Dysphagia (2019) 34:210–219
https://doi.org/10.1007/s00455-018-9926-3

ORIGINAL ARTICLE

Post-extubation Dysphagia: Does Timing of Evaluation Matter?

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Received: 29 September 2017 / Accepted: 17 July 2018 / Published online: 24 July 2018

Abstract

Swallowing evaluations are often delayed at least 24 h following extubation with the assumption that swallow function improves over time. The purpose of this prospective cohort study was to determine if dysphagia, as measured by aspiration and need for diet modification, declines over the first 24-h post-extubation, whereby providing evidence-based evaluation guidelines for this population. Forty-nine patients completed FEES at 2–4 h post-extubation and 24–26 h post-extubation. We compared Penetration–Aspiration Scale scores and diet recommendation between time points. Multivariable logistic regression models were created to investigate associations between age, reason for admission, reason for intubation, and a history of COPD and outcomes of aspiration or silent aspiration at either FEES exam. Sixty-nine percent of participants safely swallowed at least one texture without aspiration at 2–4 h post-extubation. Within participants, there was a significant decrease in penetration/aspiration at 24 h and 79% showed improvement in airway protection on at least one bolus type, suggesting an improvement in swallow function over the first day following extubation. These findings suggest that although patients may be safe to begin a modified diet soon after extubation, delaying evaluation until 24-h post-extubation may allow for a less restricted diet.

Keywords Deglutition · Deglutition disorders · Dysphagia · ICU · Intubation · Endotracheal tube

Background

Patients are at risk for oropharyngeal dysphagia following prolonged endotracheal intubation, which is typically defined as intubation for 48 h or longer [1–7]. Estimates of post-extubation dysphagia incidence vary widely in the literature from 3 [8] to 93% [9], likely due to inconsistent definitions of dysphagia, heterogeneity of the populations studied, variable evaluation time points, and differences in assessment [7, 10]. Prospective studies using fiberoptic endoscopic evaluation of swallowing (FEES) have reported incidence of aspiration ranging from 22 to 56% [1, 5, 11, 12] following extubation, with silent aspiration (aspiration without a cough response) occurring in 17–36% of patients. Post-extubation dysphagia is associated with poor patient outcomes including pneumonia, hospital mortality, and increased length of stay [13] but the paucity of evidence means that best practice guidelines regarding how and when to evaluate swallow function post-extubation do not exist [7].

A recent survey of speech pathologists (SLPs) in the U.S. found the median interval between extubation and swallowing assessment is 24 h [14]. It has been postulated that a patient's risk for aspiration will decrease over the course of the first 24 h as a result of laryngeal recovery, improved respiratory function, and improved mental status [7]. However, there is a lack of evidence to support the widespread clinical practice of postponing swallowing evaluations until 24-h post-extubation.

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This prospective observational cohort study was designed to determine if dysphagia, as measured by penetration/aspiration on FEES and need for diet modifications, decreases between 4 and 24 h after extubation within patients. We hypothesized that aspiration would be more prevalent and diets would be more restricted at the earlier evaluation.

Methods

Study Design and Setting

We conducted a prospective cohort study of patients receiving mechanical ventilation via an endotracheal tube for greater than 48 h between February 2013 and April 2015 in a 24-bed mixed medical/surgical ICU at a 565-bed academic medical center. The University of Wisconsin Institutional Review Board (IRB) approved this study.

Patients

Patients with endotracheal intubation > 48 h and approval of the treating physician were approached for participation in this study. Exclusion criteria included pre-existing or comorbid neurological disease, history of oropharyngeal dysphagia, head/neck cancer or surgery, facial fractures, need for continuous noninvasive positive pressure ventilation following extubation, *nil per os* status for reasons other than aspiration risk, elevated bleeding risk (INR $>$ 2.0, $<$ 50,000 platelets per microliter, or partial thromboplastin time greater than 1.5 times normal), inadequate alertness, or agitation. All patients in the ICU were screened for eligibility by the primary investigator while intubated. Informed consent was obtained from all participants or their surrogate decision maker prior to extubation at the request of the IRB due to the short window of time between extubation and study evaluation. Those patients without decision-making capacity for whom a surrogate decision maker consented and who regained decisional capacity prior to completion of study procedures were offered the opportunity to consent for themselves. Slow accrual was due to the stringent inclusion/exclusion criteria and challenges of achieving surrogate consent prior to extubation.

