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Predictors of Aspiration Pneumonia and Mortality in Patients with Dysphagia

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Objectives/Hypothesis: To identify risk factors for pneumonia incidence in patients with dysphagia undergoing a videofluoroscopic swallow study (VFSS) in an outpatient tertiary-care center.

Study Design: Historical cohort study.

Methods: All individuals undergoing a VFSS between 10/02/13 and 07/30/15 were identified and followed historically for 2 years. Demographic information, medical history, and fluoroscopic data were collected. The 2-year incidence of pneumonia was obtained from the medical records and telephone interview. The incidence of pneumonia and death were calculated and risk factors for pneumonia and mortality were ascertained.

Results: 689 patients were followed for 2 years. The mean age (±standard deviation) of the cohort was 65 (±15.5) years. 49% (338/689) were female. The most common causes of dysphagia were cricopharyngeus muscle dysfunction (270/689), head and neck cancer (175/689), and neurodegenerative disease (56/689). The incidence of pneumonia was 22% (153/689). The incidence of death was 11%. Multivariable logistic regression revealed that chronic obstructive pulmonary disorder [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 an elevated risk of pneumonia. 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 body mass index (OR: 1.12, 95% CI: 1.06–1.19) were independent adjusted risk factors for death.

Conclusions: The incidence of aspiration pneumonia (22%) and death (11%) within 2-years of a VFSS 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).

Key Words: Risk factors, pneumonia, mortality, swallowing impairment, dysphagia.

Level of Evidence: 4

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INTRODUCTION

Aspiration pneumonia is a prevalent condition which can result in pulmonary empyema, respiratory failure, and death. Reported mortality rates range from 10% to 70% for various populations.[1,2] The financial burden of aspiration pneumonia is significant. It results in substantial costs related to longer hospitalization, mechanical ventilation, and poor nutritional status.[3] The majority of aspiration pneumonia cases result from chronic aspiration of food, liquid, or saliva due to oropharyngeal swallowing dysfunction.[4–7] 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.[8] In 1998, Langmore et al. followed 189 elderly subjects to assess predictors of aspiration pneumonia.[9] 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.[10] The paucity of studies examining predictors of pneumonia in individuals with

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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 10/02/13 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),[11] total pharyngeal transit time (sec), hypopharyngeal transit time (sec), measurement of maximum pharyngoesophageal segment (PES) opening in the lateral fluoroscopic view (PES-L) and anterior–posterior view (PES-AP), hyolaryngeal approximation (HL_comp), and the pharyngeal constriction ratio (PCR), a validated surrogate measure of pharyngeal strength.[12] All parameters aside from the PAS were assessed during the swallow of the 20 cc bolus using Swallowtail software (Belldev Medical, Arlington Heights, IL). PAS was scored from the greatest (most severe) score observed during all study swallows.

Videofluoroscopic Swallow Studies

All subjects underwent the same standardized VFSS protocol established by our center.[12] Participants were initially positioned in the lateral view and administered 1, 3, and then 20 ml of liquid barium (60% weight/volume) in a syringe or medicine cup. This was followed by 3 ml of barium paste and then 60 ml of liquid barium which the patient drank using a straw. The patient was then positioned in the anterior–posterior view and given 3 and 20 ml liquid barium, followed by a 13 mm barium tablet. All VFSS were recorded at 30 frames per second.

Mortality data and the 2-year incidence of pneumonia was obtained from the electronic medical records and telephone interview. Pneumonia was defined as documented "pneumonia" or "chest infection" in the chart or based on patient report of pneumonia that required medical treatment.

Statistical Analysis

Pneumonia and mortality incidence were calculated and risk factors for pneumonia and mortality were evaluated separately using univariate tests followed by multivariable logistic regression for those factors significant at the 0.2 level in univariate analyses. Those variables that were not significant at the 0.2 level in the logistic regression model were removed and a final model was fit. SAS ® for Windows® version 9.4 (SAS Institute Inc., Cary, NC) version 9 and SPSS version 26 (IBM Inc., Armonk, NY) were used for all statistical calculations.

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 cricopharyngeus 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,

TABLE I.
Incidence of Pneumonia by Primary Diagnosis.

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

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

TABLE II.
Statistical Summary of Variables by Pneumonia Incidence.

	No Pneumonia Percent	Pneumonia	*P*-Value
Primary diagnosis			.17
HNC	124 (70.9%)	51 (29.1%)	.01
CVA	27 (73%)	10 (27%)	.85
Neuro	42 (75%)	14 (25%)	.44
CPMD	223 (82.6%)	47 (17.4%)	.08
Spine surgery	12 (70.6%)	5 (29.4%)	.39
Esophageal dysmotility	26 (76.5%)	8 (23.5%)	.57
GERD	32 (84.2%)	6 (15.8%)	.13
Uncertain etiology	39 (83%)	8 (17%)	.28
Gender			.19
Male	263 (75.8%)	84 (24.2%)	
Female	270 (79.9%)	68 (20.1%)	
Smoking			.39
No	297 (78.8%)	80 (21.2%)	
Past	28 (80%)	7 (20%)	
Current	188 (74.3%)	65 (25.7%)	
Trach			.002
No	521 (78.9%)	139 (21.1%)	
Yes	12 (52.2%)	11 (47.8%)	
Vallecular residue			<.001
No	320 (83.6%)	63 (16.5%)	
Yes	191 (69%)	86 (42%)	
Pyriform sinus residue			.001
No	383 (80.6%)	92 (19.4%)	
Yes	129 (68.9%)	58 (31.1%)	
	Mean (SD)		
Age	63.86 (±15.7)	68.7 (14.6)	.001
BMI	26.67 (±6.15)	26.75 (6.6)	.89
PES-L	0.82 (±0.27)	0.77 (0.3)	.09
PES-AP	1.46 (±0.44)	1.36 (0.41)	.01
	Median (IQR)		
EAT-10	15 (7–24)	15 (6–25)	.79
FOIS	6 (5–7)	6 (5–7)	.03
PAS	2 (1–2)	2 (1–5)	<.001
PCR	0.09 (0.04–0.22)	0.12 (0.06–0.3)	.01
HL_comp	3.09 (2.55–3.68)	2.93 (2.24–3.6)	.08
HPtt	0.78 (0.67–0.96)	0.85 (0.7–1.02)	.07
Totaltt	1.11 (0.93–1.4)	1.17 (0.99–1.45)	.29

