Utility of Eating Assessment Tool–10 in Predicting Aspiration in Patients with Unilateral Vocal Fold Paralysis

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Abstract

Objective. Examine the incidence of penetration/aspiration in patients with unilateral vocal fold immobility and investigate the relationship with self-reported perception of dysphagia.

Study Design. Case series with chart review.

Setting. Academic cancer center.

Subjects and Methods. Adult patients with unilateral vocal fold immobility diagnosed between 2014 and 2016 were reviewed. Patients were stratified into an aspiration group and a nonaspiration group using objective findings on flexible endoscopic evaluation of swallowing, as scored using Rosenbek’s Penetration Aspiration Scale. Objective findings were compared to patient perception of dysphagia. Bivariate linear correlation analysis was performed to evaluate correlation between Eating Assessment Tool–10 scores and presence of aspiration. Tests of diagnostic accuracy were calculated to investigate the predictive value of Eating Assessment Tool–10 scores on aspiration risk.

Results. Of the 35 patients with new-onset unilateral vocal fold immobility were evaluated, 25.7% (9/35) demonstrated tracheal aspiration. Mean ± SD Eating Assessment Tool–10 scores were 19.2 ± 13.7 for aspirators and 7.0 ± 7.8 for nonaspirators (P = .016). A statistically significant correlation was demonstrated between increasing Eating Assessment Tool–10 scores and Penetration Aspiration Scale scores (r = 0.511, P = .002). Diagnostic accuracy analysis for aspiration risk in patients with an Eating Assessment Tool–10 score >9 revealed a sensitivity of 77.8% and a specificity of 73.1%.

Conclusion. Patient perception of swallowing difficulty may have utility in predicting aspiration risk. An EAT–10 of >9 in patients with unilateral vocal fold immobility may portend up to a 5 times greater risk of aspiration. Routine swallow testing to assess for penetration/aspiration may be indicated in patients with unilateral vocal fold immobility.

Keywords
dysphagia, vocal fold immobility, aspiration, swallow outcomes

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While the impairment of phonation that occurs as a result of unilateral vocal fold immobility (UVFI) has been well characterized in the literature, its contribution to detriment in swallowing has been less thoroughly elucidated. An incidence of aspiration of 23% to 53% in patients with UVFI has been reported, the etiology of which is hypothesized to be multifactorial, with decreased laryngopharyngeal sensation and loss of motor airway protective mechanisms thought to play prominent roles.1 The resultant ineffective airway protection exposes the lungs to the potentially devastating sequelae of aspiration pneumonitis or pneumonia.2

Given that dysphagia describes a symptom rather than a diagnosis, it is important to determine if objective evidence of swallowing impairment accompanies patients’ subjective complaints of dysphagia.3 Previous studies have examined the ability of questionnaires of this type to screen for swallowing dysfunction and aspiration risk.3-6 The Eating Assessment Tool–10 (EAT-10) is a validated, self-administered, symptom-specific outcome tool developed to document and monitor dysphagia symptom severity and treatment efficacy (Table 1).3,4

Similarly, there have been several clinician-rated instruments used to objectively describe penetration or aspiration events during videoflouroscopic swallowing studies (VFSS)

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or flexible endoscopic evaluation of swallowing (FEES).\textsuperscript{7-10} Rosenbek’s Penetration Aspiration Scale is an 8-point interval scale used to describe aspiration and penetration events based on the degree to which material passes into the airway and whether it is subsequently expelled (\textbf{Table 2}).\textsuperscript{11}

Patients who complain of dysphagia may undergo objective evaluation that reveals a spectrum of swallowing impairment, from no swallow dysfunction to gross aspiration.\textsuperscript{1} Given the increased possibility of perturbances in laryngeal motor and sensory function in patients diagnosed with UVFI, there may be a disparate correlation between subjective patient-reported dysphagia symptoms and clinician-reported objective findings of aspiration and/or penetration. The purpose of this investigation was to determine the incidence of aspiration in this patient population and to evaluate the relationship of subjective measures of dysphagia in patients with UVFI to documented events of aspiration during direct laryngeal visualization of swallowing.

\section*{Methods}

\subsection*{Study Design}

This study was approved by the Institutional Review Board of Fox Chase Cancer Center (FCCC). The charts of patients diagnosed with UVFI at an academic cancer center who had undergone FEES by a certified speech-language pathologist between January 2014 and January 2016 were prospectively recorded in an electronic database. From this database, patients with complete EAT-10 scores and FEES data were identified. Individuals were excluded if they had a history of head and neck radiation, had suspected vagus nerve injury of central origin (eg, cerebrovascular accident), lacked EAT-10 or Penetration-Aspiration Scale (PAS) scores at the time of initial FEES, or were lost to follow-up. The purpose for excluding the population of previously irradiated patients and those with central vagal dysfunction was to limit the impact of more complex swallowing disorders not limited to injury of the recurrent laryngeal nerve. Abstracted data included patient demographics, oncologic diagnosis, etiology of UVFI, side of UVFI, EAT-10 score, and PAS score on FEES. The time interval between onset of UVFI and initial evaluation was not available for analysis.

