Correlation Between the Basic Video Laryngostroboscopic Parameters and Multidimensional Voice Measurements

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Summary: Objective. The aim of this study is to evaluate the correlations among the basic video laryngostroboscopic (VLS) parameters and vocal function assessed using a multidimensional set of perceptive, acoustic, aerodynamic, and subjective measurements.

Methods. Digital VLS recordings and multidimensional voice assessment were performed for 108 individuals, namely 26 healthy and 82 patients with mass lesions of vocal folds and paralysis. The VLS variables (glottal closure, regularity, mucosal wave on the affected/healthy side, symmetry of vibration, and symmetry of image) were rated and quantified on a visual analog scale. Correlations among the VLS parameters and results of acoustic voice analysis and voice range profile (VRP), data of subjective (voice handicap index [VHI] and glottal function index [GFI]), perceptual (G-grade, R-roughness, B-breathiness, A-aesthetic scale), and dysphonia severity index (DSI) measurements were tested using Pearson’s correlation coefficient.

Results. The intercorrelations of VLS parameters in vocal performance were moderate to strong and statistically significant for the entire functional measurements obtained through different modalities. The definitive correlations between VLS and VRP parameters were as follows: $r = 0.69-0.79$ for normal profile coverage, $r = 0.67-0.76$ for dynamic intensity, and $r = 0.67-0.74$ for maximum intensity. All VLS parameters correlated moderately with VHI, GFI, and DSI ($r = 0.5-0.65$, $r = 0.4-0.57$, and $r = 0.61-0.69$, respectively). The strongest correlations were found between VLS parameters and G factor of the GRBA scale ($r = 0.68-0.88$).

Conclusions. Correlation analysis of the vibratory pattern of the vocal folds obtained via VLS provides more comprehensive insight into the pathophysiology of phonation and suggests the documented and measurable evidence of complex mechanisms of vocal outcome.

Key Words: Laryngostroboscopy–Acoustic voice assessment–Voice range profile–VHI–DSI.

INTRODUCTION

Qualified and complex evaluation of patients with dysphonia and diagnostics of laryngeal diseases typically include patient’s complaints, history, perceptual assessment of voice quality and severity of dysphonia, measurement of acoustic and aerodynamic voice parameters, and visualization of larynx. This reflects voice quality as the outcome of a perceptual analysis of an acoustic signal generated mainly by vibrations of the vocal folds during phonation.

Video laryngostroboscopy (VLS) currently represents the most important and the most commonly used well-established method to visualize larynx and vocal fold vibrations. Laryngeal visualization via VLS has been shown to be critical to diagnose the underlying cause of hoarseness, thereby increasing the accuracy of diagnostics up to 68.3%. This unalterable and clinically feasible imaging tool is also implemented into practice to assess the outcomes of therapy of laryngeal diseases or functional results of phonosurgical interventions. However, a real value of VLS for diagnosis still needs more comprehensive scientific evidence.

Moreover, the subjective nature of the interpretation of the VLS examination results significantly reduces the reproducibility and the use of VLS as a research tool or as a quantitative instrument for assessment of laryngeal phonatory function. To avoid this limitation, several methods of assessment and quantification of VLS findings have been suggested elaborating different VLS rating forms. A number of VLS variables that have been evaluated include a rather wide diversity of parameters, that is, periodicity and amplitude of vocal fold vibration, mucosal wave, vertical level, glottal closure, phase closure, phase symmetry, and presence of nonvibrating portions of the vocal fold. Unfortunately, a number of VLS variables and peculiarities of the VLS parameters presented in literature differed from study to study; therefore, data and results of different studies sometimes were hardly compatible.

The most recent studies show the tendency to optimize the VLS evaluation for clinical settings reducing the number of VLS parameters and exhibiting the most reliable judgments, thus supporting the concept that even small set of stroboscopic ratings is an adequate representation for most of the variance of all laryngostroboscopic characteristics. In earlier research on quantification of the basic VLS parameters, we found a high interrater and intrarater reliability for most basic VLS parameters that revealed high sensitivity and specificity distinguishing healthy and pathological voice patient groups. However, there is a paucity of information in literature on correlations between data of VLS examination and the results of assessment of laryngeal phonatory function using other measurements.

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The aim of this study is to evaluate correlations among the basic VLS parameters and vocal function by using a multidimensional set of perceptive, acoustic, aerodynamic, and subjective measurements.

MATERIALS AND METHODS
A study group consisting of 108 individuals was examined at the Department of Otolaryngology of Lithuanian University of Health Sciences, Kaunas, Lithuania.