Investigations

Study participants underwent FEES 2–4 h after extubation. The procedure was repeated 24–26 h after extubation in participants in whom penetration or aspiration was seen on at least one trial during the first exam. To maintain consistency with clinical practice and to prevent unnecessary procedures at the request of the IRB, FEES was not repeated in patients without penetration/aspiration on the first exam. The majority of exams (114/117) were completed by the primary investigator, a SLP with 6 years of experience performing and analyzing FEES. The remaining exams were completed by one of the two additional SLPs with 3–10 years of experience completing FEES. The SLP completing the FEES was aware of the patient's history and purpose of the study. Participants were administered consistencies in the following order: 5 mL honey-thick milk, 10 mL honey-thick milk, 5 mL nectar-thick milk, 10 mL nectar-thick milk, 5 mL thin milk, 10 mL thin milk, 90 mL thin milk, and 5 mL vanilla pudding. All liquid volumes were administered via syringe with the exception of the 90 mL volume which was administered via straw. Vanilla pudding was administered via spoon. All volumes were administered twice with the exception of the 90 mL volume which was administered once. Because these patients were critically ill, liquid trials were discontinued when the SLP deemed it unsafe to continue based on clinical judgment (e.g., severity of aspiration or inability to eject aspirated material). As a result, all participants received at least one honey-thick milk and one pudding bolus. After completion of the protocol, the SLP performing the FEES was free to test postural strategies (e.g., chin tuck, head turns) or feeding strategies (e.g., single sips, alternating solids/liquids). These additional swallows were used to determine diet recommendation but were not scored by raters.

FEES equipment consisted of KayPentax Swallowing Workstation (PENTAX, New Jersey, USA), with a FNL10RP3, 3 mm nasoendoscope and camera (Watec Incorporated, New York, USA).

Data Sources

Participant demographic information was collected before the first FEES from the electronic medical record and included patient sex, age, duration of intubation, reason for intubation (respiratory failure, surgery, airway protection, cardiac arrest), reason for hospital admission (respiratory, trauma, advanced liver disease, sepsis, other), and comorbidities. Comorbidities varied and were grouped into categories including heart disease, chronic liver disease, chronic kidney disease, chronic lung disease, and active malignancy. Solid and liquid diet recommendations made by the SLP that completed each FEES were also collected. Liquid diets included thin (unrestricted), thin with chin tuck (other strategies/postures were trialed per standard of care but no other postures were recommended by treating SLP), nectar, honey, and no liquids (most restricted). Solid diets included general (unrestricted), advanced, diced, minced, puree, and no solids (most restricted).

Deidentified FEES recordings were reviewed by two graduate SLP students who were trained in FEES ratings. The KayPentax Swallow Workstation automatically converted images to digital video formats using a compression rate of 8:1. FEES were randomized and raters were blinded to the purpose of the study, participant's history, and time of FEES (i.e., 2–4 h FEES vs. 24–26 h FEES). Raters attended a training focused on rating FEES using the Penetration–Aspiration Scale, an eight-point scale of airway invasion [15] which has been shown to be reliable for FEES ratings [16]. Each rater was required to rate 20 swallows selected from the available FEES clips with 90% or better agreement with the primary investigator's ratings prior to rating study clips. Raters were asked to assign a Penetration–Aspiration Score (PAS) for each bolus type (e.g., 5 mL honey-thick liquid), ranging from 1 (no airway invasion) to 8 (silent aspiration) (Table 1). For the boluses administered twice, raters were instructed to select the worst (i.e., highest) PAS. Disagreement between raters was resolved by a third rater, an experienced SLP who was not involved in data collection and was also blinded to patient's history and time of FEES.

