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**WILEY**
Predictors of Aspiration Pneumonia and Mortality in Patients with Dysphagia

Nogah Nativ-Zeltzer, PhD; Yuval Nachalon, MD; Matthew W. Kaufman, BA; Indulaxmi C. Seenii, MD; Silvia Bastea, MD; Sukhkarai S. Aulak, MD; Sara Makkayiah, BDS; Machelle D. Wilson, PhD; Lisa Evangelista, CScD; Maggie A. Kuhn, MD, MAS; Mustafa Sahin, MD; Peter C. Belafsky, MD, PhD.

INTRODUCTION
Aspiration pneumonia is a prevalent condition which can result in pulmonary empyema, respiratory failure, and death. Reported mortality ranges from 10% to 70% for various populations. The financial burden of aspiration pneumonia is significant. It results in substantial costs related to longer hospitalization, mechanical ventilation, and poor nutritional status. The majority of aspiration pneumonia cases result from chronic aspiration of food, liquid, or saliva due to oropharyngeal swallowing dysfunction. Despite the high prevalence of aspiration pneumonia, few studies have examined risk factors for aspiration pneumonia in patients with dysphagia. Particularly lacking is knowledge of pneumonia predictive factors in patients who are undergoing a swallowing assessment in an outpatient setting, as most existing studies have focused on hospitalized patients. In 1998, Langmore et al. followed 189 elderly subjects to assess predictors of aspiration pneumonia. Dependence on others for feeding and oral care, number of decayed teeth, tube feeding, polypharmacy, and smoking were identified as independent risk factors for aspiration pneumonia. Dysphagia was found to be an important risk for aspiration pneumonia, but not sufficient to cause pneumonia unless the patient has additional risk factors. Bock et al. reported that patients with deconditioning and generalized dysphagia due to frailty and dementia have substantially increased risk of pneumonia and overall mortality. The paucity of studies examining predictors of pneumonia in individuals with...
dysphagia may result from challenges inherent in such studies, such as difficulties in maintaining long-term follow-up and variability in definitions and documentation of pneumonia. Many patients are diagnosed and treated for pneumonia in the community and these occurrences are not always recorded in the tertiary outpatient center medical records.

Videofluoroscopic swallow studies have become the gold standard for swallowing evaluation and are a common practice in out-patient clinics. Videofluoroscopic swallow study (VFSS) provides an opportunity for a thorough assessment of swallow function and aspiration risk, however, its value in identifying a patient’s risk profile for development of pneumonia is unknown. Identifying pneumonia risk factors will guide swallowing clinicians to integrate these factors into clinical decision-making and recommendations pertaining to patient’s feeding status.

The primary goal of this study was to identify risk factors for the development of pneumonia in patients with dysphagia undergoing a VFSS in an outpatient tertiary-care center. The secondary goal was to identify risk factors for death in patients with dysphagia undergoing a VFSS in an outpatient tertiary-care center.

**MATERIALS AND METHODS**

This study was approved by the UC Davis Institutional Review Board (protocol #868142). All individuals undergoing a VFSS between 10/2/13 and 07/30/15 were identified from an electronic database and followed historically but prospectively for 2 years. Patients under the age of 18 or patients who had undergone a total laryngectomy were excluded from the study. Demographic information, comorbidities, Eating Assessment Tool (EAT-10) questionnaire score, functional oral intake scale (FOIS), and the primary cause of dysphagia at the date of VFSS were obtained. Additionally, the following data were collected from the VFSS: Penetration-aspiration Scale (PAS),

<table>
<thead>
<tr>
<th></th>
<th>No Pneumonia</th>
<th>Pneumonia</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HNC</td>
<td>124 (70.9%)</td>
<td>51 (29.1%)</td>
<td>175</td>
</tr>
<tr>
<td>CVA</td>
<td>27 (73%)</td>
<td>10 (27%)</td>
<td>37</td>
</tr>
<tr>
<td>TBI</td>
<td>11 (73.3%)</td>
<td>4 (26.7%)</td>
<td>15</td>
</tr>
<tr>
<td>Neuro</td>
<td>42 (75%)</td>
<td>14 (25%)</td>
<td>56</td>
</tr>
<tr>
<td>CPMD</td>
<td>223 (82.6%)</td>
<td>47 (17.4%)</td>
<td>270</td>
</tr>
<tr>
<td>Spine Surgery</td>
<td>12 (70.6%)</td>
<td>5 (29.4%)</td>
<td>17</td>
</tr>
<tr>
<td>Esophageal dystomity</td>
<td>26 (76.5%)</td>
<td>8 (23.5%)</td>
<td>34</td>
</tr>
<tr>
<td>GERD</td>
<td>32 (84.2%)</td>
<td>6 (15.8%)</td>
<td>38</td>
</tr>
<tr>
<td>Uncertain etiology</td>
<td>39 (83%)</td>
<td>8 (17%)</td>
<td>47</td>
</tr>
</tbody>
</table>

CPMD = cricopharyngeal muscle dysfunction; CVA = cerebrovascular accident; GERD = gastroesophageal reflux disease; HNC = head and neck cancer; TBI = traumatic brain injury.

