“Hot Potato Voice” in Peritonsillitis: A Misnomer

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Summary: The “hot potato voice” is widely recognized as a symptom of peritonsillar cellulitis or abscess; yet there have been no studies assessing the resonance characteristics of the vocal tract in peritonsillitis. Analysis was undertaken of formant frequencies in the articulation of the vowels /i:/, /a:/, and /u:/ in six subjects with peritonsillitis and compared with articulation once the peritonsillitis had settled. Significant variation was found in F1 when articulating /i:/ and in F2 when articulating /a:/, which are explainable by dyskinesis of the peritonsillar musculature. These findings were compared with six subjects articulating the same vowels with and without a hot potato in their mouth. Variation was found in both F1 and F2 when articulating /i:/, which can be related to interference of the potato with movement of the anterior tongue. The changes in the vocal tract differ in these two cases and the title “hot potato voice” in peritonsillitis is a misnomer.

Key Words: Formant—Hot potato voice—Peritonsillitis—Peritonsillar abscess—Vocal tract.

INTRODUCTION

Voice changes are a well-recognized symptom in patients suffering from peritonsillitis, whether due to abscess (quinsy) or peritonsillar cellultis. The voice is said to be thick and muffled and is described as a “hot potato voice,” because it is believed to resemble the voice of someone with a hot potato in his or her mouth. There have been very few studies analyzing the profile and characteristics of the voice changes in tonsillitis or peritonsillitis and none that have compared these changes with those that occur with a hot potato in the oral cavity.

Voice is modified from the vocal fold generator by the resonating characteristics of the vocal tract, comprising the pharynx, oral cavity, and nasal tract. The shape of the vocal tract is determined by movement of the articulators, specifically the mandible, tongue, lips, and pharyngeal wall. The opening of the velopharyngeal valve will include the nasal tract in the resonator system. Alteration in the shape of the vocal tract modifies its sound transfer characteristics such that many frequencies will be attenuated and only a few allowed to pass through relatively unhindered. Those frequencies that do pass through at high amplitude are termed formant frequencies and characterize the sound that is produced. Formant frequencies (F) are numbered sequentially, and the first four or five are of importance in voice research. The first two formants (F1...
and F2) determine the actual sound produced, and the higher formants (F3, F4, and F5) determine the personal voice timbre of the speaker. Formant frequencies cannot be accurately attributed to precise or particular movements of the articulators, but some generalizations can be made. The frequency of all formants is reduced by a lengthening or increased cross-sectional area of the vocal tract, but F1 is particularly sensitive to such a change. F2 is more affected by the shape and position of the tongue; when the tongue position creates a constriction within the oral cavity or oropharynx, F2 rises in frequency, but when the oral cavity is widely patent, F2 will fall. Formant frequencies for a particular sound do vary from person to person, but they should be fairly consistent for the same person articulating the same sound.

Periodic continuous sounds such as vowels are well suited for comparative analysis of the function of the vocal tract resonator, as with vowel articulation the tract can generally be modeled as a single tube chamber. The vowel sounds /i:/ (as in seed), /a:/ (as in far), and /u:/ (as in blue) are well suited to analysis as their formant frequencies are mutually exclusive (the “vowel triangle”) and because the position of the articulators in the production of these sounds has been determined by radiological assessment in Fant’s classic treatise. In /i:/ there is a high F2 frequency and a low F1 due to a constricted oral cavity and a wide pharyngeal cavity, created by protrusion and elevation of the tongue (Figure 1). In /a:/, the reverse is true; F2 is low because the oral cavity is large, and F1 is high because the pharyngeal cavity is short and narrow, created by depression of the mandible and of the tongue (Figure 2). In /u:/, both F1 and F2 are lowered by elongation of the vocal tract from protrusion of the lips and by retraction of the tongue (Figure 3).

The effects of the faucial tonsils and the peritonsillar tissues on the shape and function of the vocal tract resonator, and therefore the voice, are not well understood. Tonsillectomy seems to have few permanent effects on speech, but marked hypertrophy of the tonsils (without inflammation) may physically interfere with the function and competence of the velopharyngeal valve and therefore lead to hypernasal speech. There have been no studies to look at changes in vocal tract resonance with tonsillitis or peritonsillitis.

