

The application of *High-Speed* camera (HS), acoustic analysis and Voice Handicap Index (VHI) questionnaire in diagnosis of voice disorders in elderly men

Authors' Contribution:

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

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ABSTRACT:

Introduction: The process of ageing begins after 60 years of age and is referred to as Presbyphonia (Vox senium). The causes include functional or organic voice disorders, often coexisting with dry upper respiratory tract infection.

Objective: The aim of the study is the use of High-Speed camera and acoustic voice analysis in diagnostics of the clinical form of presbyphonia.

Materials and methods: The study included a group of 50 men, non-smokers, age from 51 to 72, who do not use their voice professionally. High-Speed Digital Imaging and HS camera have been used, allowing evaluation of real vibrations of vocal folds, along with acoustic voice analysis using a software by DiagNova Technologies.

Results: VHI questionnaire has been used for self-assessment of voice disability. Visualizations of the larynx enabled recognition of hypofunctional dysphonia or atrophy of vocal folds that cause voice disorders. This was confirmed by parameters of voice acoustic evaluation: F_0 , NHR, narrowband spectrography. The pathological value of NHR and the presence of non-harmonic components in the range of high frequency levels indicated glottal insufficiency, recorded with the visualization technique of the larynx by HS camera. A significant shortening of maximum phonation time in relation to the control group has also been recorded.

Discussion: The objective examination of voice pathology is crucial in diagnosis and rehabilitation, however, subjective assessment of the patient is important in the scope of the procedure used. The patient's subjective self-rating assessment (VHI) confirmed the sense of voice disorders in elderly men, indicating the need for rapid and accurate clinical diagnosis.

KEYWORDS:

acoustic voice analysis, HSDI, hypofunctional dysphonia, presbyphonia, vocal fold atrophy

INTRODUCTION

The process of voice ageing, referred to as Presbyphonia or Vox Senium, begins after 60 years of age and has an individually variable course [1, 2, 3, 4, 5, 6]. The causes include changes in the lungs, pharynx as well as larynx connected with age [7]. Morphological reconstruction concerns the mucous membrane covering vocal folds and the muscles building its mass [3, 8, 9, 10, 11, 12, 13].

Elderly patients frequently reveal reduced thirst [12, 14, 15, 16]. Improper hydration increases the occurrence rate of dry upper respiratory tract infections, which further impairs the quality of voice. Proper hydration of the body increases the elasticity of mucous membranes, which is especially important in relation to the mucous membrane of vibrating vocal folds [12]. In elderly men, disturbances of voice quality of organic and functional nature are observed, often causing an increase in its pitch (senile soprano) [17, 18, 19, 20, 21, 22]. The proper functioning of vocal organ is especially important in the group of professional voice users [23, 24, 25, 26].

In assessing the quality of voice, especially after therapy and rehabilitation, self-assessment of the voice is also important. A positive result confirms the accuracy of diagnostics and the effectiveness of therapy.

Improving the quality of the voice allows continuation of professional work, enables efficient communication with the environment and improves the quality of life [3, 25, 27, 28, 29, 30, 31, 32, 33, 34]. In assessing the quality of voice in the elderly, subjective methods should not be omitted, especially after the therapy and rehabilitation. Positive self-assessment of voice is a confirmation of the accuracy of diagnosis and will enable continuation of professional work, while improving quality of life [24, 26, 35, 36].

AIM

The aim of the study is to diagnose the clinical form of dysphonia in the group of elderly men using a High-Speed(HS) camera, acoustic voice analysis and VHI questionnaire.

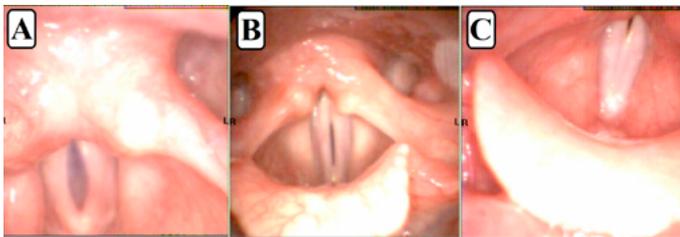


Fig. 1. Type of glottal closure (HS camera, HSDI technique); A – hypofunctional dysphonia (group I), B – vocal fold atrophy (group I), C – physiological glottal closure (group II).

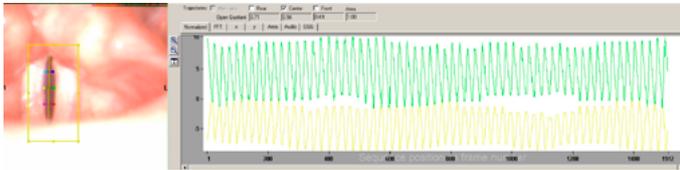


Fig. 2. Evaluation of the OQ in a patient with hypofunctional dysphonia (group I).



