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ORIGINAL ARTICLE

Perceptual and acoustic voice analysis in patients with glottis cancer after endoscopic laser cordectomy

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Bożena Kosztyła-Hojna[1ABDEF], Jarosław Łuczaj[2ABDE], Greta Berger[1ABD], Emilia Duchnowska[1DEF], Maciej Zdrojkowski[1BCE], Anna Łobaczuk-Sitnik[1EF], Jolanta Biszewska[1EF]

[1]Department of Clinical Phonoaudiology and Speech Therapy, Medical University of Bialystok, Poland; Head: Prof. Bożena Kosztyła-Hojna MD PhD
[2]Department of Otolaryngology, Medical University of Bialystok, Poland; Head: Prof. Marek Rogowski MD PhD

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ABSTRACT:

Introduction: Treatment of glottis cancer, despite oncological safety, should consider postoperative voice quality. CO_2 laser endoscopic cordectomy allows radical removal of the tumor while maintaining respiratory, defensive and phonatory functions.

The aim: The aim of the study is perceptual and acoustic evaluation of voice in patients after endoscopic CO_2 III–Va laser cordectomy due to glottis cancer.

Material and method: The study included 30 men after CO_2 cordectomy. 13 (43%) patients underwent type III cordectomy, 6 (20%) – type IV; 11 (37%) – type Va. Voice quality has been assessed 6 months after the surgery. Control group included 30 healthy men of the same age. GRBAS scale has been used in perceptual evaluation of voice. Acoustic analysis has been performed using DiagnoScope Specjalista software. Narrowband spectrography and Maximum Phonation Time (MPT) measure has been performed.

Results: In study group, voice has been classified as $G_1R_1B_0A_0S_0$ after type III cordectomy; as $G_1R_1B_1A_1S_2$ in type IV and as $G_2R_1B_1A_0S_3$ in type Va. Acoustic evaluation revealed the highest values of Fo, Jitter, Shimmer and NHR after Va cordectomy as well as non-harmonic components in narrowband spectrography and reduction of MPT.

Conclusions: Postoperative voice quality depends on the type of cordectomy. Perceptual assessment indicates that type IV and Va cordectomy cause intensification of voice disorders. Parameters of acoustic evaluation increase with the extent of the procedure. The presence of non-harmonic components in narrowband spectrography increases with the extent of cordectomy, such as the reduction of MPT. Preservation of anterior commissure influences good voice quality in perceptual and acoustic assessment.

KEYWORDS: glottis cancer, laser cordectomy, voice acoustic analysis, voice quality

ABBREVIATION

MPT – Maximum Phonation Time

INTRODUCTION

In the treatment of laryngeal cancer, additionally to the oncological result we should consider postoperative voice quality. Early recognition of glottic cancer enables the application of partial surgical procedures allowing to radically remove the tumor while maintaining basic functions of the larynx: respiratory, defensive and phonatory.

The questions most frequently asked by patients before surgery concern the possibility of using the voice after the procedure. The surgeon should inform the patient about the expected voice quality after treatment. The quality of voice after the surgery depends on the type of performed cordectomy related to the extent of the neoplastic lesion within the glottis and the produced phonatory compensation mechanism. Particular advancement in the treatment of glottic cancer is the development of reconstructive surgery, which aims to preserve phonatory function and oncological safety. Perceptual and objective methods are applied, which include GRBAS scale and acoustic analysis, are used to assess voice quality.

AIM

The aim of the study is perceptual and acoustic evaluation of voice in patients after endoscopic laser cordectomy CO_2 type III–Va due to glottic cancer.

MATERIAL AND METHODS

The study included a group of 30 men which together comprised Group I, treated at the Department of Otolaryngology, Medical

GRBAS scale			
Group I			Group II
Type of cordectomy	III	$G_1R_1B_0A_0S_0$	$G_0R_0B_0A_0S_0$
	IV	$G_1R_1B_1A_1S_1$	
	Va	$G_2R_1B_1A_0S_3$	

Fig. 1. GRBAS scale parameters in Group I and II of patients.