We undertook to analyze the voice changes in peritonsillitis in terms of alteration in formant frequencies. We also wished to compare these changes with those of a true hot potato voice, where a hot potato is placed in the oral cavity. Based on previous work, the resonance of the vocal tract would be expected to alter in peritonsillitis due to a failure of the velopharyngeal valve, but we surmised that there would be a differing change in the resonance characteristics of the vocal tract with a true hot potato voice.

**METHODS**

Two groups of participants were analyzed in this study. The first group was formed of ten consecutive adult patients who were admitted to our
hospital with peritonsillitis or peritonsillar abscess between May and July 2004. All such patients voluntarily underwent recording of their articulation of the vowels /i:/, /a:/, and /u:/ within 24 hours of admission using Speech Studio software (Laryngograph, London, U.K.). Tonsillar size was graded according to the Brodsky scale. All patients were successfully treated with intravenous antibiotics and drainage of peritonsillar abscess where this was present. These patients then underwent repeat analysis of formant articulation at least 14 days after their symptoms had settled, hence forming their own control.

A second group of participants was selected from the staff within our own department and assessed in its articulation of the same three formants. The analysis was subsequently repeated with each of these participants placing a British new potato of approximately 50 g in their oral cavity, warmed by microwave to a “hot” but not uncomfortable temperature.

None of the participants reported any previous speech disorder.

RESULTS

Of the ten participants in this study, all agreed to participate, but only six could return for repeat analysis, and so the remaining four were excluded from the study. The control group was consequently formed also of six volunteers, of comparable age. Formant frequencies were assessed with emphasis on the first two formants, assigned as F1 and F2. Table 1 shows the calculated variance in these formant frequencies between patients with peritonsillitis and their formants once the peritonsillitis has settled (F1/F1c and F2/F2c). Similarly, Table 2...
shows the calculated alteration in formant frequencies for the second group between articulation with and without a hot potato in the mouth—the "true hot potato voice" (F1h/F1c and F2h/F2c).

Statistical analysis was performed on the original formant frequency data using the Wilcoxon rank sum test. For the peritonsillitis group, this demonstrates a statistically significant reduction in F1 for articulation of /i:/ with peritonsillitis and an increase in F2 in the articulation of /a:/ in this group. In the group articulating with a hot potato, significant alterations are found with an increase in F1 and a decrease in F2 when articulating /i:/ with a hot potato. No other frequency changes demonstrated statistical significance.

**DISCUSSION**

The changes in voice that accompany tonsillitis or peritonsillitis have received little attention despite wide recognition of the fact that changes in voice can occur in this disease and the labeling of these changes as a "hot potato voice." There has been no published analysis of the alterations in the resonance characteristics of the vocal tract that may occur with peritonsillitis. This study addresses these issues and compares the findings with those of a "true hot potato" voice.

Finkelstein et al.\(^\text{12}\) observed the effect of peritonsillitis (cellulitis or abscess) on soft palate function by nasendoscopic assessment. They found peritonsillitis to cause a variable failure of the velopharyngeal valve on the side of the inflammation, with nasal escape demonstrated in some cases. This they concluded to be a result of dysfunction of the musculature in the peritonsillar region, rather than a physical interference from the mass of peritonsillar inflammation. From the changes in the appearance of the muscle attachment points within the

**TABLE 1. Formant Variance During Articulation With and Without Peritonsillitis**

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Age</th>
<th>Clinical Findings</th>
<th>Brodsky Grade</th>
<th>F1/F1c</th>
<th>F2/F2c</th>
<th>F1/F1c</th>
<th>F2/F2c</th>
<th>F1/F1c</th>
<th>F2/F2c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>19</td>
<td>Peritonsillitis</td>
<td>IV</td>
<td>0.740</td>
<td>1.161</td>
<td>0.729</td>
<td>1.257</td>
<td>0.725</td>
<td>1.291</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>21</td>
<td>Peritonsillitis</td>
<td>IV</td>
<td>0.976</td>
<td>0.825</td>
<td>0.982</td>
<td>1.023</td>
<td>0.978</td>
<td>0.871</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>16</td>
<td>Peritonsillitis</td>
<td>IV</td>
<td>0.910</td>
<td>0.866</td>
<td>0.983</td>
<td>1.227</td>
<td>1.024</td>
<td>1.427</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>35</td>
<td>Left quinsy</td>
<td>II</td>
<td>0.827</td>
<td>1.298</td>
<td>1.303</td>
<td>1.345</td>
<td>1.305</td>
<td>1.126</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>19</td>
<td>Peritonsillitis</td>
<td>IV</td>
<td>0.949</td>
<td>0.784</td>
<td>0.961</td>
<td>1.463</td>
<td>0.978</td>
<td>0.859</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>32</td>
<td>Peritonsillitis</td>
<td>III</td>
<td>0.953</td>
<td>0.985</td>
<td>1.127</td>
<td>1.070</td>
<td>1.060</td>
<td>2.258</td>
</tr>
</tbody>
</table>

