operation in 54.5% patients. In most of the cases, the mucosa was used in the defect reconstruction as potentially vibrating structure. Movements of the neolaryngeal structures were dominantly medial after partial horizontal supraglottic laryngectomy, chordectomy, hemilaryngectomy, frontolateral laryngectomy and three-quarter laryngectomy. After these types of operation, the larynx preserves physiological movements of its remaining structures. After subtotal laryngectomies, the dominant direction of movements is anteroposterior since epiglottis and arytenoid are the only remaining moving structures. In cases when only one arytenoid is present, such as after CHEP, anteroposterior movement is dominant during which the arytenoid falls anteriorly making contact with its apical part with epiglottis where the contact vibration is made. In cases when both arytenoids are present, preserved interarytenoid muscle prevents the arytenoid to fall anteriorly, therefore adduction movements are the dominant ones. Good contact between the epiglottis and arytenoid with contact vibrations are the prerequisite for satisfactory voice function. The presence of one or both arytenoids does

not affect the voice quality significantly¹³, but, on the other hand, preservation of both arytenoid shortens the time of swallowing rehabilitation¹⁴. After SCHLP, all types of laryngeal movements during phonation were recorded. Contralateral movement (hypercompensation) was noticed in single cases in all types of partial laryngectomies. The level of approximation during occlusion was dominantly glottic after partial horizontal supraglottic laryngectomies, chordectomies and three-quarter laryngectomies. After frontolateral laryngectomies, glottic and ventricular level of approximation were equally present, while after hemilaryngectomy ventricular level was the dominant one. Vestibular approximation was recorded after CHEP and SCHLP. After near-total laryngectomy, the contact was recorded along the inferior edge of the preserved vocal fold. Most (72.7%) of the operated patients had insufficient occlusion of the neolarynx due to postoperative defect. In this study, after partial horizontal supraglottic laryngectomy, minimal glottic gap was found in more than half of the patients but with no significant affect on the voice quality since only the glottic gap bigger than 1 mm causes breathy voice according to Schneider and Bigenzahn¹⁵.

Similar results, in regard to presence of vibrations, movement of the neolarynx during phonation, occlusion of the neolarynx after analysing results after every single type of partial laryngectomy, were found by other authors¹⁶⁻²¹.

Conclusion

The dominant site of vibration after partial horizontal supraglottic laryngectomy, chordectomy, frontolateral laryngectomy and three-quarter laryngectomy is the preserved vocal fold. The false vocal fold is a dominantly vibrating structure after hemilaryngectomy, while after subtotal and near-total laryngectomy it is the arytenoid. After most of partial laryngectomies, vibrations can occur in the zone of the defect reconstruction. After partial horizontal supraglottic and vertical partial laryngectomies, movements of the larynx during phonation are mostly medial, while after subtotal laryngectomies these movements are anteroposterior. Vocal insufficiency of the neolarynx is present in most of the operated patients. Videostroboscopy is a usefull method in evaluation of the phonation mechanisms after different partial laryngectomies. Without compromising oncological radicality, whenever it is possible, the types of partial laryngectomies that provide approximation and vibration at the glottic level or the ones with the best possible neolarynx occlusion, should be performed. In order to improve the quality of life and professional activity, all the patients with postoperative moderate and severe hoarsness, should be referred to the phoniatician and speech therapist for examination and voice therapy. The aim of this early rehabilitation is to increase the strenght, endurance and flexibility of the remaining laryngeal structures and encourage development of new zones of vibration.

