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Comparative analysis of voice in diagnostics of T1 and T2 vocal cord carcinoma

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BACKGROUND: *Dysphonia is the most frequent symptom of vocal cord carcinoma. In the diagnostics of the disease subjective and objective methods of examination (acoustic analysis of a voice signal) and a laryngostroboscopy and aerodynamic examination are used.*

METHODS: *Our clinical prospective study consisted of 40 male patients, who had malignant tumors of one vocal cord - right or left. All the patients underwent otorhinolaryngological and phoniatric examination. The quality of voice was evaluated and estimated according to the 4-level GIRBAS scale (grade-instability-roughness-breathiness-asthenic-strain). Aerodynamic analysis dealt with vital capacity (VC), maximum phonation time (MPT) and phonation quotient (PQ).*

RESULTS: *Vibration of vocal cord did not exist in 60% of cases. Instability and strained voice was present in 100% of cases. Mean average value of phonation quotient was 303.33 ml/s. The influence of roughness (R), instability (I), asthenic (A), and strain (S) on the total degree of dysphonia (G), was in all cases in a significantly positive correlation with the level of statistic significance $p<0.01$ for I, R and S, and level $p<0.05$ for A. Nonvibration of a vocal cord had significant influence on the grade of dysphonia and strain (negative correlation, level $p<0.01$), and on the instability (negative correlation, level $p<0.01$). Maximum phonation time had statistically significant influence (negative correlation) on the phonation quotient.*

CONCLUSION: *The voices of all patients who had glottal carcinoma T1 and T2 were psychoacoustically characterized by strain and instability of phonation. It is certain that a patient has glottal carcinoma if he/she has values of phonation quotient higher than 300 ml/s, nonvibration of a vocal cord in laryngostroboscopy, and strained voice in psychoacoustic analysis.*

KEY WORDS: *Voice Disorders; Speech Acoustics; Laryngeal Neoplasms; Vocal Cords*

INTRODUCTION

Vocal cord carcinoma is known as a disease of men. It has higher incidence among city people and some races, and its connection with the abuse of alcohol and tobacco is well known. As the contributory causes there are air pollution, radiation, chronic laryngitis, and excessive use of voice. Genetic and hormonal factors (testosterone), certainly take a special place when etiology of this disease is discussed (1).

The same as pain is an "alarm" that warns that something serious is happening in the organism, dysphonia is also an "alarm" that should make a patient see an otorhinolaryngologist or a phoniatrist, especially when it lasts longer than two or three weeks. Subjective acoustic analysis of voice, which analyzes tumorous dysphonia, is one of the methods that are used daily (2,3). If a "listener" is trained, important data on voice condition are gained. Besides subjective methods, objective methods of examination are also used in diagnostics: acoustic analysis of a voice signal, laryngostroboscopy (4), aerodynamic examination, and finally a biopsy of a vocal cord tissue.

Abbreviations: SAA-subjective acoustic analysis, RBH-roughness-breathiness-hoarseness, GRBAS-grade-roughness-breathiness-asthenic-strain, RBAD-ruoghness-breathiness-asthenic-degree, GIRBAS-grade-instability-roughness-breathiness-asthenic-strain

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MATERIALS AND METHODS

In our clinical prospective study, the observed sample was made of 40 men who had carcinoma of one vocal cord. All the patients underwent otorhinolaryngological and phoniatric examination in the clinic. The subjective acoustic analysis of their voices was performed with the patients pronouncing numbers from 1 to 10 in the comfortable zone. The voices were saved in a computer program and then on a compact disc. Afterwards two listeners listened to the voices separately.

The evaluation of the quality of voice was conducted according to the GIRBAS scale. The phenomena of voice were marked by the English words G-grade, I-instability, R-roughness, B-breathiness, A-asthenic, S-strain. The evaluation was performed for every acoustic parameter according to the following values: 0=nonexistent, 1=light or of the low degree, 2=moderate or of the medium degree, 3=intense or of the high degree. In the case of the presence of whisper, the patient was marked as aphonic. After the evaluation of the quality of voice, the listeners gave the final mark by comparison.

Phonation quotient (PQ) was determined by aerodynamic examination. First, the vital capacity was measured by *Drager, Spirotron 2A* device. The examined patient, after series of normal respirations, breathed in maximally and then breathed out into the plastic ending connected to the device. The device automatically measured the values of vital capacity and a range of other, for this study, less important parameters. The maximum phonation time (MPT) was determined when the patient, after a maximum inspiration, phonated vocal *a* as long as he had breath, and the time was measured by a stopwatch. Phonation quotient was determined as the quotient of vital capacity (VC) and maximum phonation time for the vocal *a*, and the value was expressed in ml/s.

After the direct laryngomicroscopy, to which all the patients were subjected under the total anesthesia, tissues of vocal cords' growths were histopathologically examined. The statistic analysis of data consisted of minimum and maximum value, medium value, modal value, Pearson's coefficient of linear correlation and statistic significance.