In cases where the liquid portion of the study was terminated due to aspiration, the last PAS rating was extrapolated to subsequent liquid volumes (e.g. PAS 7 on 5 mL nectar was applied to subsequent volumes of nectar and thin boluses). This scoring method was selected because participants in this study were critically ill and it was unsafe to continue to expose them to repeat aspiration for study purposes. PAS scores were condensed into a three-point scale of airway invasion: normal (PAS 1–2), penetration (PAS 3–5), and aspiration (6–8) [17].

Statistical Analysis

We planned to enroll 100 participants, since we estimated that approximately 25% of the participants would not meet the post-extubation criteria and therefore would not be eligible to participate, leaving 75 remaining participants. We estimated that 80% of participants would aspirate during the initial swallow study, and also accounted for 10 potential 'dropouts' between the first and second FEES, leaving approximately 50 subjects. The maximum width of a large sample 95% confidence interval for the percentage with improvement would be 27.72% and the maximum width of a 90% Wilson score confidence interval would be 22.66% based on these 50 participants.

Within-participant comparisons were made using the Sign test and by calculating percent improvement. The Sign test analyzed differences in the three-point airway invasion score (normal, penetration, aspiration) between FEES for each bolus type. Percent of improvement between exams was also calculated by determining the percent of boluses with improved airway invasion score at the second FEES for each participant (e.g., moving from aspiration to penetration, penetration to normal, or aspiration to normal). For example, participants who had improvement in airway protection on the two honey-thick boluses and two nectar-thick boluses but no change on the three thin boluses or pudding bolus had improvement on 4/8 boluses or a 50% improvement.

For between-participant analysis, aspiration was dichotomized into aspiration (PAS of 6–8) on any trial versus no aspiration. Silent aspiration was dichotomized into silent aspiration (PAS 8) on any trial versus no silent aspiration across all trials. Fisher's exact test was used to determine if sex, reason for admission, or a history of COPD were predictors of aspiration on at least one bolus or silent aspiration on at least one bolus. Satterthwaite t tests were used to answer the same question for age and duration of intubation. Significance level was $p < 0.05$.

Multivariable logistic regression models were created to investigate associations between patient factors and outcomes of aspiration or silent aspiration at either the first or second FEES. Variable selection for these models was informed by bivariate analyses as well as a priori selection. Models included age, admitting diagnosis, reason for intubation, and a history of COPD (regardless of whether

Table 1 Ratings of airway invasion

Description	PAS	Airway invasion
Material does not enter airway	1	Normal
Material enters airway, remains above the vocal folds, and is ejected	2	
Material enters airway, remains above the vocal folds, and is not ejected	3	Penetration
Material enters the airway, contacts the vocal folds, and is ejected	4	
Material enters the airway, contacts the vocal folds, and is not ejected	5	
Material enters the airway, below the vocal folds, and is ejected	6	Aspiration
Material enters the airway, below the vocal folds, and is not ejected despite effort	7	
Material enters the airway, below the vocal folds, and is not ejected, no effort	8	

this contributed to reason for intubation). Odds ratios were converted to risk ratios, since the outcomes of interest did not satisfy the rare outcome assumption [18].

Results

Participants

Ninety-four patients or their surrogates provided consent for participation prior to extubation. Sixty-eight patients completed the first FEES and 49 completed both exams. Reasons for not undergoing the second FEES included functional swallow, development of one or more exclusion criterion, and patient declining the second evaluation (Table 2).

Mean participants age was 56.4 years. Twenty-six were women (38.2%). Mean duration of intubation was 118.6 h. Respiratory failure was the most common indication for intubation and a respiratory diagnosis was the most common reason for hospital admission (Table 3).

Comparison Between FEES Exams (Between-Participant Analysis)

Aspiration was observed on at least one volume in 57% (39/68) of participants during the first FEES and 59% (29/49) during the second FEES. Sixty-nine percent (47/68) of participants were recommended for an oral diet after the first FEES, with 22% (15/68) recommended for a general diet with thin liquids (with or without chin tuck) and 47% (32/68) recommended for a modified diet (i.e., solid or liquid restrictions due to dysphagia). Seventy-six percent (37/49) were recommended for an oral diet after the second FEES, with 14% (7/49) recommended for a general diet with thin liquids (with our without chin tuck) and 61% (30/49) recommended for a modified diet.

