THE NEW ARMENIAN MEDICAL JOURNAL
Vol.12 (2018), No 4, p. 58-63

THE FUNCTIONAL STATE OF LARYNX IN OCCUPATIONAL VOICE USERS WITH CHRONIC TONSILLITIS

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Received 28/04/2018; accepted for printing 22/09/2018

Abstract

Chronic tonsillitis contributes to the functional dysphonia emergence and voice acoustic characteristics deterioration. The study of larynx functional state in 42 occupational voice users with a compensated form of chronic tonsillitis included videolaryngostroboscopy, acoustic analysis of the voice using the "LingWaves Voice Program", and the Voice Handicap Index. After the washing course of palatine tonsil lacunas, the positive dynamics of the average values of the vibratory insufficiency index from 1.8 to 1.4 points (in patients with hypotonic dysphonia) and the dysphonia severity index from 3.2 to 4.3 points were noted. The tonal range of the speech voice has expanded by 5 semitones, and the vocal voice - by 3.5 semitones. The results of assessing the state of the voice apparatus using the Voice Handicap Index questionnaire showed a reliable positive tendency in all the criteria of the questionnaire. The duration of "S" and "Z" increased significantly, by 3.3 and 6.3 seconds, respectively. The frequency and dynamic ranges of spoken text increased by 1 semitone and 1 dB, respectively. The Maximum phonation time showed a positive tendency, having increased by 3.9 seconds, and jitter decreased by 0.05%. The irregularity coefficient of the vocal fold closure showed positive trend of 6% - from 0.83 to 0.78 according to the index. 42 patients underwent videolaryngostroboscopy, only in 8 (19%) patients no changes in the larynx were detected; in the remaining 34 the existing pathological changes were distributed among the nosological forms as follows: functional dysphonia was noted in 26 (61.9%) patients, of them, 2 patients (4.7%) had hypo-hypertonic dysphonia and in 24 (57.1%) hypotonic dysphonia; chronic laryngitis occurred in 8 (19%) patients. Chronic tonsillitis should be considered as one of the reasons for the functional dysphonia development. Sanitation of palatine tonsils lacunae improves the vocal functional state, which is confirmed by the results of acoustic analysis of the voice, videolaryngostroboscopy and Voice Handicap Index questionnaire.

Keywords: *chronic tonsillitis, functional dysphonia, acoustic analysis of the voice, video laryngostroscopy, Voice Handicap Index.*

Introduction

Voice plays a huge communicative role in our life, and especially in the professional activity of people whose voice and speech are their "tools". Violations of voice formation can lead to temporary or permanent professional disability [*Vasilenko Yu, 2013*].

According to modern concepts, chronic tonsillitis is characterized as a multifactorial immunopathological process that can promote the local and systemic complications with the development of cardiovascular, neuroendocrine, immunological and metabolic syndromes [*Lukan N et al., 2010; Kryukov A.I., et al., 2009*]. The problem of chronic tonsillitis effect on voice has not found its final solution so far [*Shteyman K, 1930; Jarboe J et al., 2001; Celebi S et al., 2011; Angotoeva I, Rudin L, 2012; Atan D et al., 2017*].

Russian authors cite data on the presence of laryngeal pathology in patients with chronic tonsillitis in s20-25% to 84-92.5% of cases [*Shamsheva T, 1984; Ivanova O, 2009; Rudin L, 2012*]. Thus, the problem of studying the effect of chronic tonsillitis on the clinical and functional state of the larynx remains relevant.

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Maksimov I. notes that the pain arising from tonsillopharyngitis does not allow the complex motor act, carried out by the pharynx, to be performed fully and in dynamics. In addition, the inflammatory process in the area of the mucous membrane disrupts the normal functioning of the receptor elements n. trigeminus (V), n. glossopharyngeus (IX), n. vagus (X), as a result of which changes occur both in the timbre and in the normal mode of vibration of the vocal folds [*Maksimov I, 1987*].

Methods of organ preserving treatment of chronic tonsillitis are especially relevant for professional vocalists [*Eyges S, 1936; Preobrazhensky B, 1954; Preobrazhensky B, Popova G, 1970; Maksimov I, 1987; Romanenko S, Pavlikhin O, 2010; Khamzaliyeva R et al., 2012*].