**RESULTS**

Six hundred and eighty-nine patients who had undergone a VFSS due to dysphagia were followed for 2 years. The mean age (±standard deviation) of the cohort was 65 (±15.5) years. 49% (338/689) was female. The most common causes of dysphagia were cricopharyngeal muscle dysfunction (270/689), head and neck cancer (175/689), and neurodegenerative disease (56/689) (Table I). The 2-year incidence of death was 11% (77/689). The incidence of pneumonia was 22% (153/689). Older age, presence of tracheotomy, vallecular and pyriform sinus residue, lower FOIS, history of head and neck cancer, reduced UES opening, elevated PAS, and elevated PCR were significantly associated with the incidence of pneumonia in univariate analyses (P < .05) (Table II). A history of hypertension, congestive heart failure, COPD, and kidney disease were all significantly associated with the development of pneumonia (P < .05). Multivariable logistic regression revealed that COPD (odds ratio [OR] = 2.36, 95% confidence interval [CI]: 1.33–4.19), hypertension (OR = 1.82, 95% CI: 1.23–2.73), tracheotomy status (OR = 2.96, 95% CI: 1.09–7.99), and vallecular residue (OR = 1.88, 95% CI: 1.24–2.85) were all significantly associated with the development of pneumonia after adjusting for other risk factors. Kidney disease neared statistical significance (OR = 2.36, 95% CI: 0.85–6.54). The final model was 70% predictive (c = 0.7) of pneumonia development.

Male gender, older age, lower BMI, history of smoking, presence of tracheotomy, higher EAT-10 score, lower (worse) FOIS score, higher PAS score, higher PCR, reduced PES measurements, prolonged hypopharyngeal transit time, vallecular and pyriform sinus residue,
primary diagnosis of dysphagia of either head and neck cancer (HNC), cricopharyngeal muscle dysfunction or gastroesophageal reflux disease (Table III) were all significantly associated with death in univariate analysis. COPD, Neurodegenerative disease, kidney disease, cancer (non-HNC) were also significantly associated with death in univariate analysis. In multivariate regression, the following factors were found to be predictors of mortality: Kidney disease (OR = 1.27, 95% CI: 1.02–9.9), COPD (OR = 3.27, 95% CI: 1.65–6.49), vallecular residue (OR = 2.35, 95% CI: 1.35–4.1), male gender (OR = 2.21, 95% CI: 1.25–3.92), and low BMI (OR: 1.12, 95% CI: 1.06–1.18).
1.19). The final regression model for mortality showed a predictive value of 77% (c = 0.77).

**DISCUSSION**

We examined risk factors for pneumonia development and death in a cohort of 689 patients with dysphagia. Older age, presence of tracheotomy, vallecular and pyriform sinus residue, lower FOIS, reduced UES opening, elevated PAS, and elevated PCR as well as several medical comorbidities were significantly associated with pneumonia in univariate analysis. Although we identified older age as a risk factor for incident pneumonia, previous investigations have conflicting data.\(^{10,12,14}\) Older adults may be more susceptible to developing pneumonia due to lower functional status, age-associated changes in respiratory function, swallowing changes with age, and diminished respiratory clearance.\(^{15,16}\) In our investigation, older age was not associated with pneumonia in the multivariate analysis and additional research is necessary to clarify this association (Table IV).

Higher penetration-aspiration scores were also significantly associated with incidence pneumonia in univariate analysis. The PAS quantifies the depth of airway invasion and the physiologic response to it.\(^{17}\) Patients with PAS scores greater than 5 were 2.2 times more likely to develop pneumonia compared to those with lower scores. This finding is supported by a study reporting a high incidence of silent aspiration in patients with community-acquired pneumonia.\(^{18}\) In a recent study by Bock et al.,\(^{10}\) PAS score was associated with decreased time to first pneumonia occurrence on univariate but not multivariate analysis, however, their study cohort included only patients with a PAS score of 5 or greater. While the PAS provides measurement of some of the characteristics of aspiration severity (depth and response), it does not quantify the amount of aspiration or its frequency. In our investigation, PAS was not associated with pneumonia in the multivariate analysis and additional research is necessary to clarify this association (Table V).