Fig. 3. Collective analysis of acoustic parameters of voice (DiagNova Technologies); A – hypofunctional dysphonia (group I), B – euphonic voice (group II).

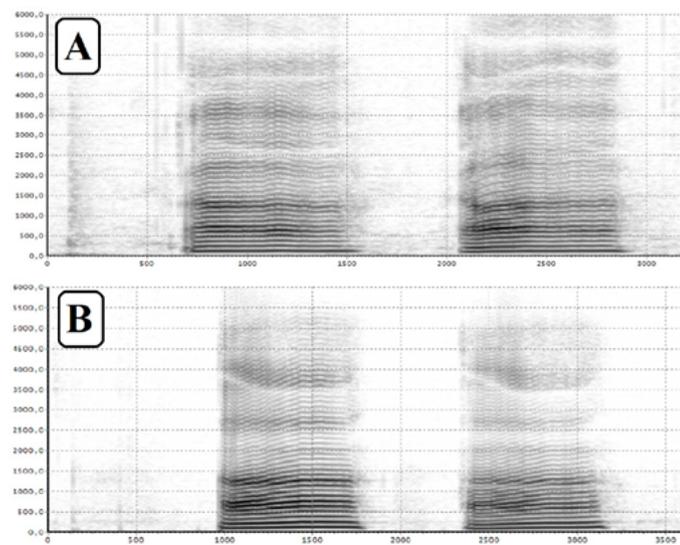


Fig. 4. Narrowband spectrography (DiagNova Technologies); A – hypofunctional dysphonia (group I), B – euphonic voice (group II).

MATERIAL AND METHODS

The study included a group of 50 men – Group I, aged 61 to 72. The average age was 67. The men included were non-smokers, without reflux disease, chronic inflammation of the upper respiratory tract

and who did not use voice professionally. Control group – Group II – consisted of 30 men, aged 29 to 38. The average age was 33. The men included were non-smokers, without gastrointestinal and pulmonary diseases, who did not use voice professionally.

Patients have been diagnosed at the Department of Clinical Phonaudiology and Speech Therapy of the Medical University of Białystok in 2018–2019. In the assessment of the clinical form of voice pathology, visualisation methods of the larynx and acoustic examination have been used. Imaging of the larynx has been performed using a High-Speed (HS) camera – with a 90° rigid endoscope and High-Speed Digital Imaging (HSDI) by R. Wolf in HRES system ENDOCAM 5562. The recording has been performed during phonation of vowel ‘i’. The recorded, 2-second, sequence has been analysed for a period of 8 minutes including assessment of the real vibrations of vocal folds using playback function. Mucosal Wave (MW), regularity, symmetry and amplitude of vibrations have been estimated. Glottal closure type has been classified according to the guidelines of the Committee on Phoniatrics of the European Laryngological Society (ELS), where: type A is a rectangular glottal closure, type B – hourglass, type C – triangular, type D – ‘V’ shape and type E – middle. Open Quotient (OQ) value has been determined in the anterior, middle and posterior segments of the glottis.

Acoustic voice analysis has been performed using DiagnoScope Specjalista by DiagNova Technologies. The analysis has been conducted during phonation of vowel ‘a’ (threefold) and the sentence ‘Dziś jest ładna pogoda’ (‘The weather today is nice’). Fundamental Frequency (F_0) was evaluated as well as Jitter, Shimmer, Noise-to-Harmonics Ratio (NHR). Narrowband spectrography and Maximum Phonation Time (MPT) have also been analyzed.

Voice Handicap Index (VHI) questionnaire was used in self-assessment of the patients’ voice, defining the vocal disability rate in three areas of life – functional, emotional, physical. The total VHI score is from 0 to 120 points, where a value of up to 30 points indicates slight disability; from 31 to 60 points – medium; over 61 points – significant disability of voice. Statistical analysis of the results of MPT was performed using the one-way analysis of variance, assuming a statistical significance level at $p < 0.05$.

RESULTS

In Group I, in 31 (62%) men, the reduction of mucosal wave (MW) has been recorded with physiological or slightly decreased vibration amplitude. Vocal fold vibrations were regular, symmetrical and synchronous. In 19 (38%) patients mucosal wave limitation (MW) has been recorded with significant increase in vibration amplitude. The vibrations of vocal folds were irregular and asymmetrical. In 50 (100%) examined men, dryness of the laryngeal mucous membrane was found with the presence of dense secretion sticking the vocal folds.

In Group II, in 28 (93%) men, mucosal wave (MW) was physiological, in 2 (7%) slightly increased. In 30 (100%) subjects, vibration amplitude was normal, vocal fold vibrations regular and symmetric.