Table 2 Reasons for not completing first or second FEES

Reason	*n*
Reason for not completing first FEES after consent (26/94)	
Patient death	5
Need for tracheostomy	4
Patient declined after extubation	3
Extubation outside of SLP coverage hours	3
Elevated bleeding risk	3
Extubation to NIV	3
Reduced level of alertness	2
Made NPO by treating physician	1
New stroke on MRI	1
Error in recording FEES	1
Reason for not completing second FEES after completing first (19/68)	
Functional swallow at first FEES (PAS = 1)	9
Patient declined second FEES	4
Worsened hypoxemia	3
NPO in anticipation of surgery	1
Reduced level of alertness	1
Made NPO by treating physician	1

SLP speech pathologist, *NIV* noninvasive ventilation

Comparison Between FEES Exams (Within-Participant Analyses; *N* = 49)

Analysis of individual bolus types (e.g., 5 mL honey-thick) revealed that a majority of participants, ranging from 65 to 91% depending on bolus type, had either no change or improvement (moving from aspiration to penetration, penetration to normal, or aspiration to normal) in airway protection at the second exam for all bolus types (Fig. 1). Improvement between FEES was statistically significant for 5 mL honey-thick ($p = 0.008$), 10 mL honey-thick ($p = 0.03$), 5 mL nectar-thick ($p = 0.004$), 5 mL thin ($p = 0.03$), and pudding ($p = 0.03$).

Eighty percent of participants (39/49) showed improved airway protection on at least one bolus type at the second FEES, and among those that improved, the mean percent improvement was 43% (standard deviation 20%). Twenty percent (10/49) did not show improved airway protection on any bolus type. Sex, age, duration of intubation, reason for intubation, reason for admission, and a history of COPD were not significantly associated with percent improvement.

Fifty-one percent of subjects had improvement in their solid diet recommendation between the two FEES and 47% had improvement in their liquid recommendation. Of those that improved, the majority improved on one solid diet level (e.g. moving from puree to minced diet) and two liquid levels (e.g. moving from honey-thick to thin liquids) (Fig. 2). Two participants' diets were downgraded; both exhibited a decline in mental status between evaluations.

Aspiration and Silent Aspiration (Between-Participant Analysis, *N* = 68)

Aspiration was observed on at least one volume in 68% (46/68) participants during at least one FEES exam. Bivariate analysis found that reason for admission was significantly associated with aspiration on the first FEES, with patients in the "other" category being most likely to aspirate at the first exam (9/11), followed by liver (7/9), trauma (8/11), respiratory (11/21), and sepsis (4/16) ($p = 0.02$) and similar pattern seen at the second exam: "other" (7/7) followed by liver (5/7), sepsis (5/8),

Table 3 Demographics and clinical characteristics

Variable	First FEES (n = 68)	Both FEES (n = 49)
Female sex, n (%)	26 (28%)	20 (41%)
Age in years, mean (SD)	56.4 (14.2)	57.3 (13.7)
Duration of intubation in hours, mean (SD)	118.6 (72.8)	116.0 (73.2)
Reason for admission		
Respiratory, n (%)	21 (31%)	18 (37%)
Sepsis, n (%)	16 (23%)	8 (16%)
Trauma, n (%)	11 (16%)	9 (18%)
Liver disease, n (%)	9 (13%)	7 (14%)
Other*, n (%)	11 (16%)	7 (14%)
Reason for intubation		
Respiratory failure, n (%)	44 (65%)	34 (69%)
Surgery**, n (%)	16 (23%)	8 (16%)
Airway protection, n (%)	6 (9%)	5 (10%)
Cardiac arrest, n (%)	2 (3%)	2 (4%)
Comorbidities***		
Heart disease, n (%)	12 (18%)	9 (18%)
Chronic liver disease, n (%)	11 (16%)	9 (18%)
Chronic kidney disease, n (%)	11 (16%)	7 (14%)
Chronic lung disease, n (%)	19 (28%)	17 (35%)
Active malignancy, n (%)	5 (7%)	3 (6%)