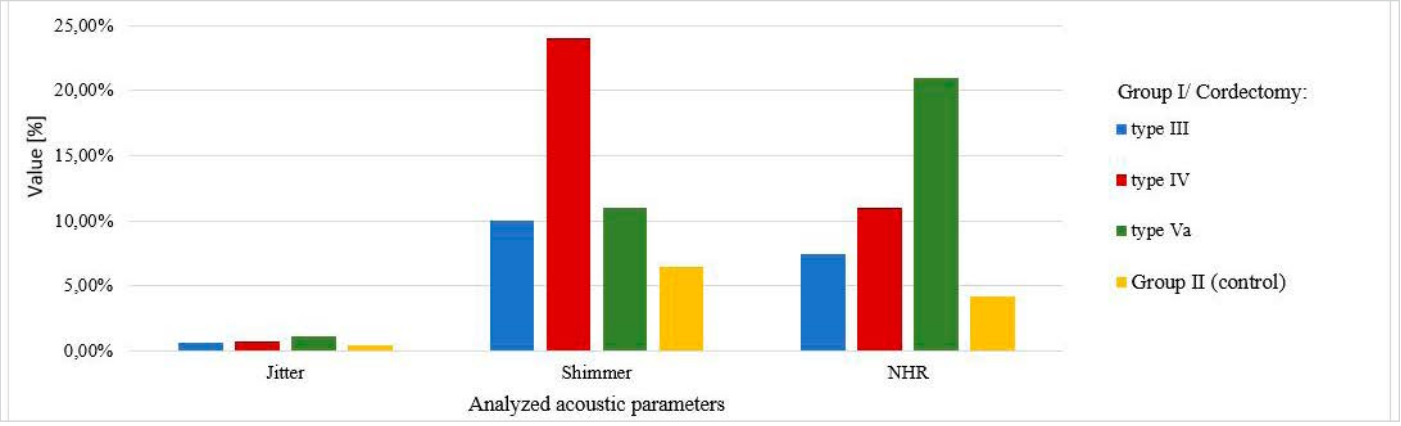

Fig. 2. Average values of analyzed acoustic parameters in Group I and II of patients.

University of Białystok between 2010 and 2018 and diagnosed at the Department of Clinical Phonoaudiology and Speech Therapy, Medical University of Białystok. The age of patients ranged from 61 to 72, while the average age was 67. Patients were smokers, without pulmonary, allergic and gastrological diseases and did not use their voice professionally. Thirteen (43%) patients underwent type III laser cordectomy, 6 (20%) – type IV cordectomy, and 11 (37%) type Va. Tracheotomy has not been necessary in operated patients. Voice quality assessments were performed 6 months after the surgery.

The control group – Group II, included men between 37 and 76 years of age. The average age was 64 years. The patients were smokers, without pulmonary, allergic and gastrological diseases, who did not use their voice professionally and with euphonic (physiological) voice.

Voice quality assessment was based on the standardized perceptual GRBAS scale proposed by the Japanese Society of Speech Therapists and Phoniatrists, assessing the severity of hoarseness – G (Grade), roughness of voice – R (Roughness), breathiness – B (Breathiness), asthenia of voice – A (Asthenia) and voice strain – S (Strain). The severity of parameters was determined using 0–3 scale, where 0 is physiological (euphonic) voice; 1 – mild; 2 – moderate; 3 – severe intensity of symptoms.

Acoustic voice analysis was performed using DiagnoScope Specjalista f. DiagNova Technologies. The study consisted in the phonation of vowel "a" twice in isolation at intervals of 1 second. The study was performed in a room with limited reverberation time and background noise level using a Shure SM86 microphone, placed 10 cm from the subject's mouth during the recording of voice samples.

Values of the following parameters were analyzed: F0, Jitter, Shimmer, NHR. Narrow-band spectrography was also performed as well as measurement of the Maximum Phonation Time (MPT).

One-way analysis of variance was used in the statistical assessment of obtained results.

RESULTS

Using the assessment of voice quality with GRBAS scale in patients from Group I, in 13 (43%) patients (type III cordectomy) we registered a voice classified as $G_1R_1B_0A_0S_0$; in 6 (20%) patients (type IV cordectomy) – $G_1R_1B_1A_1S_1$; while G2R1B1A0S3 was recorded in 11 (37%) patients (type Va cordectomy). In Group II, the voice of patients was classified as $G_0R_0B_0A_0S_0$.

In Group I, 13 (43%) patients who underwent type III cordectomy were found with an average value of F0 at 138 Hz; Jitter 0.6%; Shimmer 10%; NHR 7.5%. The average value of MPT was 11 seconds.

In 6 (20%) patients who underwent type IV cordectomy, the average value of F_0 was 167 Hz; Jitter 0.75%; Shimmer 24%; NHR 11%. The average value of MPT was 5.6 seconds.

In 11 (37%) patients who underwent type Va cordectomy, the average value of F_0 was 180 Hz; Jitter 1.1%; Shimmer 11%; NHR 21%.

The average value of MPT was 4.8 seconds (Fig. 2.).

In patients from Group I, spectrographic analysis revealed the presence of harmonic components in the range of low and medium frequency levels and the presence of non-harmonic components in the range of medium and high frequency levels in 4 (13%) patients after type IV cordectomy and in 9 (30%) patients after type V cordectomy.

In Group II – control group, 27 (90%) subjects were found with voice classified as $G_0R_0B_0A_0S_0$, and 3 (10%) as $G_0R_0B_0A_1S_0$ on the GRBAS scale.