R E F E R E N C E S

1. *Davies L, Welch HG.* Epidemiology of head and neck cancer in the United States. *Otolaryngol Head Neck Surg* 2006; 135(3): 451–7.
2. *Sparano A, Ruiz C, Weinstein GS.* Voice rehabilitation after external partial laryngeal surgery. *Otolaryngol Clin North Am* 2004; 37(3): 637–53.
3. *Makieff M, de la Breteque A, Guerrier B, Giovanni A.* Voice handicap evaluation after supracricoid partial laryngectomy. *Laryngoscope* 2009; 119(4): 746–50.
4. *Mumović MG.* Dysphonia treatment after partial laryngectomy by larynx compression [dissertation]. Novi Sad: Faculty of Medicine, University of Novi Sad; 2008. (Serbian)
5. *Mumović MG.* Vocal therapy with larynx compression after partial laryngectomy. *Med Pregl* 2011; 64(6–7): 357–61.
6. *Weinstein GS, Laccourreye O, Brasnu D, Laccourreye H.* Organ preservation surgery for laryngeal cancer. San Diego: Singular Publishing Group; 1999.
7. *Weinstein GS, O'Malley WB, Snyder W, Hockstein GN.* Transoral robotic surgery: supraglottic partial laryngectomy. *Ann Otol Rhinol Laryngol* 2007; 116(1): 19–23.
8. *Montgomery WW.* Surgery of the larynx, trachea, oesophagus and neck. Philadelphia, PA: Saunders; 2002.
9. *Pearson BW, De Santo LW, Olsen KD, Salassa JR.* Results of near-total laryngectomy. *Ann Otol Rhinol Laryngol* 1998; 107(10 Pt 1): 820–5.
10. *Laccourreye O, Isboo E, de Mones E, Garcia D, Kania R, Hans S.* Supracricoid hemilaryngopharyngectomy in patients with invasive squamous cell carcinoma of the pyriform sinus. Part I: Technique, complications, and long-term functional outcome. *Ann Otol Rhinol Laryngol* 2005; 114(1 Pt 1): 25–34.
11. *Večerinina S.* Laryngeal function after partial laryngectomy [dissertation]. Zagreb: Faculty of Medicine, University of Zagreb; 1976. (Croatian)
12. *Kendall AK, Browning MM, Skovlund MS.* Introduction to high speed imaging of the larynx. *Curr Opin Otolaryngol Head Neck Surg* 2005; 13(3): 135–7.
13. *Makieff M, Giovanni A, Guerrier B.* Laryngostroboscopic evaluation after supracricoid partial laryngectomy. *J Voice* 2007; 21(4): 508–15.
14. *Luna-Ortiz K, Núñez-Valencia ER, Tamez-Velarde M, Granados-García M.* Quality of life and functional evaluation after supracricoid partial laryngectomy with cricothyroidopiglotomy in Mexican patients. *J Laryngol Otol* 2004; 118(4): 284–8.
15. *Schneider B, Bigenzahn W.* Influence of glottal closure configuration on vocal efficacy in young normal-speaking women. *J Voice* 2003; 17(4): 468–80.
16. *Hirano M, Kurita S, Matsuoka H.* Vocal function following hemilaryngectomy. *Ann Otol Rhinol Laryngol* 1987; 96(5): 586–9.
17. *Mandell LD, Woo P, Behin SD, Mojica J, Minasian A, Urken LM, et al.* Videolaryngostroboscopy following vertical partial laryngectomy. *Ann Otol Rhinol Laryngol* 1999; 108(11): 1061–7.
18. *Szmeja Z, Leszczyńska M.* Voice function in patients after extended fronto-lateral laryngectomy. *Eur Arch Otorhinolaryngol* 1999; 256(8): 418–22.
19. *Biacabe B, Crevier-Buchman L, Hans S, Laccourreye O, Brasnu D.* Phonatory mechanisms after vertical partial laryngectomy with glottic reconstruction by false vocal fold flap. *Ann Otol Rhinol Laryngol* 2001; 110(10): 935–40.
20. *Marioni G, Marchese-Ragona R, Ottaviano G, Staffieri A.* Supracricoid laryngectomy: is it time to define guidelines to evaluate functional results? A review. *Am J Otolaryngol* 2004; 25(2): 98–104.
21. *Hanamitsu M, Kataoka H, Takeuchi E, Kitajima K.* Comparative study of vocal function after near-total laryngectomy. *Laryngoscope* 1999; 109(8): 1320–3.

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