In Group I, 28 (56%) men revealed type E of glottal closure, and 19 (38%) – type C coexisting with type E. In Group II, in 30 (100%) men, physiological glottal closure has been observed (Fig. 1.).

In Group I, the mean value of open quotient (OQ) in the anterior segment was 0.3, in the middle segment 0.89, in the posterior segment 0.49. In Group II, the mean value of open quotient (OQ) in the anterior segment was 0.42, in the middle segment – 0.55, in the posterior segment – 0.51 (Fig. 2.). In Group I, in 39 (78%) patients, the average value of F₀ was 160 Hz, and in 11 (22%) – 135 Hz. In Group II, in 30 (100%) subjects, F₀ was 130 Hz on average.

In Group I, in 48 (96%) patients, pathological values of Jitter (mean: 1.2%), Shimmer (mean: 11%), NHR (mean: 7.9) have been recorded. In 2 (4%) values were normative. In Group II, in 30 (100%) subjects, values of Jitter (mean: 0.49%), Shimmer (mean: 3.2%), NHR (mean: 2.9) were within normal limits (Fig. 3.). In group I, in 50 (100%) subjects, narrowband spectrography revealed non-harmonic components in the range of high frequency levels and harmonic components within lower frequencies.

In group II, in 28 (93%) men, harmonic components have been recorded in all frequency levels, and in 2 (7%) the appearance of a few non-harmonic components in the high frequency range has been observed (Fig. 4.).

In Group I, the average value of the Maximum Phonation Time (MPT) was 12 seconds. In Group II, the average MPT value was 26 seconds (Tab. I.).

In Group I, in 15 (30%) men, slight voice disability has been recorded (mean 28 points). In 22 (44%) subjects, an average voice disability has been found (mean 52), and in 13 (26%) – severe voice disability (average 77 points). In Group II, 30 (100%) men had an average voice disability of 8 points.

Disorders of voice quality accompany certain periods of human life [37, 38]. Kosztyła-Hojna, Pruszewicz et al. [5, 7, 39] reported the occurrence of dysphonia during puberty, pregnancy, menopause in women and in advanced age. People over 65, despite their age, often remain professionally active, therefore, immediate and accurate diagnosis of laryngeal pathology is of key importance.

In the diagnosis of clinical form of dysphonia, modern objective methods ensuring diagnostic success should be applied.

Objective methods include the unique High-SpeedDigital Imaging (HSDI) technique with High-Speed(HS) camera, allowing the recording of real vibrations of vocal folds impossible to observe by other techniques such as, for example, stroboscopy [28, 30, 31, 34, 40]. Acoustic analysis of the voice, allowing the assessment of many important voice parameters, is important in objective diagnostics of the voice and in monitoring of therapeutic results [6, 25, 29, 32, 33, 37].

In the assessment of voice quality, the sensitive criterion of the existing pathology is simple analysis of the Maximum Phonation Time (MPT) [2, 5, 7, 32]. In the evaluation of dysphonia severity and monitoring of the effects of therapy and rehabilitation, voice examination

based on the patients' self-assessment is not without significance. Voice self-assessment questionnaire – Voice Handicap Index (VHI) allowing to determine the rate of voice disability, complements and subjectively confirms objective diagnostics of larynx pathology. In the analyzed group of elderly men, disturbances in the regularity of vocal fold vibrations with mucosal wave reduction were observed.

In 19 (38%) patients, an increase in vibration amplitude has been observed, in the remaining 31 (62%) the vibration amplitude was physiological or slightly reduced. The increase in the vibration amplitude with limitation of the mucosal wave confirm the hypofunctional character of phonation. The reduction of vibration amplitude with limitation of the mucosal wave indicates the existence of atrophic changes in the mucous membrane of the vocal folds. Similar changes in larynx in the elderly have been reported by Kosztyła-Hojna et al. and Pruszewicz [5, 7]. According to Andrea, Baker, Behlau, Kosztyła-Hojna, Paul, Wilson et al. [5, 18, 19, 20, 22, 31], hypofunctional dysphonia and vocal fold atrophy cause glottal insufficiency, especially in the middle segment. In 56% of the analyzed group of men, the middle type of glottal insufficiency has been recorded – type E (according to ELS), and in 38%, type E coexisted with type C.

The highest OQ value – on average 0.89 – has been recorded in the middle segment, significantly lower – 0.49 – in the posterior segment. The obtained values of Open Quotient confirmed the clinical form of glottal insufficiency (type E or type E and C) diagnosed in the group of examined men. Evaluation of the morphology of the mucosal wave, especially the increase in its amplitude with the reduction of mucosal wave (MW), enabled the recognition of hypofunctional dysphonia. Reduction of the vibration amplitude of vocal folds and reduction of the mucosal wave (MW), in the assessment of real vibration using the HS camera and HSDI technique confirmed vocal fold atrophy.