In group II, 30 (100%) subjects were found with an average value of F_0 – 135 Hz; Jitter – 0.62%; Shimmer – 6.4%; NHR – 3.7%. The average value of MPT was 22 seconds (Fig. 3. and 4.).

In Group II, 27 (90%) subjects were found with harmonic components in the low and high frequency levels. In 3 (10%) subjects, apart from harmonic components in the low and medium frequency levels, non-harmonic components in the high frequency range were recorded.

No recurrence of cancer has been observed in any of the patients.

DISCUSSION

Radiotherapy and laser cordectomy are applied in the treatment of low grade glottic cancer [1]. Therapeutic methods, in addition to oncological safety, should also consider the preservation of physiological functions of the larynx: respiratory, defensive and phonatory [2, 3, 4]. Voice quality after treatment of glottic cancer is crucial for the patient and should be considered when choosing therapeutic method [5]. According to Rydell et al. [6], the quality of voice after radiation therapy is better than after endoscopic laser treatment. Perceptual assessment of voice using GRBAS after type I and II laser cordectomy performed by Tomifuji [5] indicated a similar voice effect as in radiotherapy, while after type IV and V cordectomy the voice quality was worse than after radiotherapy. According to the author, the quality of voice depends on the type of cordectomy performed [5]. Similar results have been obtained by Hong et al. [1] using perceptual and acoustic assessment of voice in patients treated with surgery and radiation therapy. The results of voice quality using GRBAS scale differed statistically significantly between the analyzed groups of patients, similar as acoustic assessment parameters: F0, Jitter, Shimmer, NHR. However, the MPT was extended in the group of operated patients. Good voice quality results were observed after radiotherapy of early glottic cancer. Radiation therapy is a method of choice when the priority is good postoperative voice quality. The voice was periodically deteriorated due to increasing edema of the vocal folds after radiation [7, 8].

The use of CO_2 laser does not cause postoperative edema of the vocal folds or tissue necrosis. According to Hamzany et al. [9], the disadvantage of radiation therapy is an extended treatment period, inflammation of laryngeal structures, dryness of the upper respiratory tract mucosa and high cost of therapy. The advantage is high

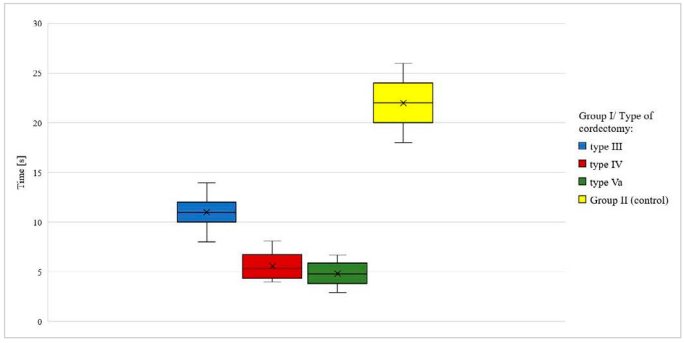

Fig. 3. Comparison of MPT value in Group I and II of patients.

	Groups	Number	Total	Average	Variance	
	type III	13	143	11	2,6666667	
	type IV	6	33,6	5,6	2,136	
	type Va	11	52,9	4,809091	1,3309091	
	Groupe II	30	660	22	4,4137931	
Source of variance	SS	df	MS	F	p-value	F Test
Between groups	3348,723	3	1116,241	339,7457	6,882E-36	2,769431
In groups	183,9891	56	3,285519			
Total	3532,713	59				

Fig. 4. One-way analysis of variance of MPT in Group I and II of patients.

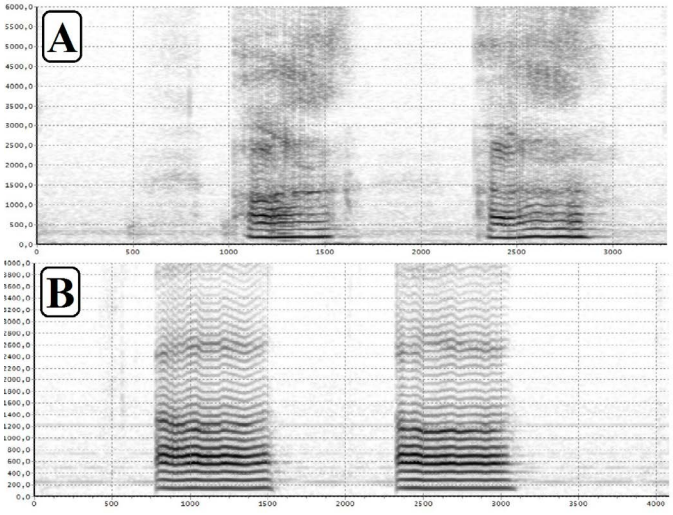

Fig. 5. Narrowband spectrography in Group I and II of patients. A – in patient after type IV cordectomy (Group I). B – in patient from control group (Group II).