*Includes the following reasons for hospital admission: renal mass, cardiac arrest, heart failure, thoracic aortic aneurysm, drug overdose, diabetic ketoacidosis, and cervical fusion

**Type of surgery: abdominal (n = 8), vascular (n = 4), trauma/other (n = 4)

***Some participants had no relevant comorbidities and some had more than one comorbidity

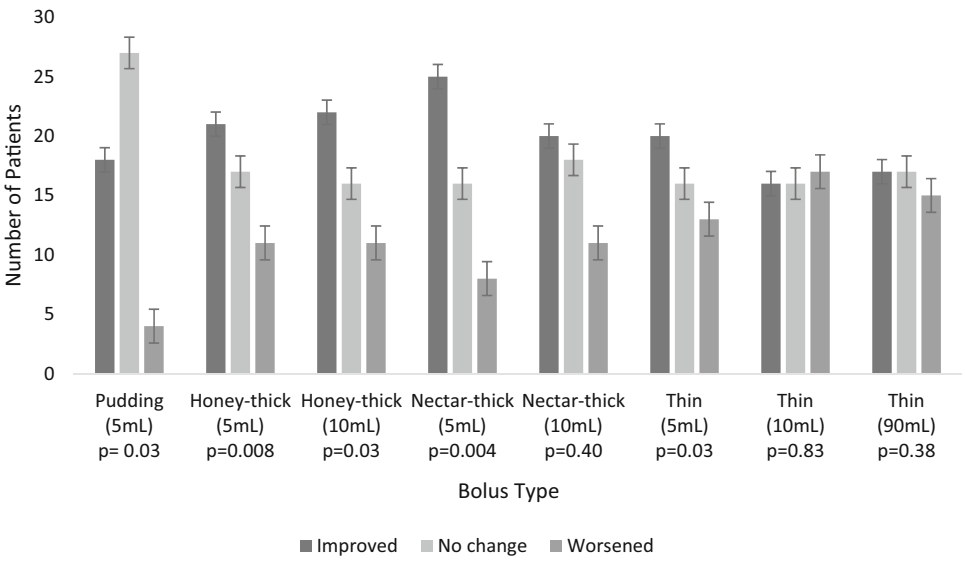

Fig. 1 Change in airway invasion score (normal, penetration, aspiration) between first and second FEES (improved, no change, worsened) in each consistency trial

respiratory (9/18), and trauma (3/9), though at the second examination the association between admission diagnosis and aspiration was not statistically significant across groups (p = 0.07). Sex, age, reason for intubation, duration of intubation, and history of COPD were not associated with aspiration at either evaluation time.

Multivariable models revealed that reason for admission and history of COPD were significantly associated with aspiration during either exam (Table 4). Participants admitted with advanced liver disease or trauma were 60% more likely to aspirate. Participants with a history of COPD were also 60% more likely to aspirate. There was no

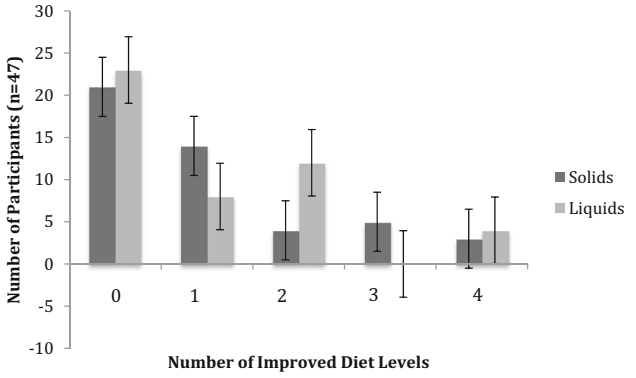

Fig. 2 Change in solid and liquid restrictions between the first FEES (2–4 h post-extubation) and second FEES (24–26 h post-extubation)

statistically significant association between age or reason for intubation and aspiration.