The most predictive factors for pneumonia development were COPD, renal disease, tracheotomy status, hypertension, and presence of pharyngeal residue. Previous research has demonstrated a bi-directional relationship between swallowing dysfunction and COPD; swallow dysfunction is exacerbated by COPD due to impaired swallow-breathing coordination, thereby increasing the risk of aspiration pneumonia, which can worsen pulmonary function.\(^9\) Langmore et al. found that COPD was one of the strongest predictors of pneumonia development in nursing home residents.\(^9\)

Individuals with renal disease are at high risk of developing infections, and pneumonia is the most common infection in this population.\(^{19,20}\) Chou et al.\(^{21}\) found that patients with chronic kidney disease at outpatient settings were at a 1.4-fold higher risk for developing pneumonia compared to those without kidney disease. This risk factor for pneumonia has not been highlighted previously in literature specific to patients with dysphagia and comorbid kidney disease.

The significant association of swallowing metrics derived from the VFSS highlight its clinical value for assessing pneumonia risk. The most predictive factor from the test was the finding of vallecular residue. The presence of residue is likely secondary to weak pharyngeal constriction and tongue base retraction as reflected in the higher (worse) PCR scores in the pneumonia group compared to the no-pneumonia group. Residue in the pharynx has the potential to be aspirated after the swallow, thereby increasing the risk of aspiration pneumonia development. The strength of the association between post-swallow residue and pneumonia may guide clinicians to avoid recommending interventions that can potentially increase residue in patients with evidence of bolus residue on VFSS.

The two-year mortality rate for this cohort was high (11%). The most significant predictors of mortality were kidney disease, COPD, vallecular residue, male gender, and low BMI. Male patients with dysphagia had 2.21 times the risk of dying compared to female patients (p < .01). This difference may be secondary to the increased prevalence of smoking and head and neck cancer in men; however, these factors do not fully explain the gender difference in mortality. Although a low BMI was not significantly associated with an increased risk of developing pneumonia, it was found to be an independent risk factor for death in this population. These findings highlight the importance of nutritional status...
in this patient group. The strong association of increased post-swallow residue in the pharynx with incidence of mortality requires further investigation and may suggest that residue aspirated after the swallow places individuals at risk for life-threatening pulmonary complications.

This study is not without limitations. This was a retrospective study and relies on information from medical records and patient reports which may be subject to recall bias. We also recognize that definitions of a pneumonia event can vary widely in clinical reports and at times can be conflated with other respiratory infections. Also, as with all regression studies, the outcomes may be affected by the variables included in the analysis. It is plausible that additional variables not evaluated in this study, such as history of medical/surgical treatment or dysphagia therapy, may have affected the results of this study. In addition, this study was conducted in a tertiary dysphagia center and thus findings from this study may not be generalizable to other patient groups. It is also possible that a follow-up period longer than 2 years would have resulted in different outcomes, particularly in patients with a medical history of degenerative conditions or radiation therapy for HNC, as their swallow function deteriorates over time. Nonetheless, data from this study suggest individuals with COPD and kidney disease are 2.2 times more likely to develop pneumonia (95% CI = 1.49–4.55, 1.08–7.21 respectively) and individuals with pharyngeal bolus residue were 1.9 times more likely to develop pneumonia. Independent risk factors of mortality were kidney disease (OR = 1.27, 95% CI: 1.02–9.9), COPD (OR = 3.27, 95% CI: 1.65–6.49), vallecular residue (OR = 2.35, 95% CI: 1.35–4.1), male gender (OR = 2.21, 95% CI: 1.25–3.92), and low BMI (OR: 1.12, 95% CI: 1.06–1.19). Clinicians can utilize these findings to counsel patients of their increased risk and to guide joint decision-making regarding oral feeding. Patients with risk factors may also require more frequent monitoring of their pulmonary status.

CONCLUSION

The incidence of aspiration pneumonia (22%) and death (11%) within 2-years of a video-fluoroscopic swallow study was high. The greatest adjusted risk factors for incident pneumonia were tracheotomy (OR = 3.0), COPD (OR = 2.4) and vallecular residue (OR = 1.9). The greatest adjusted risk factors for death were COPD (OR = 3.3), vallecular residue (OR = 2.3), and male gender (OR = 2.2).

BIBLIOGRAPHY