The purpose of the study is to increase the efficiency of diagnosis of vocal functional disorders in patients who are occupational voice users with chronic tonsillitis.

MATERIAL AND METHODS

The study included 43 occupational voice users, 18 to 58 years old (12 men and 31 women) with a compensated form of chronic tonsillitis, who complained of discomfort in the oropharynx, periodic withdrawal of caseous-purulent plugs from palatine tonsils lacunae, periodic hoarseness, rapid fatigue of the voice, congestion of mucus in the laryngopharynx. The study did not include patients with abnormalities and traumas of the facial skull, with a history of gastro-esophageal reflux disease, with any form of hearing loss, with psycho-neurological diseases; patients who had previously had tonsillotomy, adenotomy; patients who had ever undergone a voice correction. Patient examination scheme included clinical history, general ear nose throat (ENT) and phoniatric examination, assessment of the vocal functional state, using acoustic analysis of the voice, videolaryngostroboscopy and a specialized Voice Handicap Index (VHI). Videolaryngostroboscopy: an electronic stroboscope "EndoSTROB-XION" with technical characteristics 90-240*V*, 50-60*Hz*, 150*W*, 2.5*A* was used to assess vibration of vocal folds. For an objective characterization of laryngostroboscopic picture, a system of scoring of the vocal fold vibration by Ivanchenko G.F. was used. The main parameters of laryngostroboscopic picture were evaluated (Table1):

The total number of points was divided by 5 and the index of the vibratory insufficiency was calculated. The normal rate is 1 point [*Ivanchenko G, 1992*].

Computer acoustic voice analysis: voice recording was performed using the LingWAVES 3.1 program, and the sound level meter of the WEVOSYS German company. According to the instructions of the recording equipment used, the voice recording was conducted in a quiet room (the level of extraneous noise below 40-45 *dB*) on the personal computer with the operating system Windows 8.0, with an E-350 processor, a 1600 *MHz* processor, 2048 MB RAM, DDR3 1066 *MHz* memory, with a hard disk capacity of 1000 *GB*. The sound level meter was mounted on a tripod with adjustable height for each patient at a distance of 30 *cm* from the patient's mouth. The signal was recorded without amplification and filters on the sound plateau of the computer. The recorded voice is stored in a WAV audio file.

TABLE 1

The main parameters of laryngostroboscopic picture

Laryngostroboscopic image parameters	Grade	Points
The presence of the vocal fold vibration	saved on both sides	1
	saved on one side	2
	absent on both sides	3
Change in vibration frequency	synchronous, uniform vibration	1
	one voice fold vibrates with a lower frequency than the other	2
	irregular vibration	3
Change in the vibration amplitude:	the same amplitude of the vocal folds	1
	disorder on one side	2
	disorder on both sides	3
Change in the phase of the glottis closure	complete glottis closure	1
	incomplete glottis closure	2
	no glottis closure constantly	3
Change in the opening phase:	the edge of the vocal folds is moderately and uniformly concave	1
	the vertical component is increased or absent	2
	different levels of vocal folds	3

The investigated acoustic parameters are presented in table 2. To determine the dynamic and tonal ranges of the spoken voice (relaxed spoken text), patients were offered a phonetically balanced (representative text) reading [*Smirnova N, Khitrov M, 2013*].

As a conservative method of treatment, we applied a course of palatine tonsil lacunae lavage with an 0.05% aqueous solution of chlorhexidine digluconate consisting of 7-8 procedures, with one-day interval. The study of the larynx functional state was carried out before the course of conservative treatment and a day after it.

For the statistical processing of the results, the following methods were used: the Shapiro-Wilk test to test the hypothesis of the data distribution normality, the Wilcoxon test for connected samples, the Bonferroni correction for multiple testing and the chi-squared test with the Yates correction. To describe the parameters studied, the median was used as a measure of the mean, and the interquartile range (MR) was used as a measure of variation. The null hypothesis was rejected at a significance level of p<0.05. The statistical analysis was carried out using the R version 3.4.2 software in R studio version 1.1.383.