Silent aspiration (aspiration without a cough response) was seen on at least one trial in 56% (38/68) of participants. Bivariate analysis found that age, reason for admission, and a history of COPD were associated with silent aspiration at both FEES exams. Participants with silent aspiration on the first FEES were older (mean age of 60.8 vs. 53.5 years, $p = 0.04$), as were participants with silent aspiration on the second FEES (61.1 vs. 53.4 years, $p = 0.05$). Participants with a history of COPD were also more likely than those without a history of COPD to silently aspirate at the first FEES (66.7 vs. 32.1%, $p = 0.03$) and the second FEES (83.3 vs. 40.5%, $p = 0.02$). Participants admitted for a liver diagnosis were most likely to silently aspirate on the first exam (7/9), followed by "other" reason for admission (6/11), trauma (5/11), respiratory failure (7/21), or sepsis (2/16) ($p = 0.02$). A similar pattern was seen at the second FEES with silent aspiration seen most frequently in participants admitted for a "other" reason (7/7), followed by liver diagnosis (5/7), respiratory failure (9/18), sepsis (2/8), and trauma (2/9) ($p = 0.01$). Sex, reason for intubation, and duration of intubation were not significantly associated with silent aspiration.

Multivariable analysis revealed that age, reason for admission, reason for intubation, and a history of COPD were each significantly associated with silent aspiration during either exam (Table 4). Participants age 65 or older were twice as likely to silently aspirate, as were participants admitted with advanced liver disease or trauma, and participants with history of COPD. Participants intubated for surgery or airway protection were substantially less likely to silently aspirate that those intubated for respiratory failure.

The most challenging trial, 90 mL thin liquid, was not administered to all participants due to aspiration on earlier trials. Of those that did receive this volume, 36% (19/53) had silent aspiration on at least one FEES. None of the previously mentioned participant factors were significantly associated with silent aspiration on the 90 mL volume.

Discussion

In this prospective cohort study, we found that the majority of participants that completed both evaluations had improvement in swallow function between 4 and 24 h following extubation, as measured by a reduction in penetration/aspiration seen on FEES and fewer diet restrictions within patients. This supports the hypothesis that swallowing function begins improving relatively quickly

Table 4 Multivariable analysis of associations** between demographic, clinical factors and aspiration, silent aspiration at first or second FEES evaluation

Variable	Risk of aspiration***		Risk of silent aspiration	
	Risk ratio (95% CI)	p	Risk ratio (95% CI)	p
Age 65 years or older	1.5 (1.0–1.6)	0.07	2.0 (1.3–2.1)	0.01*
Admitting diagnosis				
Respiratory	Referent	–	Referent	
Advanced liver disease	1.6 (1.1–1.6)	0.02*	2.1 (1.7–2.2)	< 0.01*
Trauma	1.6 (1.1–1.6)	0.03*	2.0 (1.1–2.2)	0.04*
Sepsis	1.2 (0.6–1.6)	0.44	0.8 (0.19–1.8)	0.75
Other	1.5 (0.8–1.6)	0.12	1.8 (0.72–2.1)	0.14
Intubated for surgery or airway protection	0.5 (0.1–1.1)	0.08	0.01 (0.01–0.60)	0.01*
Diagnosis of COPD	1.6 (1.1–1.6)	0.03*	2.1 (1.5–2.2)	< 0.01*

*$p < 0.05$

**Multivariable logistic regression, with odds ratios converted to risk ratios

***Aspiration defined as PAS of 6, 7, or 8; Silent aspiration defined as PAS of 8

following extubation. The clinical implications of this finding, however, are not as clear.

On one hand, the fact that the majority of patients demonstrated improvement in their dysphagia as shown by reduction in penetration/aspiration and improved diets at the later evaluation suggests that waiting until 24-h post-extubation to evaluate swallowing would result in less aspiration and fewer diet restrictions. Because it is not feasible or cost-effective to routinely repeat FEES within 24 h on the same patient, holding the evaluation until closer to 24 h may increase the likelihood of the patient safely taking an oral diet. On the other hand, it is unclear whether the magnitude of the reduction in dysphagia over 24 h is clinically significant. Sixty-nine percent of patients were recommended for an oral diet at the earlier evaluation, implying that the majority of extubated patients are safe to begin oral alimentation the same day as extubation and that routinely performing earlier instrumental evaluations would result in faster resumption of oral nutrition and medication, reducing the need for temporary enteral access placement and tube feeding. It is easy to conceive that this would be preferable for patients, even if the clinical benefits of this reduced delay to oral intake are uncertain. In addition, the majority of patients only improved one diet level over the first 24 h (e.g. moving from honey-thick to nectar-thick liquids). It is unclear whether this small improvement justifies delaying the evaluation. While practice guidelines should not be based on single study, our results suggest that best practice may fall somewhere in the middle, with early evaluations for low-risk patients and postponing evaluations for higher risk patients until closer to 24-h post-extubation.