The worst PAS score across all consistencies tested during FEES was selected for analysis. Using a classification schema similar to Cheney et al, aspirators were defined as those patients with a PAS $\geq 5$, while nonaspirators were those patients with a PAS $<6$.

\section*{Statistical Methods}

Baseline patient characteristics were analyzed through descriptive statistics as mean $\pm$ standard deviation (SD). Discrete variables were then compared using a \(\chi^2\) test of independence. Mean EAT-10 for the groups with and without aspiration was compared using a Wilcoxon rank-sum test.

To identify an optimal EAT-10 value as the cutoff for risk and predictive assessment of aspiration, we calculated the sensitivity, specificity, positive likelihood ratios, negative likelihood ratios, positive predictive values, negative predictive values, and diagnostic odds ratios for each point in the EAT-10 scale, similar to the approach of Regan and Regan.\textsuperscript{12} While the mean EAT-10 of nonaspirators was 7, using the approach described above allowed us to determine that an EAT-10 value of 10 afforded the most accurate predictive value for our patient cohort.

The relative risk and 95\% confidence interval (CI) for the association between an EAT-10 $>9$ and the incidence of aspiration on FEES were calculated. Bivariate linear correlation analysis was performed for the association between EAT-10 score and presence of aspiration. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and relative risk (RR) of aspiration were calculated. SPSS Statistics 24 (SPSS, Inc, an IBM Company, Chicago, Illinois) was used for all statistical analyses.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{To What Extent Are the Following Scenarios Problematic for You?} & 0 = No Problem & 4 = Severe Problem \\
\hline
1. My swallowing problem has caused me to lose weight. & 0 & 1 & 2 & 3 & 4 \\
2. My swallowing problem interferes with my ability to go out for meals. & 0 & 1 & 2 & 3 & 4 \\
3. Swallowing liquids takes extra effort. & 0 & 1 & 2 & 3 & 4 \\
4. Swallowing solids takes extra effort. & 0 & 1 & 2 & 3 & 4 \\
5. Swallowing pills takes extra effort. & 0 & 1 & 2 & 3 & 4 \\
6. Swallowing is painful. & 0 & 1 & 2 & 3 & 4 \\
7. The pleasure of eating is affected by my swallowing. & 0 & 1 & 2 & 3 & 4 \\
8. When I swallow food sticks in my throat. & 0 & 1 & 2 & 3 & 4 \\
9. I cough when I eat. & 0 & 1 & 2 & 3 & 4 \\
10. Swallowing is stressful. & 0 & 1 & 2 & 3 & 4 \\
\hline
\textbf{Total EAT-10} & 0 & 1 & 2 & 3 & 4 \\
\hline
\end{tabular}
\caption{Eating Assessment Tool–10 (EAT-10).\textsuperscript{a}}
\end{table}

\textsuperscript{a}A version of the Eating Assessment Tool–10, a 10-item self-administered instrument validated by Belafsky et al\textsuperscript{4} and used to assess subjective dysphagia complaints.
values <.05 were considered statistically significant for all analyses.

**Results**

The initial electronic database query yielded 52 patients diagnosed with UVFI; all charts were reviewed; 17 patients were excluded due to incomplete EAT-10 or PAS data or lack of follow-up. A total of 35 patients were included in the statistical analysis. Patient demographic data for the overall patient cohort, including age, sex, side of UVFI, and etiology of UVFI, are detailed in Table 3. Etiologies of immobility in our study varied from thoracic malignancy causing compression or direct invasion of the recurrent laryngeal nerve in 20 patients (57.1%), iatrogenic injury from thoracic surgical procedures in 10 patients (28.6%), metastatic disease to the lungs causing nerve compression or invasion in 2 patients (5.7%), and unknown in the remainder. In total, 8.6% of patients (3 patients) were restricted from oral intake at the time of initial FEES.

All patients underwent swallowing evaluation with liquid, pureed, and solid consistencies, with the worst PAS score being included in the statistical analysis. In total, 72.2% (25/35) of patients demonstrated no evidence of aspiration (PAS ≤ 6) and were found to have a mean EAT-10 of 7.0 ± 7.8 (range, 0-24). This was found to be statistically significantly different from the remaining 25.7% (9/35) of patients who demonstrated some degree of aspiration (PAS > 6) with a mean EAT-10 of 19.2 ± 13.7 (range, 0-40), as detailed in Table 4.