Significance: \(P < 0.05\) Nil Nil \(P < 0.05\) Nil Nil

**Notes:** F1c = first formant frequency with peritonsillitis, F1 = control, formant frequency without peritonsillitis.

**TABLE 2. Formant Variance During Articulation With and Without a Hot Potato**

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Age</th>
<th>F1h/F1c</th>
<th>F2h/F2c</th>
<th>F1h/F1c</th>
<th>F2h/F2c</th>
<th>F1h/F1c</th>
<th>F2h/F2c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>28</td>
<td>1.315</td>
<td>0.637</td>
<td>1.332</td>
<td>1.031</td>
<td>0.937</td>
<td>1.118</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>36</td>
<td>1.049</td>
<td>0.791</td>
<td>0.967</td>
<td>0.966</td>
<td>0.868</td>
<td>0.838</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>32</td>
<td>1.121</td>
<td>0.625</td>
<td>0.785</td>
<td>0.803</td>
<td>1.208</td>
<td>0.679</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>29</td>
<td>1.505</td>
<td>0.670</td>
<td>1.000</td>
<td>0.975</td>
<td>0.975</td>
<td>0.877</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>33</td>
<td>1.059</td>
<td>0.780</td>
<td>1.124</td>
<td>0.864</td>
<td>0.842</td>
<td>1.231</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>27</td>
<td>1.213</td>
<td>0.651</td>
<td>0.977</td>
<td>0.857</td>
<td>0.864</td>
<td>0.855</td>
</tr>
</tbody>
</table>

Significance: \(P < 0.05\) \(P < 0.05\) Nil Nil \(P < 0.05\) Nil Nil

**Notes:** F1h = first formant frequency with hot potato, F1c = control.
soft palate, they concluded that the ipsilateral levator veli palatini muscle, as well as the ipsilateral palatopharyngeus, were most affected by peritonsillitis dyskinesis. The voice changes were found to resolve not immediately on drainage or resolution of peritonsillar inflammation, but within 1 to 3 days, supporting the analysis in this study of patients with peritonsillitis within 24 hours of admission and reanalysis after at least a 14-day interval.

The data presented here of formant analysis in the articulation of /i:/, /a:/, and /u:/ demonstrate notable changes in vocal tract resonance with peritonsillitis. The results that found statistical significance in this study are a consistent reduction in F1 when articulating /i:/ and a consistent increase in F2 when articulating /a:/.

In forming the sound /a:/, the tongue and mandible are depressed to create a large oral cavity, with a constriction point more posteriorly in the oropharynx—between the tip of the velum and the posterior tongue (Figure 2). The velopharyngeal valve seems to be under less strain than in the articulation of /i:/ because the pharyngeal cavity is comparatively narrow, allowing the lateral pharyngeal walls to assist in closure. On this premise F1 would not be expected to alter significantly with failure of the musculature of the peritonsillar tissues as the overall volume of the vocal tract alters little if the velopharyngeal valve achieves closure. If we now look at the F2 formant, we can predict that the diameter of the constriction point in the oropharynx in articulating /a:/ is likely to be the primary determinant of the frequency value of F2. This constriction point is between the tip of the velum and the posterior tongue; the predominant muscle involved in apposition of these structures is likely to be the palatoglossus. Palatoglossus is one muscle that has been demonstrated to exhibit dysfunction in peritonsillitis, and poor contraction of this muscle would lead to a larger gap between the tongue base and the tip of the velum. This would manifest as a reduction in the F2 frequency, as we have demonstrated.

