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The Accuracy of the Bedside Swallowing Evaluation for Detecting Aspiration in Survivors of Acute Respiratory Failure

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Abstract

Background—Dysphagia with subsequent aspiration occurs in up to 60% of acute respiratory failure (ARF) survivors. Accurate bedside tests for aspiration can reduce aspiration-related complications while minimizing delay of oral nutrition. In a cohort of ARF survivors, we determined the accuracy of the bedside swallowing evaluation (BSE) and its components for detecting aspiration.

Methods—Patients who were extubated after 24 hours of mechanical ventilation were eligible for enrollment. Within three days of extubation, patients underwent comprehensive BSE including 3-ounce water swallowing test (3-WST), followed by a gold standard test for aspiration, flexible endoscopic evaluation of swallowing (FEES).

Results—45 patients were included in the analysis. Median patient age was 55 years (IQR=47–65). Median duration of mechanical ventilation was 3.3 days (IQR 1.8–6.0). 14 patients (31%) aspirated on FEES. Physical exam findings on BSE and abnormal swallowing during trials of different consistencies were variably associated with aspiration. Compared to FEES, the 3-WST yielded a sensitivity of 77% (95%CI=50–92%), specificity of 65% (95%CI=47–79%), and AUC=0.71; an SLP's recommendation for altered diet yielded a sensitivity of 86% (95%CI=60–96%), specificity of 52% (95%CI=35–68%), and AUC=0.69; an SLP's recommendation for NPO yielded a sensitivity of 50% (95%CI=27–73%), specificity of 94% (95%CI=79–98%), and AUC=0.72.

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Conclusions—The BSE and its components, including the 3-WST, demonstrated variable accuracy for aspiration in survivors of ARF. Investigation to determine the optimal non-invasive test for aspiration in ARF survivors is warranted.

Clinical Trials Registration—ClinicalTrials.gov Identifier: NCT02363686, Aspiration in Acute Respiratory Failure Survivors

Background

For the 455,000 survivors of acute respiratory failure (ARF) each year, aspiration is a devastating complication that can develop after initiating oral nutrition[1]. Previous studies have shown that up to 60% of ARF survivors are at risk for aspiration after extubation. Up to 25% aspirate “silently,” without signs on clinical exam[2–8]. Aspiration is associated with pneumonia, feeding tube and tracheostomy placement, longer ICU and hospital stay, and increased hospital mortality[9–16]. Yet, delaying oral nutrition is associated with prolonged enteral tube feeding and increased health-related costs[17]. The ability to easily and accurately diagnose aspiration in ARF survivors could minimize complications of aspiration while limiting unnecessary delay of oral feeding.

In most hospitals, speech and language pathologists (SLPs) determine when ARF survivors can resume oral feeding[18]. SLPs commonly use bedside assessments to provide feeding recommendations in this population[18]. The tools used vary between hospitals and SLPs, from simple screening exams like the 3-ounce water swallowing test (3-WST), to comprehensive bedside swallowing evaluations (BSEs). BSE is a history and physical examination followed by assessment of the patient’s ability to swallow boluses of different consistencies, and may include tools like 3-WST. SLPs do not routinely perform gold standard tests such as videofluoroscopic swallow study (VFSS) or flexible endoscopic evaluation of swallowing (FEES)[18]. This is partially due to concerns about safely transporting critically ill patients to radiology for VFSS and lack of equipment or expertise for FEES[18].

Previous reports have examined the accuracy of BSE to detect aspiration. However, those studies focused on patients recovering from stroke or included a heterogeneous population. None focused exclusively on ARF survivors. Suggested mechanisms for aspiration after mechanical ventilation include “unlearning” of muscle memory, residual sedative medication effects, and injury to the mucosa or peripheral nerves from the endotracheal tube[8, 19–23]. Due to differing mechanisms of aspiration in other populations, some predictive components of BSE may not apply to ARF survivors[24–27]. In a cohort of ARF survivors, we evaluated the accuracy of the following bedside tests to detect aspiration: the BSE physical examination, BSE trials of different consistencies, 3-WST, and SLP recommendations based on the overall BSE. We used FEES as the gold standard assessment of aspiration.