Although it was not the primary aim of our study, our results may offer insights into risk stratification. Factors that were shown to increase risk for both aspiration and silent aspiration were advanced age, a history of COPD (even if this was not the reason for ICU admission) as well as admission for liver disease or trauma. When we review our results within the context of previously published dysphagia research, it is not surprising that age increased risk for aspiration, as this has been shown in several other studies examining post-extubation dysphagia [3, 5, 6, 19, 20]. This may be due to the fact that elderly patients are at increased risk for baseline dysphagia [21, 22] and that even healthy elderly patients without clinically significant dysphagia have changes to their swallowing mechanics [23–25]. These deficits could be exacerbated by either the overall impact of critical illness or the local impact of the endotracheal tube on the larynx and pharynx. Similarly, our observed association between COPD and a higher likelihood of post-extubation dysphagia may be explained by pre-existing but undiagnosed dysphagia related to poor coordination of breathing and swallowing or pre-existing laryngeal sensory impairment [26, 27] both of which may be exacerbated by recent mechanical ventilation. Our results also found a significant association between both admission for liver disease and trauma and aspiration/silent aspiration, though the number of patients in each category was small. These patient populations require further study prior to making generalizations about their risk for post-extubation dysphagia.

In addition to these factors, patients intubated for respiratory failure were more likely to silently aspirate than those intubated for either surgery or airway protection. It is possible that patients intubated for respiratory failure were intubated more emergently and under less controlled conditions than those intubated for surgery or airway protection, and as a result sustained more trauma to their pharynx and larynx during the intubation. Previous research has suggested that patients intubated for respiratory failure have a high rate of complications [28] and increased laryngeal trauma could contribute to reduction in airway closure during swallowing and reduced sensory feedback needed for adequate timing of swallowing mechanics and cough response to aspiration. Further investigation is warranted.

Duration of intubation has previously been shown to increase risk for post-extubation dysphagia [2, 3, 6, 13, 19, 20], but our study did not find increased risk with increased duration of intubation. The majority of previous studies used clinical swallowing evaluations as their method of assessment which rely heavily on signs of aspiration such as cough, throat clearing, or wet voice to assess for aspiration. It is possible that clinical swallowing evaluations may yield more false positives due to hoarse or breathy vocal quality that mimics wet voice. In fact, our results add to the evidence from multiple studies using FEES that showed no association between duration of intubation and aspiration [1, 5, 11]. This could be explained by the direct visualization of aspiration that is possible during FEES, reducing reliance on signs of aspiration that have low specificity. On the other hand, the previously mentioned studies that found an association between duration of intubation and dysphagia were larger with between 150 and 909 participants, while our study only had 68 participants, and previous studies with FEES had between 51 and 84 participants. These smaller samples may not be large enough to find a statistically significant differences and therefore, longer duration of intubation should still be considered a risk factor for post-extubation dysphagia. Another possible explanation for the lack of association between dysphagia and duration of intubation in our study and other studies using FEES [1, 5, 11] is that we excluded patients that were intubated fewer than 48 h. Prior research in cardiac surgery patients showed an increased risk for dysphagia in patients intubated longer

than 48 h [20] and prior research in patients with neurologic impairment found that intubation longer than 7 days (168 h) was associated with moderate-severe dysphagia [13]. The mean duration of intubation in our cohort was 119 h. Perhaps the increased risk for dysphagia with increased duration of intubation plateaus and therefore was not measured in our cohort of patients with prolonged intubation.