With /u:/, the most important alteration of the resonator is its elongation by protrusion of the lips and retraction of the posterior tongue (Figure 3). The predominant muscles involved in achieving this vocal tract shape are the orbicularis oris and the styloglossus. The movement of these muscles and consequent positioning of articulators should not be affected by peritonsillar inflammation, and the function of the velopharyngeal valve in articulating /u:/ does not seem to be under strain as again the lateral pharyngeal walls can assist in closure. We find neither F1 nor F2 show significant variance in the articulation of /u:/ with peritonsillitis.

The findings of alterations in formant frequencies in peritonsillitis can therefore be related to changes in the shape of the vocal tract resonator, which in turn is explainable by a dyskinesis of the muscles of the peritonsillar tissue. We can...
undertake a similar analysis of alterations in the vocal tract shape with the true hot potato voice, where a hot potato is placed in the oral cavity.

With a hot potato in the mouth we would expect no reason why there should be compromise in the function of the peritonsillar muscles or the dependent velopharyngeal valve. The hot potato will not cause muscular dysfunction as it is not applied to the oropharyngeal wall and is held too anterior in the oral cavity to cause physical interference with the velum. However, a hot potato would be expected to alter the characteristics of the oral cavity resonance through a restriction of movements, especially elevation, of the tongue.

Our findings support this notion. There is no significant change in the frequencies of F1 or F2 with articulation of /a:/, which requires tongue and mandibular depression and apposition of the velum and tongue base; a hot potato should not impede these movements. Similarly there is no significant change in the formants for articulation of /u:/, as neither retraction of the tongue nor protrusion of the lips is affected by a hot potato, which can be held in the anterior oral cavity when forming such a sound. With /i:/, however, the findings are of a consistent increase in the frequency of F1 and a consistent decrease in F2. The change in F1 is the opposite of the alteration in this formant we find with peritonsillitis. Articulation of /i:/ requires the tongue to elevate to constrict the oral cavity anteriorly. The mandible in such articulation is naturally not depressed, so as to not place undue strain on the tongue in achieving this position. With a hot potato, these movements would theoretically be impeded. The hot potato will physically interfere with the elevation and apposition of the anterior tongue to the hard palate, and the potato cannot be held in the posterior oral cavity for fear it may pass back into the oropharynx. Instead the tongue must be held comparatively depressed anteriorly to accommodate the potato, and consequently, the mandible is held in a more depressed position than would be the norm in articulating /i:/ . The failure of the tongue to adequately constrict the anterior oral cavity is reflected as a reduction in the F2 formant frequency. The more depressed position of the mandible leads to a shortening of the resonating chamber of the pharyngeal cavity, because the distance from the larynx to the oral cavity is reduced. This is reflected as an increase in the F1 formant frequency.

There are multiple factors to account for the voice in peritonsillitis, including mass inflammatory effect, dyskinesia, neuropathy, and soft tissue displacement, which we have found to be too variable and difficult to quantify. We also appreciate that this is a small cohort of patients, but this is a preliminary study of the effects of peritonsillitis on speech, and despite a small sample size, we have demonstrated statistically significant alterations in the resonating characteristics of the vocal tract. We have also demonstrated these changes to be different from those that occur with a hot potato in the mouth. A larger study, which could include direct assessment of the function of articulators and extend formant analysis to the higher formants, would be useful to confirm the findings presented here and to analyze some of the more subtle alterations in formant frequencies that may occur with peritonsillitis.

CONCLUSIONS

The alterations in formant frequencies in articulating /i:/, /a:/, and /u:/ with peritonsillitis have been shown to be a reduction in F1 in articulating /i:/ and an increase in F2 in articulating /a:/. These are explainable by changes in the shape of the vocal tract through dysfunction of the peritonsillar musculature. In a true hot potato voice, however, the changes are an increase in F1 and a reduction in F2 in articulating /i:/ . This is related to interference with the anterior tongue function from the physical presence of the potato. These changes in vocal tract function and resonating characteristics are not synonymous, and we suggest the term “hot potato voice” in the context of voice changes consequent to peritonsillar inflammation is a misnomer.

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REFERENCES