Bivariate linear correlation analysis revealed a statistically significantly correlation between EAT-10 and PAS scores for the entire cohort (r = 0.511, P = .002). Tests of diagnostic accuracy, including sensitivity, specificity, PPV, NPV, and RR, were calculated for all points on the EAT-10 scale to define the EAT-10 cutoff that would provide the most optimal diagnostic accuracy (Table 5). The sensitivity, specificity, PPV, and NPV of an EAT-10 of ≥ 9 in predicting aspiration risk were 77.8%, 73.1%, 50.0%, and 90.5%.

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**Table 2. Final Version of Rosenbek’s Penetration Aspiration Scale.**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material does not enter the airway</td>
</tr>
<tr>
<td>2</td>
<td>Material enters the airway, remains above the vocal folds, and is ejected from the airway</td>
</tr>
<tr>
<td>3</td>
<td>Material enters the airway, remains above the vocal folds, and is not ejected from the airway</td>
</tr>
<tr>
<td>4</td>
<td>Material enters the airway, contacts the vocal folds, and is ejected from the airway</td>
</tr>
<tr>
<td>5</td>
<td>Material enters the airway, contacts the vocal folds, and is not ejected from the airway</td>
</tr>
<tr>
<td>6</td>
<td>Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway</td>
</tr>
<tr>
<td>7</td>
<td>Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort</td>
</tr>
<tr>
<td>8</td>
<td>Material enters the airway, passes below the vocal folds, and no effort is made to eject</td>
</tr>
</tbody>
</table>


**Table 3. Subgroup Analysis of Demographic and Clinical Variables.**

<table>
<thead>
<tr>
<th></th>
<th>All Cases (n = 35)</th>
<th>No Aspiration (n = 26)</th>
<th>Aspiration (n = 9)</th>
<th>Significance^a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD (range)</td>
<td>68.6 ± 12 (64-73)</td>
<td>68.2 ± 12.6 (36-93)</td>
<td>69.6 ± 10.6 (54-86)</td>
<td>.420</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td>.627</td>
</tr>
<tr>
<td>Female</td>
<td>18 (51.4)</td>
<td>14 (53.8)</td>
<td>4 (44.4)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>17 (48.6)</td>
<td>12 (46.2)</td>
<td>5 (55.6)</td>
<td></td>
</tr>
<tr>
<td>Side of VFI, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td>.785</td>
</tr>
<tr>
<td>Right</td>
<td>5 (14.3)</td>
<td>4 (15.4)</td>
<td>1 (11.1)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>29 (82.9)</td>
<td>21 (80.8)</td>
<td>8 (88.9)</td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>1 (2.9)</td>
<td>1 (3.8)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Etiology of VFI, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td>.568</td>
</tr>
<tr>
<td>Thoracic malignancy</td>
<td>20 (57.1)</td>
<td>14 (53.8)</td>
<td>6 (66.7)</td>
<td></td>
</tr>
<tr>
<td>Thoracic surgery</td>
<td>10 (28.6)</td>
<td>7 (26.9)</td>
<td>3 (33.3)</td>
<td></td>
</tr>
<tr>
<td>Metastases^b</td>
<td>2 (5.7)</td>
<td>2 (7.7)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
<tr>
<td>Idiopathic</td>
<td>3 (8.6)</td>
<td>3 (11.5)</td>
<td>0 (0.0)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: SD, standard deviation; VFI, vocal fold immobility.

^aχ^2^ test used to compare discrete variables.

^bMetastases refer to nonthoracic malignancies that have become metastatic to the lungs, resulting in compression or direct invasion of the recurrent laryngeal nerve.
Cheney et al., who demonstrated a linear correlation likely to aspirate.

No aspiration (n = 26) 7.0 ± 7.8 (0-24) .016
Aspiration (n = 9) 19.2 ± 13.7 (0-40)
All (N = 35) 10.2 ± 10.9 (0-40)

Table 6. Diagnostic Accuracy and Relative Risk for Aspiration of EAT-10 Score >9.

<table>
<thead>
<tr>
<th>EAT-10 Score</th>
<th>Aspiration Risk, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>77.8</td>
</tr>
<tr>
<td>Specificity</td>
<td>73.1</td>
</tr>
<tr>
<td>PPV</td>
<td>50.0</td>
</tr>
<tr>
<td>NPV</td>
<td>90.5</td>
</tr>
<tr>
<td>RR (95% CI)</td>
<td>5.25 (1.27-21.69)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; EAT-10, Eating Assessment Tool–10; NPV, negative predictive value; PPV, positive predictive value; RR, relative risk.

