Phonation Threshold Flow Measurements in Normal and Pathological Phonation

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Abstract

Background: Phonation threshold flow (PTF) may provide a tool to assess laryngeal function and could differentiate between normal and pathological voices.

Methods: The Kay Elemetrics Phonatory Aerodynamic System (PAS) was used to collect mean flow rate (MFR) and PTF measurements from 40 normal subjects, 21 patients with vocal fold nodules, and 23 patients with vocal fold polyps. Gender based differences were assessed using a t-test. The effect of vocal pathology on PTF and MFR was determined with an ANOVA. Diagnostic potential was evaluated using a receiver operation characteristics (ROC) analysis.

Results: Both PTF (p=0.047) and MFR (p=0.008) were significantly affected by gender. Using a two-way ANOVA and correcting for gender differences, the influence of pathology on PTF was determined to be significant (p<0.001). Post-hoc tests found a significant difference between normal and polyp subjects (p=0.001), but not normal and nodule subjects (p=0.177) or nodule and polyp subjects (p=0.246). ROC analysis found that PTF (AUC=0.691) and MFR (AUC=0.684) had a similar diagnostic utility.

Conclusions: PTF can be used to differentiate between normal and pathological voices. As a parameter which is experimentally sensitive to the biomechanical parameters providing its theoretical basis, it could be used clinically to analyze laryngeal functionality. Future research could focus on measuring PTF in other pathologies, such as paralysis or scarring, which would also affect the effort required to produce voice.

Introduction

• Aerodynamic parameters reflect vocal health (1,2) and can be used to differentiate normal from pathological voices (2,3)
• Phonation threshold pressure (PTP) reflects ease of phonation (4), but can be difficult to measure
• Phonation threshold flow (PTF) is the minimum flow needed for phonation (5)

U_{flow} = \sqrt{R_{V} \cdot R_{p} \cdot P_{f}}

• Polyps and nodules increase airflow by preventing complete glottal closure (6)
• PTF is sensitive to changes in glottal abduction and hydration (7,8)
• Flow can be measured more easily than pressure
• Extraoral flow transducer and airflow mask (5)

Subjects

• 40 normal; 21 with vocal fold nodules; 23 with vocal fold polyp
• Subjects were age- and gender-matched

Methods

Experimental design

• Subjects phoned constant /a/ into tube at 72 dB to measure MFR
• Subjects phoned at soft intensity and decreased intensity over three to five seconds until phonated ceased (Fig. 1)
• Airflow at time where SPL = 50 dB was recorded as PTF

Data analysis

• Two-way ANOVA and Bonferroni post-hoc tests for inter-group MFR and PTF comparisons
• ROC analysis to evaluate diagnostic utility

Subjects were age- and gender-matched

Experimental design

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• Subjects phoned at soft intensity and decreased intensity over three to five seconds until phonated ceased (Fig. 1)
• Airflow at time where SPL = 50 dB was recorded as PTF

Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>n</th>
<th>Age (years)</th>
<th>MFR (L/s)</th>
<th>PTF (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Male</td>
<td>21</td>
<td>33.8 ± 11.5</td>
<td>0.11 ± 0.04</td>
<td>0.05 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>19</td>
<td>35.5 ± 12.2</td>
<td>0.15 ± 0.09</td>
<td>0.06 ± 0.04</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40</td>
<td>34.6 ± 11.7</td>
<td>0.13 ± 0.07</td>
<td>0.06 ± 0.03</td>
</tr>
<tr>
<td>Nodule</td>
<td>Female</td>
<td>12</td>
<td>42.3 ± 10.2</td>
<td>0.13 ± 0.07</td>
<td>0.06 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>11</td>
<td>43.2 ± 5.76</td>
<td>0.34 ± 0.18</td>
<td>0.16 ± 0.09</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>23</td>
<td>42.7 ± 8.20</td>
<td>0.23 ± 0.17</td>
<td>0.11 ± 0.08</td>
</tr>
<tr>
<td>Polyps</td>
<td>Female</td>
<td>21</td>
<td>39.3 ± 8.99</td>
<td>0.16 ± 0.07</td>
<td>0.08 ± 0.05</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>11</td>
<td>43.2 ± 5.76</td>
<td>0.34 ± 0.18</td>
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<td>0.11 ± 0.08</td>
</tr>
<tr>
<td>Overall</td>
<td>Female</td>
<td>33</td>
<td>38.0 ± 10.7</td>
<td>0.16 ± 0.11</td>
<td>0.08 ± 0.06</td>
</tr>
</tbody>
</table>

Table 1. Summary statistics for subjects in normal, nodule, and polyp groups. All numbers presented as mean ± standard deviation. n = sample size; MFR = mean flow rate; PTF = phonation threshold flow.

Discussion

Trends and experimental design

• Data collected from normal and pathological subjects provide support for PTF as a parameter which could be used to assess both normal and pathological voices (Figs. 2, 3)
• Significant difference in PTF between males and females
• Could be attributed to males having longer vocal fold; PTF is proportional to vocal fold length
• 8 subjects were tested, but 14 did not appear to adhere to study protocol
• Due to post-pharyngeal expiratory airflow peak, recorded PTF was greater than MFR
• Possible that experiment disrupted normal respiratory rhythm and these subjects felt urge to exhale upon trial completion
• Attempts to minimize potential confounding effects
• Airflow tube used instead of mask to eliminate variability associated with mask placement
• Trial length kept below five seconds to avoid vocal fatigue

Clinical potential of PTF

• PTF is easier to measure and more sensitive to abduction than PTP
• Combining PTF and PTP to find threshold power may be optimal approach
• ROC analysis demonstrated PTF has comparable diagnostic utility to MFR (Fig. 4)
• Significant difference not found between subjects with polyps and subjects with nodules
• There was a discernible difference (polyps=0.11±0.08; nodules=0.08±0.05) (Table 1)
• Additional studies with improved measurement precision and increased sample size could find significant differences
• PTF is theoretically (5) and experimentally dependent upon laryngeal health and tissue characteristics

References


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