The application of High-Speedcamera (HS) and HSDI technique is, therefore, a valuable diagnostic tool, allowing clear differentiation of vocal fold atrophy with the hypofunctional dysphonia. The results of acoustic analysis of voice are the confirmation of the visualization assessment of the larynx. Hypofunctional dysphonia and vocal fold atrophy usually cause an increase in the fundamental frequency of the laryngeal tone (F₀). In 78% of diagnosed men, the average value of F₀ was 160 Hz, in 22% – 135 Hz. In the analyzed group, an increase in the mean value of F₀ has been observed in relation to the control group, where the F₀ average value was 130 Hz.

Similar results have been obtained by Brockman-Bauser and Kosztyła-Hojna [5, 37] in the study of patients with glottal insufficiency and vocal fold atrophy. The lack of glottal closure causes changes in the value of many parameters in acoustic evaluation of the voice, especially the NHR value. In the analyzed group, 96% of patients were found with pathological values of Jitter, Shimmer, NHR, and only 4% of the examined values were normative. In the control group, parameters of acoustic evaluation were correct.

A valuable complement to the acoustic analysis of voice is narrowband spectrography, which allows to assess the noise component generated in the glottis, especially in glottal insufficiencies.

Tab. I. One-way analysis of variance test—Maximum Phonation Time (MPT).

GROUPS	OBSERVATIONS	SUM	AVERAGE	VARIANCE		
Group I	50	603.5	12.07	12.40826531		
Group II	30	778	25.93333	3.926436782		
Variance source	SS	df	MS	F	p-value	F Test
Between groups	3603.6	1	3603.6	389.3778	4.65E-32	3.963472
In groups	721.8717	78	9.254765			
Total	4325.472	79				

The presence of non-harmonic components within high frequencies has been recorded in all examined men. In the control group, harmonic components in the range of low and high frequencies have been found in 98% of patients. Narrowband spectrography confirmed the lack of glottal closure with hypofunctional dysphonia or atrophy of vocal folds registered in elderly men using visualization methods.

Glottal insufficiency also reduced the Maximum Phonation Time (MPT) to an average value of 12 sec. in the examined group in relation to the control group, where the average MPT value was 26 sec. The obtained results are consistent with the reports of many authors [4, 5, 7, 37]. Objective examination of voice pathology is crucial in the diagnosis and monitoring of therapy and rehabilitation, however, subjective assessment of the patient, especially regarding the effects of treatment, is important in the scope of the procedure used and should not be omitted. The discovery of severe disability of voice in 26%; moderate in 44% and mild in 30% of patients in subjective self-assessment of the voice, confirms the need for immediate and accurate diagnosis of the clinical form of dysphonia in order to ensure appropriate comfort of life for the elderly.

Glottal insufficiency in elderly men also caused a statistically significant reduction of the Maximum Phonation Time (MPT) to the average value of 12 seconds compared to the control group, where the MPT value was on average 26 seconds. The obtained results of MPT value assessment are consistent with the reports of many authors [4, 5, 7, 37].

Objective diagnostics of the voice is crucial in the diagnosis, monitoring of therapy and rehabilitation, however, subjective evaluation conducted by the patients is of key importance regarding the procedure used and should not be omitted. The discovery of

severe disability of the voice in 26% of patients; moderate in 44% and mild in 30% of examined men in subjective self-assessment of the voice, confirms the need for immediate and accurate diagnosis of the clinical form of dysphonia in elderly men.

CONCLUSIONS

1. Hypofunctional dysphonia or vocal fold atrophy is the cause of disturbances in voice quality in elderly men;
2. The use of HS camera and HSDI technique in the assessment of mucosal wave morphology (MW) allows objective diagnosis of the form of hypofunctional dysphonia or vocal fold atrophy;
3. The results of acoustic voice analysis, especially F_0 and NHR, confirm the visualisation of the diagnosis of the clinical form of voice quality disorders in elderly men;
4. Narrowband spectrography, showing the presence of numerous non-harmonic components in the range of high frequencies, is a valuable complement of the acoustic assessment of voice confirming the existence of glottal insufficiency;
5. The prolongation of Maximum Phonation Time (MPT) is caused by glottal insufficiency in hypofunctional dysphonia or vocal fold atrophy;
6. Self-assessment of the voice (VHI) in patients with vocal fold atrophy and hypofunctional dysphonia confirms mild voice disability, indicating the necessity of objective diagnostics of the clinical form of Presbyphonia.

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