Table 5. Penetration/Aspiration Results on Flexible Endoscopic Evaluation of Swallowing.

<table>
<thead>
<tr>
<th>EAT-10 Score</th>
<th>Present (n)</th>
<th>Absent (n)</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;9</td>
<td>7(a)</td>
<td>7(b)</td>
<td>14</td>
</tr>
<tr>
<td>&lt;10</td>
<td>2(c)</td>
<td>19(d)</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>26</td>
<td>35</td>
</tr>
</tbody>
</table>


respectively. Individuals with an EAT-10 of >9 were 5.25 times more likely to aspirate (95% CI, 1.27-21.69), as detailed in Table 6. These calculations suggest that an EAT-10 score of >9 may be a clinically useful threshold for consideration of instrumental evaluation in this patient population.

Discussion

The data in the current investigation provided evidence to suggest that EAT-10 scores from patients with UVFI have a linear correlation with objective findings during endoscopic swallow evaluation. Of the 35 patients diagnosed with UVFI included in this study, 9 (25.7%) demonstrated evidence of tracheal aspiration. These individuals were found to have significantly elevated scores on a self-administered dysphagia questionnaire compared to their counterparts in whom no aspiration was noted on FEES. These findings support the notion that patients with UVFI are at increased risk for swallowing dysfunction and demonstrate the utility of screening tools to investigate the potential for compromised airway protection in this patient population. It is important to note that an EAT-10 of <10 does not abolish the possibility of aspiration in a patient with UVFI, but our data suggest that patients with a score >9 are up to 5.25 times more likely to aspirate.

The results of the present study confirm the findings of Cheney et al., who demonstrated a linear correlation between increasing EAT-10 score and incidence of aspiration, reporting a sensitivity of 71% and a negative predictive value of 89% with regard to aspiration risk for an EAT-10 score >15. Regan et al. also reported similar findings for patients with chronic obstructive pulmonary disease, investigating the predictive utility of an EAT-10 score >9, and demonstrated a diagnostic odds ratio of 38.50. These 2 studies investigated very different patient populations and did not make any comment on the mobility of the vocal folds in their respective cohorts, making direct comparison difficult.

While an expanding body of literature supports the utility of self-administered swallow questionnaires in predicting penetration or aspiration, particularly the EAT-10, none of these instruments were designed as diagnostic modalities. As many as 60% of individuals with vocal fold motion impairments may report dysphagia, and in this series, we found that aspiration was present in 25.7%. Given the panoply of etiologies that may account for UVFI, defining a ubiquitous cutoff point for EAT-10 is difficult. In examining the varied range of cutoff values between the similar studies conducted by Cheney et al. and Regan et al., this point is well illustrated. In those patients with UVFI for whom sensory impairment is more likely, a lower EAT-10 value should raise suspicion in the clinician and prompt swallow evaluation to confirm swallow safety.

Dysphagia in a patient with UVFI is not uncommon and is likely multifactorial in nature. Concomitant impairments of laryngeal motor and sensory mechanisms are likely contributors to this dysphagia. Multiple studies have investigated the incidence of aspiration in patients with UVFI, with numbers ranging from 23% to 53%, likely reflecting the varied patient populations included in these investigations. Given the complex pathophysiology of dysphagia in patients with UVFI, it is difficult to ascribe the etiology of aspiration or penetration to any particular element of motor or sensory dysfunction. While patient-reported measures to quantify dysphagia severity are useful in establishing a base of evidence upon which the rationale for direct laryngeal imaging and treatment efficacy may be based, they may not be sufficient to predict aspiration in patients with UVFI. Clinicians should thus consider more liberal use of direct laryngeal examination via FEES given the possibility of reduced predictive value of patient-reported instruments in patients with UVFI.
There are several methodological limitations to our current study. The limitations inherent to any retrospective study are represented in this study, including lack of follow-up in a number of patients. The small sample size of the present study also makes drawing definitive conclusions difficult, as is made clear by results of statistical analyses.

Conclusion

Individuals with UVFI are at increased risk for swallow dysfunction and the concomitant pulmonary compromise that may follow. Subjective dysphagia demonstrates utility in predicting aspiration risk in this patient population. A linear correlation exists between EAT-10 and PAS scores, with those demonstrating an EAT-10 score >9 possessing up to 5 times greater risk for aspiration. Given the complex etiology of swallow dysfunction in this group, more liberal utilization of objective methods for swallow evaluation should be considered.

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Author Contributions

Steven A. Zuniga, designed study, drafted and edited manuscript, accountable for paper; Barbara Ebersole, designed study, drafted and edited manuscript, accountable for paper; Nausheen Jamal, designed study, drafted and edited manuscript, accountable for paper.

Disclosures

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References