The normal voice subgroup was composed of 26 selected healthy volunteer individuals from a random group of 42 subjects who considered their voice as normal. They had no complaints concerning their voice and no history of chronic laryngeal diseases or other long-lasting voice disorders. The voices of this group of individuals were also evaluated as healthy voices by clinical voice specialists. Furthermore, no pathological alterations in the larynx of the subjects of the normal voice subgroup group were found during VLS. Acoustic voice signal parameters of these normal voice subgroup subjects that were obtained using Voice Diagnostic Center lingWaves software, Version 2.5 (WEVOSYS, Forchheim, Germany) were within the normal range.

The pathological voice subgroup consisted of 82 patients who represented a rather common, clinically discriminative group of laryngeal diseases, that is, mass lesions of vocal folds and paralysis. Mass lesions of vocal folds included in the study consisted of nodules, polyps, cysts, papillomata, keratosis, and carcinoma. Pathological voice group patients were recruited from consecutive patients who were diagnosed with the laryngeal diseases mentioned previously. The clinical diagnosis was based on typical clinical signs revealed during VLS and direct microlaryngoscopy. The final diagnosis was proven by the results of histological examination of removed tissue in all cases of mass lesions of vocal folds. The required sample size for achieving 80% power was fulfilled.

Demographic data of the total study group and diagnoses of pathological voice group are presented in Table 1. These patients were serially enrolled and, therefore, likely represented the real incidence of pathologies in our series.

Digital high-quality VLS recordings were performed with the XION EndoSTROB DX device (XION GmbH, Berlin, Germany) using a 90° rigid endoscope. The subjects were seated for the VLS examination. The VLS examination and recordings were performed during modal phonation, that is, each subject was asked to sustain the vowel “ee” at a steady, comfortable pitch and loudness. Phonation time was kept long enough to allow for registration of a sustained phonation and at least one complete cycle of vibration.

The following basic VLS parameters were evaluated and quantified using a 100-mm long visual analog scale (VAS): glottal closure—longitudinal, oval, hourglass-shaped gap; regularity of vibrations—defined as the degree to which one phonatory cycle suits the next; mucosal wave on affected side; mucosal wave on healthy side; symmetry of glottal image; and symmetry of vibration.13 A score of “zero” (extreme left) meant normal perception of the parameter (no deviance), whereas “100” (extreme right) meant extreme deviance of the parameter evaluated.1,14

Digital VLS recordings were rated two times with the time interval of 1 year by three experienced laryngologists/phoniatrians. To evaluate interrater and test-retest reliability, the intra-class correlation coefficients (ICCs) were calculated, and moderate-to-almost perfect levels (ICC 0.46–0.90) of interrater reliability were revealed for most of the basic VLS parameters. The ICC of the test-retest reliability was 0.71–0.95, *P* < 0.001, respectively.

To verify the reliability of visual-perceptive measurements of distinct VLS parameter—glottal closure—objective analysis of frozen VLS images was performed and relative glottal area—RGA (RGA = glottal area of the maximum opening [GAmax]/glottal area of maximum closure [GAmim]) was calculated. Detailed description of the investigation of reliability of VLS parameters, sensitivity, and specificity of VLS parameters separating normal voice and pathological voice groups was presented in our previous study elsewhere.13

Voice assessment
Vocal function was evaluated using a multidimensional set of perceptive, acoustic, aerodynamic, and subjective measurements.

| TABLE 1. Demographic Data of the Study Group |

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Number (n = 108)</th>
<th>Female (n = 58)</th>
<th>Male (n = 50)</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyp</td>
<td>30</td>
<td>12</td>
<td>18</td>
<td>44.2 ± 11.8</td>
</tr>
<tr>
<td>Nodules</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>38.0 ± 11.5</td>
</tr>
<tr>
<td>Cyst</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>32.3 ± 8.5</td>
</tr>
<tr>
<td>Reinke’s hyperplasia</td>
<td>9</td>
<td>9</td>
<td>0</td>
<td>52.7 ± 8.5</td>
</tr>
<tr>
<td>Carcinoma</td>
<td>11</td>
<td>0</td>
<td>11</td>
<td>58.8 ± 5.7</td>
</tr>
<tr>
<td>Vocal fold paralysis</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>54.3 ± 13.8</td>
</tr>
<tr>
<td>Keratosis</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>54.1 ± 14.2</td>
</tr>
<tr>
<td>Papillomatosis</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>38.0 ± 21.4</td>
</tr>
<tr>
<td>Normal voice</td>
<td>26</td>
<td>15</td>
<td>11</td>
<td>30.8 ± 10.9</td>
</tr>
</tbody>
</table>

*Abbreviations:* *x*, mean; SD, standard deviation.