Our study also highlights the high risk for silent aspiration in recently extubated patients. Previous studies completing FEES in this population have shown lower rates of silent aspiration (17–25%) [1, 12] than our study. One possible reason is that our FEES were completed within 26 h of extubation, which is generally earlier than other published literature, which would identify more patients with silent aspiration if this risk dissipates in the days following extubation. Our results also challenge the widely held belief that silent aspiration is extremely unlikely when patients are challenged with large volumes such as 90 mL [29]. The surprisingly high rate of silent aspiration with 90 mL volume raises concern about the sensitivity of a 90-mL water challenge in recently extubated patients. Further research on the 90-mL water challenge in recently extubated patients, also known as the Yale Swallow Protocol, is needed. For the time being, the high percentage of silent aspiration seen in recently extubated patients, both in our study and previous studies, highlights the importance of instrumental assessments in this population, particularly in high risk patients. FEES has previously been shown to be well tolerated by other acute care populations [30], and may be even better tolerated in recently extubated patients due to reduced sensation from the recent intubation. In addition, it can be performed at the patient's bedside and gives immediate data on swallow timing, airway invasion, laryngeal closure, and residue which are the most commonly impaired areas of swallowing in recently extubated patients [11], making it an excellent tool for evaluating swallow function in the ICU.

Our study does have several limitations that warrant discussion. Not all participants completed both FEES exams. Nineteen patients (28%) completed the first FEES but did not complete the second FEES. Nine of those patients (13%) were not offered a FEES due to a functional swallow seen on first exam; we felt comfortable with the assumption that they would have no reason to have an increase in dysphagia related to their intubation with additional time post-extubation. Ten additional patients (15%), however, did not complete the second FEES for other reasons, either by choice or due to change in medical status. It is impossible to say whether their swallowing function would have showed the same improvement as the other patients who completed the protocol in its entirety and if and how exclusion of these patients influenced our findings. Secondly, because it was unsafe to subject patients to repeated aspiration for research, not all participants completed all bolus viscosities during each FEES. The SLP preforming the FEES used their clinical judgement on when to terminate liquid trials based on severity of aspiration. PAS scores were then extrapolated for all subsequent trials. We felt comfortable with this method of scoring as this is the assumption that is typically used in clinical practice, however, because individual swallows vary, it is possible that aspiration would not necessarily have occurred on all subsequent trials. Third, our protocol only followed patients for 26-h post-extubation. It is possible that further improvements would be seen with additional time, which would be clinically relevant information in evaluation and treatment planning in this population. Fourth, we excluded patients with known risk factors for dysphagia. Therefore, it is unclear if the findings generalize to specialized ICU populations such as stroke. Fifth, there are additional variables that may influence post-extubation aspiration that were not measured during our study including type and dosing of sedative medications and presence of nasogastric tubes. Sixth, the speech pathologist making diet recommendations was not blinded to the patient's history or time of evaluation, which may have biased the recommendations. Lastly, the primary outcome variable used was the PAS, which, while a validated tool for rating airway invasion, may not be adequate in measuring clinically significant change. Future studies looking at additional outcomes such as laryngeal sensory response, pharyngeal residue, or amount of patient intake may offer additional insight.

Conclusion

It is a common clinical practice to delay swallowing evaluation until 24 h or longer post-extubation based on the assumption that swallowing function will improve over these first 24 h. Our findings confirm this hypothesis that swallow function starts to improve relatively quickly post-extubation; however, 69% of patients were recommended for an oral diet within 4 h of extubation based upon FEES evaluation. Concomitantly, the high rate of aspiration observed at both the early (2–4 h) and later evaluations (24–26 h) highlights the importance swallowing assessment in recently extubated patients. Lastly, the high rate of silent aspiration also supports the need for instrumental swallowing assessment, particularly in vulnerable ICU patients.

Acknowledgements The authors would like to acknowledge Glen Leverson, PhD, for his assistance with statistical analysis.

Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflicts of interest.

Ethical Approval All procedures performed were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the University of Wisconsin Institutional Review Board.

Informed Consent Informed consent was obtained from all participants or their surrogate prior to participating in this research study.

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