Results and discussion

The distribution of the voice most objective acoustic parameters results differed from the normal (the level of significance of the Shapiro-Wilk criterion was <0.05), which was the reason for choosing the non-parametric Wilcoxon test for further comparison. The results of acoustic analysis of voice showed that after a course of washing the lacunae of the palatine tonsils, statistically significant changes in the majority of objective acoustic parameters of voice are observed, the significance level p<0.05 of the Wilcoxon test. In order to correct a multiple comparison of the results of voice acoustic parameters to the obtained significance levels of the Wilcoxon test, the Bonferroni correction was applied. As a result, the differences in most indicators remained significant (the significance level was p<0.05 after the Bonferroni amendment) (Table 2).

Statistically significant changes were also made in the results of the VHI questionnaire as a whole and in its 3 components: a decrease in the coefficient of the physiological component of the questionnaire (Table 2).

However, the change in the number of acoustic parameters was not statistically significant (Table 2).

Among 42 patients who underwent videolaryngostroboscopy, only 8 (19%) patients did not have any changes in the larynx, the remaining 34 patients had the following pathological changes: functional dysphonia was noted in 26 (61.9%) patients, hypo-hypertonic dysphonia was detected in 2 patients and hypotonic dysphonia was revealed in 24 (57.1%) patients; chronic laryngitis occurred in 8 (19%) patients. In patients with hypotonic dysphonia (n=24) the glottis during phonation had an oval or triangular shape, the vocal fold vibration had an asynchronous character with videolaryngostroboscopy prior to the course of treatment. On breathing in the medial vocal fold edge, the gaping of the laryngeal ventricles was determined. The index of vibratory insufficiency in these patients ranged from 1.4 to 1.8 points.

Two patients suffered a hypo-hypertonic dysphonia, which is characterized by a hypotonic vocal fold and hypertensive vestibular one. With videolaryngostroboscopy, the vocal folds were in a hypotonic state, the vestibular and aryteno-epiglottic folds were hyperemic and injected with blood vessels as a result of the forced phonation. During phonation, the vestibular folds tightly closed over the vocal folds, and at the time of inspiration they contracted to normal sizes and did not interfere with the examination of the vocal folds. It was not possible to evaluate the stroboscopic picture in these patients because during phonation the vocal folds were not visible. Chronic catarrhal laryngitis was observed in 8 (19%) patients: vocal fold vibration was weakened, the phenomenon of marginal displacement of the mucosa was negative with videolaryngostroboscopy. In this subgroup of patients, the index of vibratory insufficiency was 2.0 to 2.4 points.

On repeated examination, 1-2 days after the end of the treatment, 24 (57.1%) of 42 patients had normalization of the videostroboscopic picture,