recovery rate and good voice quality. According to Mehel et al. [10], Remacle et al. [11], Gandhi et al. [12] oraz Xu et al. [13], the disadvantage of CO_2 laser surgery is permanent deterioration of the voice, while advantages include faster healing process, lower costs of therapy and a shorter treatment period, as well as the elimination of negative effects of irradiation. According to Kishimoto [14] and Xu et al. [15], voice quality in patients after CO_2 laser cordectomy stabilizes 6 months after surgery. In the analyzed group of patients, voice quality was assessed 6 months after surgery, which is consistent with the author's recommendations.

The result of laser cordectomy is the formation of post-operative scars immobilizing vocal folds and post-operative tissue loss in the glottis [16]. Morphological reconstruction within the vocal fold

mucosa deteriorates voice quality which is visible in perceptual and acoustic assessment results [5, 7, 17]. The cause is connected with the lack of full glottal closure [17]. In the analyzed group of patients, perceptual assessment of voice quality disorders with GRBAS scale revealed the most significant severity of symptoms – $G_2R_1B_1A_0S_3$ – in patients after Va laser cordectomy. The acoustic evaluation of voice revealed high value of F_0 parameter as well as Jitter, Shimmer and NHR in all patients after laser cordectomy, especially after type Va.

Similarly high values of acoustic parameters after laser cordectomy have been recorded by Hong [1], Djukic [7] and Tamura et al. [8]. Often, after laser cordectomy, compensatory glottal closure with atrial folds is observed, which causes the alteration of values of acoustic parameters, especially an increase of F_0, Jitter, and Shimmer [17]. In the analyzed group of patients, significant reduction of MPT has also been found, especially in the group of 11 patients who underwent Va type cordectomy. The reduction of MPT after laser cordectomy has also been recorded by Laoufi et al. [18].

According to Lee et al. [3], MPT and acoustic parameters of voice after laser cordectomy due to glottic cancer were close to normative values. According to Osuch-Wójcikiewicz et al. [19] excision of the anterior commissure impairs the development of phonatory compensation mechanism and causes poorer postoperative quality of voice. According to Ma [20], Mendelsohn et al. [21] and Mannelli et al. [22], the quality of voice after laser CO_2 cordectomy is better than after classic cordectomy due to a reduced postoperative healing process after the laser procedure. In analyzed group of patients, removal of the anterior commissure – type Va cordectomy, resulted in deterioration of voice quality in perceptual assessment using GRBAS scale and in the acoustic assessment of voice. What is more, an increase in MPT has been observed.

In the studies of Krengli [23] and Peretti et al. [24] statistically significant differences in the values of Jitter, Shimmer, NHR parameters after laser cordectomy compared to the control group occurred after type III, IV and V cordectomy. No statistically significant differences in the values of acoustic evaluation parameters after type I and type II cordectomy have been observed. The values did not differ also in comparison to the control group. In an own study, the analyzed group of patients revealed values of acoustic parameters and MPT statistically significantly different in comparison to the control group. Spectrographic analysis of voice in patients with glottic cancer who were subject to IV and Va type cordectomy, revealed the presence of numerous non-harmonic components within high frequencies. Similar results have been obtained by Krengli et al. [23] while analyzing the acoustic parameters of voice in patients after type II, III, IV and V of endoscopic laser cordectomy.

Unsatisfactory post-operative voice quality after laser cordectomy may be improved with medialization procedures such as injection techniques, thyroid plastics or medialization using mucous – muscular lobes [25, 26, 27, 28, 29]. Evaluation of the effects of CO_2 laser endoscopic cordectomy includes self-assessment of post-operative voice quality performed by patients after surgery, which, according to many authors [25, 30, 31], is a crucial factor.

CONCLUSIONS

1. Postoperative voice quality depends on the type of endoscopic laser cordectomy performed;
2. In perceptual assessment using GRBAS, type IV and Va cordectomy, the severity of postoperative dysphonia increases;
3. The parameters of acoustic evaluation of voice: F0, Jitter, Shimmer, NHR after cordectomy increase along with the extent of the procedure;
4. The presence of non-harmonic components in narrowband spectrography in type IV and Va increases, while MPT is significantly reduced;
5. Preservation of the anterior commissure in endoscopic laser cordectomy does not cause a significant increase of acoustic and perceptual voice assessment parameters.

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Corresponding author: Department of Clinical Phonoaudiology and Speech Therapy, Medical University of Bialystok, Szpitalna Street 37, 15-295 Bialystok, Poland; Phone: +48 (85) 748 56 52; E-mail: fono@umb.edu.pl

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