RESULTS

The examined group consisted of 40 men aged from 39 to 65 years, the average of X=53.3 years of age. There were 28 patients (70%) with right vocal cord carcinoma and 12 patients (30%) with left vocal cord carcinoma. According to the TNM classification, there were 26 patients (65%) with T1 vocal cord carcinoma and 14 (35.00%) with T2 vocal cord carcinoma.

Histopathological examination showed that 38 patients (95%) had planocelular vocal cord carcinoma, while 2 patients (5%) had verrucous vocal cord carcinoma. Laryngostroboscopy showed that in 24 cases (60%) a diseased vocal cord was without mucous wave (nonvibrating vocal cord), 8 patients (20%) had a nonvibrating segment of a vocal cord with the change of all vibration characteristics of the remaining part of the vocal cord, while 8 patients (20%) had, in most part, preserved movement of a vocal cord, without any important changes of vibration characteristics. A significant negative correlation between the value T and the movement of the vocal cord (Pearson's coefficient r= -0.41) was found.

During subjective acoustic analysis (SAA), apart from the basic psychoacoustic phenomena, height and strength of voice, a special attention was given to the pathological phenomena of voice. The total degree of dysphonia was determined according to the GIRBAS scale. It was present in all cases, equally moderate (40%) and intensive (40%). Instability of voice, as the second element of the scale, also existed in all 100% of cases, equally light (40%) and moderate (40%). Roughness existed in 75% of cases, and it was mostly intensive roughness, in 30% of patients. Breathiness was present in 2 cases (5%) and it was of the low degree. Asthenic voice was present in 50 % of cases, and moderate in 25% of cases (modal value =2). All 100.00% of patients suffered from strained voice, and mostly it was moderate in 45% of cases (modal value = 2). None of the patients had aphonia.

The values of Pearson's coefficient linear correlation for the influence of pathological phenomena of voice on the total grade of dysphonia are presented in the Table 1.

Table 1. Values of Pearson's coefficient of linear correlation and values of statistic significance of influence of psychoacoustic pathological phenomena on the degree of dysphonia

Psychoacoustic pathological phenomenon/Grade of dysphonia	Pearson's coefficient of linear correlation (r)	Level of statisticsignificance (p)
A: G *Astenity: Grade*	0.44	p<0.05
S: G *Strain: Grade*	0.52	p<0.01
I: G *Instability: Grade*	0.52	p<0.01
R: G *Roughness: Grade*	0.62	p<0.01

The influence of the mobility of a vocal cord on psychoacoustic pathological phenomena: roughness, instability and strain, is particularly interesting. Pearson's coefficient of linear correlation for the influence of mobility on roughness, strain and instability of phonation are presented in the Table 2.

The values of phonation quotient were between 161.00 ml/s and 592.00 ml/s. The average value was 303.33 ml/s. The average VC was 3724.00 ml and the average MPT was 13.65 s. Maximum phonation time and phonation quotient were in negative correlation with the value of Pearson's coefficient of linear correlation r= -0.77, and the level p<0.01.

Table 2. Values of Pearson's coefficient of linear correlation and values of statistic significance of psychoacoustic pathological phenomena and vocal cord nonvibration

Nonvibration/Psychoacoustic pathological phenomenon	Pearson's coefficient of linear correlation (r)	Level of statistic significance (p)
Nonvibration: Grade	0.49	p<0.01
Nonvibration: Instability	-0.51	p<0.05
Nonvibration: Strain	-0.51	p<0.01

DISCUSSION

Diagnostic evaluation of voice disorders always demands examination of phonation system, psychological and social evaluation, however in the first place there is auditory impression that significantly contributes to diagnosis (5). By subjective acoustic analysis, i.e. the perception of psychophysiologic characteristics of voice, a human ear can register pathological changes in voice, but it cannot determine the character of growths on vocal cords (1). Dejonckere (6) uses GIRBAS scale, which describes a large number of phenomena that follow a process of phonation, for psychoacoustic analysis of voice. He adds voice instability to these pathological parameters assuming that this phenomenon is always present in pathological voice and that it is independent on the degree of voice quality.

Dysphonia is a phonation disorder that appears only on the glottis level (7,8). Therefore all the changes on vocal cords, as the central part of glottis, cause hoarseness, which is the most frequent and the best-known symptom of dysphonia and is often used as the synonym for it. All the growths on vocal cords, irrespective of their nature, change voice characteristics, above all its clearness. The same process on vocal cords can cause different pathological phenomena of voice. The same pathological phenomena can be caused by different pathological processes on vocal cords. Beside the existence of pathological phenomena of voice, all the major characteristics of voice - height, strength and timbre, can be changed (1).

Roughness is caused by aperiodicity of vibration of vocal cords, hoarseness by air turbulence on the glottis level, and breathiness by insufficient occlusion of glottis.