CPMD = cricopharyngeal muscle dysfunction; CVA = cerebrovascular accident; FOIS = functional oral intake scale; GERD = gastroesophageal reflux disease; HL_comp = hyolaryngeal complex movement; HNC = head and neck cancer; HPtt = hypopharyngeal transit time (sec); IQR = interquartile range; PAS = Penetration Aspiration Scale; PCR = pharyngeal constriction ratio; PES-AP = pharyngoesophageal segment in the anterior–posterior view (cm); PES-L = Pharyngoesophageal segment in the lateral view (cm); SD, standard deviation; Totaltt = total transit time (sec).

TABLE III.
Statistical Summary of Variables by Mortality Incidence.

	Survived Percent	Deceased	*P*-Value
Primary diagnosis			<.001
HNC	137 (78.3%)	38 (21.7%)	<.001
CVA + TBI	49 (94.2%)	3 (5.8%)	.66
Neuro	43 (75.4%)	14 (24.6%)	.003
CPMD	251 (93%)	19 (7%)	.01
Spine surgery	15 (88.2%)	2 (11.8%)	.82
Esophageal dysmotility	33 (97.1%)	1 (2.9%)	.87
GERD	38 (100%)	0 (0%)	.002
Uncertain etiology	43 (91.5%)	4 (8.5%)	.41
Gender			.001
Male	296 (85.3%)	51 (14.7%)	
Female	315 (93.2%)	23 (6.8%)	
Smoking			.01
No	345 (91.5%)	32 (8.5%)	
Past	32 (91.4%)	3 (8.6%)	
Current	212 (83.8%)	41 (16.2%)	
Trach			.04
No	589 (89.2%)	72 (10.8%)	
Yes	17 (73.9%)	6 (26.1%)	
Vallecular residue			<.001
No	357 (93.2%)	26 (6.8%)	
Yes	229 (82.7%)	48 (17.33%)	
Pyriform sinus residue			.001
No	435 (91.6%)	40 (8.4%)	
Yes	153 (81.8%)	34 (18.2%)	
	Mean (SD)		
Age	64.3 (±15.6)	71.6 (±12.8)	<.001
BMI	27.11 (±6.2)	23.4 (±5.3)	<.001
PES-L	0.81 (±0.3)	0.74 (±0.3)	.04
PES-AP	1.5 (±0.43)	1.33 ± (0.48)	.06
	Median (IQR)		
EAT-10	14 (7–23)	20 (8–29)	.03
FOIS	6 (5–7)	5 (4–7)	.01
PAS	2 (1–2)	3 (2–8)	<.001
PCR	0.09 (0.04–0.21)	0.21 (0.09–0.32)	<.001
HL_comp	3.09 (2.54–3.7)	2.8 (2.23–3.37)	.02
HPtt	0.8 (0.67–0.96)	0.85 (0.73–1.15)	.01
Totaltt	1.12 (0.93–1.4)	1.16 (1–1.69)	.1

CPMD = cricopharyngeal muscle dysfunction; CVA = cerebrovascular accident; FOIS = Functional Oral Intake Scale; GERD = gastroesophageal reflux disease; HL_comp = hyolaryngeal complex movement; HNC = head and neck cancer; HPtt = hypopharyngeal transit time (sec); IQR, interquartile range; PAS = Penetration Aspiration Scale; PCR = Pharyngeal constriction ratio; PES-AP = Pharyngoesophageal segment in the anterior–posterior view (cm); PES-L = Pharyngoesophageal segment in the lateral view (cm); SD, standard deviation; Totaltt = total transit time (sec).

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–

TABLE IV.
Multivariable Model For Pneumonia.

	Odds Ratio	95% Confidence Interval	*P*-Value
Tracheotomy	2.955	1.093–7.992	.0328
Hypertension	1.828	1.227–2.725	.0031
COPD	2.363	1.330–4.198	.0034
Kidney disease	2.357	0.850–6.536	.0996
HNC	1.316	0.840–2.063	.2312
CPMD	0.790	0.524–1.191	.2602
PAS	1.064	0.975–1.162	.1658
Residue_vallecula	1.881	1.242–2.849	.0029

COPD = chronic obstructive pulmonary disorder; CPMD = cricopharyngeal muscle dysfunction; HNC = head and neck cancer; PAS = Penetration Aspiration Scale.

TABLE V.
Multivariable Model for Mortality.

	Odds Ratio	95% Confidence Interval	*P*-Value
Cancer	0.789	0.404–1.541	.4883
Renal	0.314	0.101–0.976	.0452
Neuro	0.516	0.243–1.096	.0852
COPD	0.306	0.154–0.606	.0007
Residue_val	0.426	0.245–0.740	.0025
Gender	0.452	0.255–0.803	.0067
BMI	0.889	0.840–0.940	<.0001

BMI, body mass index; COPD = chronic obstructive pulmonary disorder.

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.[10,13,14] 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 ivestigation, 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).

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