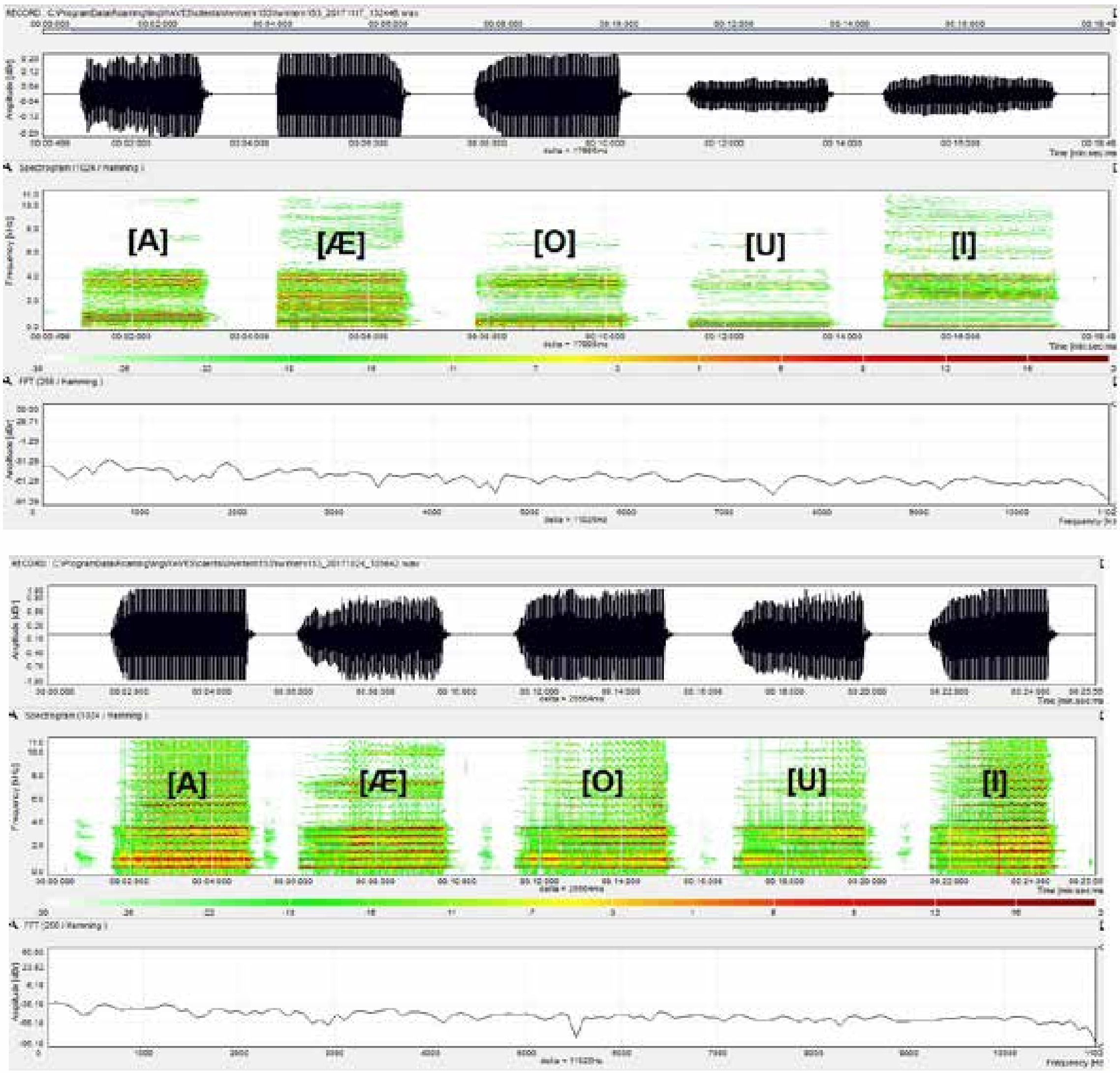
TABLE 2

Dynamics of acoustic voice parameters after a course of sanation of palatine tonsils lacunae

Acoustic parameter	Median andinterquartile range				The level of significance after the Bonferroni amendment
	before treatment		after treatment course		
Tonal range of speech voice (Hemitones)	16	(10.7-19)	21	(17.2-25.7)	p<0.05
Tone range of the vocal voice (Hemitones)	26.5	(21-31.7)	30	(24.2-34)	p<0.05
The pitch frequency (F0) (*Hz*)	228	(201.8-267.3)	219.6	(195-243.4)	p>0.05
Dynamic range of speech voice (*d*B)	36	(33-39.7)	40	(36-44.7)	p<0.05
The dynamic range of the vocal voice (*d*B)	42.5	(34-47)	45	(39-55.7)	p>0.05
Soft voice (*dB*)	56	(54-58.7)	56.5	(54-58)	p>0.05
Normal voice (*dB*)	66	(64-69)	66	(64-70)	p>0.05
Loud voice (*dB*)	77	(73-79)	78	(73.2-80.7)	p>0.05
Shout (*dB*)	98.5	(91.2-102)	100.5	(95.2-105.7)	p>0.05
Maximal intensity of vocal voice (*dB*)	105.5	(101.2-111.7)	108.5	(103.2-114)	p>0.05
Minimal intensity of vocal voice (*dB*)	65	(60-72)	62	(57-67.7)	p>0.05
Maximum phonation time *(sec)*	15.4	(13.2-20)	19.3	(16.1-23.6)	p<0.05
Duration of “S” *(sec)*	11.1	(8-15.1)	14.4	(10.5-19.6)	p<0.05
Duration of “Z” *(sec)*	11.6	(8.9-15)	17.9	(13.3-20.5)	p<0.05
S/Z ratio	0.98	(0.83-1.11)	0.85	(0.74-1.07)	p>0.05
Shimmer (%)	5.28	(4.69-7.27)	4.94	(4.24-5.63)	p>0.05
Jitter (%)	0.17	(0.12-0.28)	0.12	(0.1-0.17)	p>0.05
Overall severity	0.9	(0.79-1.02)	0.9	(0.8-0.97)	p>0.05
Irregularity	0.83	(0.78-0.97)	0.78	(0.71-0.84)	p<0.05
Noise	0.34	(0.29-0.5)	0.31	(0.23-0.43)	p>0.05
Dysphonia severity index (DSI)	3.2	(1.4-3.9)	4.3	(2.85-4.9)	p<0.05
VHI (total)	14.5	(11-20)	7	(3.2-10)	p<0.05
VHI (physiological component)	4	(3-6.7)	3	(1-4)	p<0.05
VHI (physical component)	7	(6-9)	3	(1-4)	p<0.05
VHI (emotional component)	3	(1-5)	0	(0-1.7)	p<0.05
Frequency range of spoken text (Ht)	10	(9-11)	11	(9-11)	p>0.05
Dynamic range of spoken text (*d*B)	17.8	(15-19)	18.8	(16.7-21.4)	p>0.05