It is already known that a change in mobility (flexibility) of a vocal cord causes the increase of roughness. Looseness of a vocal cord, which can be seen with Rajnke's edema, decreases or stops the process of vibration, which is also the case with carcinoma changes of a vocal cord, though the causes are different (9).

Carcinoma changed cover of a vocal cord, i.e. its increased inflexibility, leads to aerodynamic changes that result in hoarseness. The reflexive activation of ventricular folds due to the loss of elasticity of a diseased vocal cord, disables its complete movement towards the medial line, therefore the phase of the closure is incomplete. The level of turbulent motion of the airflow depends on the size and the shape of the narrowing of the airways. Increased resistance to the expiratory airflow leads to a turbulent motion of the air and noise appears. The turbulence is also increased by the existence of an obstacle, a rough surface on the way of the airflow, such as a carcinoma changed vocal cord. Nonvibrating vocal cord significantly disturbs the air flow, hence the more intense the hoarseness, the lighter the movement of the vocal cord cover (3).

However, the increase of phonation instability and voice strain is present in these cases, as well. The damage of the laryngeal mechanoreceptors destroyed by the tumor process, or simply anaesthetized, causes the loss of fine regulation mechanisms, and the instability of the height of voice appears. (3). The negative quotient of linear correlation for all three elements, roughness, strain and instability, shows that the lighter the movement of a vocal cord, the more intense the pathological phenomena are. This is quite understandable since every morphological change damages the phonation function. The influence of roughness, instability, asthenia, and strain on the total degree of dysphonia, is in all cases in a significantly positive correlation with the level of statistic significance $p<0.01$ for I, R and S, and level $p<0.05$ for A. Dejonckere compared the degree of dysphonia, roughness, breathiness and asthenia/strain with the parameters of objective acoustic analysis of voice and he found that in all cases the positive correlation was significant, with the level $p<0.01$. It should be noticed that this author describes asthenia and strain as one pathological phenomenon. In this work all the psychoacoustic pathological phenomena are described separately, because they can be heard as separate by careful listening, and the statistic analysis of data proved that they are not always connected and that they have different values and different influence on the grade of dysphonia.

Even Leonardo da Vinci noticed that the main factor that allows creation of voice is the transformation of the expiratory airflow into vibrations of vocal cords. The closure of vocal cords similar to valvula creates an obstacle to the expiratory airflow, and it starts vibrations of vocal cords.

The term phonation capability includes many factors and among them sustained phonation. According to Hirano (10) normal values for men are 25 to 30 seconds and for women 15 to 25 seconds. The maximal value is higher for men than for women, however there is no significant difference between the minimal levels for both sexes. In clinical practice the value of MPT under 10 is considered abnormal.

Subglottal pressure can be expressed as Psub=MFRxGR, where MFR is medium airflow through glottis and GR is glottal resistance. Hirano finds that the connection between the medium airflow and phonation quotient (PQ) is highly positive. Since the measuring of PQ is less complicated, he recommends PQ as a substitute for MFR in clinical work, especially because glottal resistance cannot be measured directly and demands further examination. Hirano considers PQ to be normal from 120 to190 ml/s. He finds that PQ is abnormally high with many lesions on vocal cords: nodules, polyp, edema and carcinoma.

The value of PQ of 303.33 ml/s means that the value of phonation quotient for a patient with vocal cord carcinoma T1 and T2 is significantly higher. By comparison of these two values with the group of patients with Rajnke's edema, which are a considerable obstacle to the expiratory airflow due to their mass and looseness, no statistically significant difference is found. This leads to conclusion that nonvibrating vocal cord is a significant "mass" that causes resistance to expiratory airflow. High negative correlation of phonation quotient and maximum phonation time can be interpreted as following: the shorter the MPT, the higher the value of PQ. This is understandable and in agreement with the results given in the discussion of subjective acoustic analysis, considering the significantly disturbed phonation conditions. This finding was also confirmed in the control group, where Pearson's coefficient of linear correlation is significantly negative, $r=-0.45$ and $p<0.05$.

MPT has higher values than control group because although phonation conditions are disturbed, the healthy vocal cord acts compensatory, trying to achieve "minimum glottal field", while with Rajnke's edema it is harder due to the mass and looseness of vocal cords. The findings of the aerodynamic examinations used in this study prove their importance in diagnostics of vocal cord carcinoma, especially if the value of PQ exceeds 300 ml/s. Of course, as in any other study in field of phoniatry, comparative analysis is invaluable.

CONCLUSION

Voice of all patients who had glottal carcinoma T1 and T2 were psychoacoustically characterized by strain and instability of phonation. Nonvibration of a vocal cord had significant influence on the degree of dysphonia, roughness, instability and strain. It is certain that a patient has glottal carcinoma if he/she has values of phonation quotient higher than 300 ml/s, nonvibration of a vocal cord in laryngostroboscopy, and strained voice in psychoacoustic analysis.

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