Delineating Swallowing Safety & Efficiency Impairment Profiles in Amyotrophic Lateral Sclerosis.

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BACKGROUND:
- Dysphagia (swallowing impairment) occurs in a reported 85% of ALS patients (Chen and Garrett, 2005) and is characterized by impairments in swallowing safety (swallowed material entering the airway) and efficiency (pharyngeal residue).
- Despite the high prevalence of dysphagia in ALS, the relative appearance and profiles of impairments in swallowing safety vs. efficiency is unknown.

AIMS:
1. Determine profiles of swallowing safety and efficiency in ALS.
2. Determine the relative appearance of unsafe vs. inefficient swallowing in ALS.

METHODS: Participants:
- Eighty individuals with ALS were enrolled in this study.
- Race: 90% Caucasian, 5% African American, 1.3% Asian, 1.3% Native Hawaiian, 2.5% Unknown.
- Disease Onset Type: 50% Spinal, 43% Bulbar, 7% Mixed.

Table 1. Patient Demographics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>63.6</td>
<td>7.0</td>
<td>58 - 85</td>
</tr>
<tr>
<td>ALSFRS-R Total</td>
<td>38</td>
<td>8.7</td>
<td>30 - 48</td>
</tr>
<tr>
<td>ALSFRS-R Bulbar</td>
<td>9.1</td>
<td>2.3</td>
<td>6 - 15</td>
</tr>
<tr>
<td>Disease Duration</td>
<td>26.8</td>
<td>5.0</td>
<td>21 - 109</td>
</tr>
</tbody>
</table>

Procedures: Videofluoroscopic Swallowing Examination:
- A videofluoroscopic swallowing examination (VFSE; Fig. 1) with a standard bolus presentation (Table 2) was completed.
- Two independent and blinded raters analyzed all swallows with a 100% agreement requirement. Discrepancy meetings were used to finalize ratings not in agreement.

Table 2. Standardized Protocol.

<table>
<thead>
<tr>
<th>Bolus Type</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-mL Thin Liquid</td>
<td>3</td>
</tr>
<tr>
<td>Cup Sip Thin</td>
<td>1</td>
</tr>
<tr>
<td>Consecutive Sips Thin</td>
<td>1</td>
</tr>
<tr>
<td>Teaspoon Thin Honey</td>
<td>3</td>
</tr>
<tr>
<td>Teaspoon Paste</td>
<td>2</td>
</tr>
<tr>
<td>½ Cracker w/ Paste</td>
<td>1</td>
</tr>
<tr>
<td>13mm Barium Tablet</td>
<td>1</td>
</tr>
</tbody>
</table>

RESULTS:

Validated Outcomes of Swallowing:
- The worst PAS score across trials was used for statistical analysis and established criteria used for binary safety classifications:
  - Safe Swallowing: Worst PAS = 2
  - Unsafe Swallowing: Worst PAS ≥ 3

Penetration Aspiration Scale:

<table>
<thead>
<tr>
<th>Material</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material does not enter</td>
<td>Safe</td>
</tr>
<tr>
<td>Material enters airway,</td>
<td></td>
</tr>
<tr>
<td>remains above vocal</td>
<td></td>
</tr>
<tr>
<td>fold(s), and is ejected</td>
<td></td>
</tr>
<tr>
<td>from airway</td>
<td></td>
</tr>
<tr>
<td>Material enters airway,</td>
<td>Penetration</td>
</tr>
<tr>
<td>remains above vocal</td>
<td></td>
</tr>
<tr>
<td>fold(s), and is not</td>
<td></td>
</tr>
<tr>
<td>ejected from airway</td>
<td></td>
</tr>
<tr>
<td>Material enters airway,</td>
<td>Aspiration</td>
</tr>
<tr>
<td>contacts the vocal</td>
<td></td>
</tr>
<tr>
<td>fold(s), and is not</td>
<td></td>
</tr>
<tr>
<td>ejected from airway</td>
<td></td>
</tr>
<tr>
<td>Material enters airway,</td>
<td></td>
</tr>
<tr>
<td>passes below vocal</td>
<td></td>
</tr>
<tr>
<td>fold(s), not ejected</td>
<td></td>
</tr>
<tr>
<td>out of airway</td>
<td></td>
</tr>
<tr>
<td>Material enters airway,</td>
<td></td>
</tr>
<tr>
<td>passes below vocal</td>
<td></td>
</tr>
<tr>
<td>fold(s), ejected into</td>
<td></td>
</tr>
<tr>
<td>larynx or out of airway</td>
<td></td>
</tr>
</tbody>
</table>

Swallowing Efficiency:
- The ASPEKT residue component (Steele, 2019) was used to index efficiency.
- Established binary efficiency classifications were derived:
  - Efficient Swallowing: Cup sip total residue = <3%
  - Inefficient Swallowing: Cup sip total residue = ≥3%

ASPEKT area of residue outlines in the valleculae (orange, V), pyriform sinuses (red), PS and extra pharyngeal spaces (yellow, EX) are expressed as a percentage relative to the C2-C4 vertebrate distance squared (blue line).

Statistical Analysis:
- Descriptive statistics and a chi-square analysis were performed.

RESULTS:

Safety Profiles:
- Raw PAS data are presented in Table 3 and safety classifications in Figure 3.
- 60% of patients demonstrated safe swallowing and 40% unsafe swallowing.
- The most common aspiration response profile was silent aspiration (no cough).

Table 3. Raw PAS data.

<table>
<thead>
<tr>
<th>PAS</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:</td>
<td>28</td>
<td>35%</td>
</tr>
<tr>
<td>2:</td>
<td>20</td>
<td>25%</td>
</tr>
<tr>
<td>3:</td>
<td>12</td>
<td>15%</td>
</tr>
<tr>
<td>4:</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>5:</td>
<td>2</td>
<td>2.5%</td>
</tr>
<tr>
<td>6:</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>7:</td>
<td>1</td>
<td>1.3%</td>
</tr>
<tr>
<td>8:</td>
<td>13</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

RESULTS:

Swallowing Efficiency Profiles:

Fig. 4A. Mean percent residue across sites. The vallecular site was noted to have the highest degree of residue and the pyriform the least.

Swallowing Efficiency Profiles:

Fig. 4B. Binary efficiency ratings revealed that 61% of ALS patients had inefficient swallowing.

CONCLUSIONS:
- Unsafe and inefficient swallowing was noted in 40% and 61% of ALS patients respectively.
- Thus, efficiency impairments were more prevalent than safety impairments in this cohort.
- Impairments in swallowing efficiency were four times more likely to be the presenting dysphagia impairment vs. safety impairments.
- These cross sectional data suggest an evolution of dysphagia impairment profiles.
- Future work is needed that incorporates longitudinal research designs to further elucidate these preliminary findings.