hypotonic dysphonia was preserved only in 7 patients. Comparison of these differences with the help of the chi-square test with the Yates correction showed statistically significant changes: the value of the chi-square test is 20, the significance level is p<0.05. Thus, we can conclude that the course of tonsil crypts sanitation contributed to the normalization of the vocal fold tone. The index of vibratory insufficiency decreased to 1.2-1.4 points. Organic changes persisted in 8 patients with chronic catarrhal laryngitis. There were no pronounced changes in the stroboscopic pattern after the end of treatment. Vocal folds were weakened, the phenomenon of marginal displacement of the mucosa was negative.

In our study we used spectrography as an objective method for evaluating the formant and overtone composition of the Russian alphabet vowels. We estimated the spectrograms by Yanagihara in the modifications of Wilson, Shilenkova and Korotchenko, where five types of spectrograms were distinguished [*Shilenkova V, 2015*]. 11 of 42 spectrograms before the treatment were classified as type II, where noise components were expressed in



A

B

*FIGURE 1. A 23-year-old female singer (soprano) before (**A**) and after (B) the course of treatment with hypotonic dysphonia.*
*(**A**) - In the spectra of [A], [Æ], [I] harmonic components are not clearly differentiated, in the second formant replaced by non-expressed noise components. Type II spectrogram*
*(**B**) - Constant harmonic components are pure, expressed in all vowels, do not contain noise components. Type 0 spectrogram.*

the spectra of sounds "A", "Æ" and "I" with the presence of additional noise in the high frequencies. In 18 cases before the treatment the spectrograms corresponded to type I, where in spectra of "A", " Æ" and "I" unexpressed noise components were noted. In 7 patients with chronic laryngitis spectrograms were type III where harmonic components in the spectra of sounds "A", " Æ" and "I" are not clearly differentiated, completely or partially replaced by noise components.

After the treatment the spectrograms were as follows: among 20 patients with hypotonic dysphonia who had type I spectrograms before the treatment positive dynamics were observed in 13 cases – they had type 0 spectrograms. Among 11 patients with type II spectrograms before the treatment 8 cases became type I spectrograms after the treatment, type 0 - in 2 cases and 1 case remained type II (Fig.1 and 2). In 8 patients with chronic laryngitis significant dynamics was not observed.

CONCLUSION

1. Chronic inflammation of the palatine tonsils affects the larynx functional state.
2. Conservative treatment of the patients with simple and toxic-allergic 1 forms of chronic tonsillitis contributes to the positive dynamics of the basic voice acoustic parameters - the coefficient of instability of the pitch frequency (jitter), the index of dysphonia, the expansion of the tonal and dynamic range,

the maximum phonation time, the decrease in the irregularity of the vocal folds clamping.

3. Conservative treatment in patients with simple and toxic-allergic 1 forms of chronic tonsillitis contributes to positive dynamics in the patients' life quality according to the Voice Handicap Index questionnaire.
4. Conservative treatment in patients with simple and toxic-allergic 1 forms of chronic tonsillitis contributes to the positive dynamics of the vocal folds tone according to videolaryngostroboscopy.
5. The spectrography of vowels clearly shows the dynamics of the of vowel formant composition before and after treatment of chronic tonsillitis.

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