Materials and Methods

We prospectively enrolled patients at a single university-affiliated tertiary referral center. Patients were eligible if they were: a) 18 years old, b) mechanically ventilated for ≥ 24

hours, and c) extubated. Exclusion criteria included tracheostomy, 72 hours since extubation, preexisting dysphagia, history of head or neck surgery/radiation, contraindication to oral nutrition, or presence of a neurological disease that could acutely impair swallowing. The patient or surrogate decision maker signed an informed consent form for participation. The Colorado Multiple Institutional Review Board (COMIRB Panel B, COMIRB #12-0184 APP001-2) approved this study.

Bedside Swallowing Evaluation

An SLP reviewed the patient's medical record and performed an exam, starting with the clinician's judgement of lip movement and seal; tongue movement and strength; volitional cough strength; dentition; voice quality; and amount of assistance required with feeding. The patient was seated as upright as possible. The SLP then administered five standard consistencies. When possible, boluses were administered from lowest to highest aspiration risk: 1) 1 tsp ice chips, 2) 1 tsp nectar-thick liquids, 3) 1 tsp pureed solids (applesauce or vanilla pudding), 4) 5 ml thin liquids (water or milk), and 5) solids (¼ graham cracker or ½ saltine). The SLP watched for five pre-defined signs of aspiration after each bolus:

Cough: A cough or choking sound within 10 seconds.

Throat clearing: Presence of throat clearing within 10 seconds.

Change in vocal quality: Vocal quality was dichotomized as normal/abnormal. Development of abnormal vocal quality within 10 seconds was a positive finding.

Wet breath sounds: Gurgling is a low/medium-pitched rattling sound on inhalation or exhalation. Development of gurgling within 10 seconds was a positive finding.

Stridor: Stridor is a harsh vibrating sound on inhalation or exhalation. Development of stridor within 10 seconds was a positive finding.

Breath sounds and stridor were assessed by auscultating over the thyro-cricoid space or listening to the patient's breathing without a stethoscope. If any of the five signs occurred, the trial of that consistency was recorded as consistent with aspiration. A decrease in pulse oximetry >3% at any point during BSE was recorded. A bolus could be withheld if the SLP had safety concerns.

Following the trials of varying consistencies, the SLP administered the 3-WST. The 3- WST could be withheld for safety concerns. Patients undergoing 3-WST received three ounces of water and were instructed to drink the entire amount without interruption via cup or straw[28–30]. Criteria for a positive 3-WST were: inability to drink the entire amount, cough or choking up to 1 minute afterwards, or change in vocal quality. Finally, the SLP documented diet recommendations and whether instrumental testing (VFSS or FEES) was indicated.

The accuracy of the overall BSE was assessed using two different definitions of aspiration. The first was a more liberal definition: patients recommended any alteration in their diet, including NPO, had a positive BSE for aspiration; patients recommended a "normal diet" (regular solids and thin liquids) had a negative BSE. The second definition was stricter:

patients recommended to be NPO had a positive BSE; patients allowed oral intake had a negative BSE.

A second SLP or study investigator who was blinded to the BSE subsequently performed the FEES. At the discretion of the SLP/investigator, intranasal lidocaine spray could be administered before laryngoscope insertion. The SLP/investigator then administered the same five consistencies and amounts as on BSE. After each swallow, the laryngoscope was advanced to closely view the airway for 10 seconds before recording the results of that trial. If necessary, patients could drink water between trials to clear remaining residue. Each FEES trial was scored using the Penetration Aspiration Scale (PAS) (Table 1 [31]). The primary outcome of FEES was presence of aspiration (PAS $\geq$ 6) on any consistency.

After enrollment, chart review was performed. Basic demographic information such as age, race, and gender were collected, as well as more specific information, including APACHE II score and Charlson Comorbidity Index, Confusion Assessment Method for the ICU (CAM-ICU), and Activity Measure for Post-Acute Care (AM-PAC) short form scores. The AM-PAC is a valid and reliable instrument for assessing weakness and function. The AM-PAC basic mobility Inpatient Short Form includes six questions that assess how much assistance an individual requires from another person for specific tasks such as: turning from the back to the side while in bed without using bedrails, and moving to and from a bed to a chair. Each of the six questions is scored from one (indicating total assistance) to four (indicating no assistance). The overall score ranges from 6–24 with lower scores reflecting more disability. [32, 33].

Data was analyzed using JMP[®] Pro (Version 12.0.1, SAS Institute Inc., 2015). Paired dichotomous data were analyzed using McNemar's test. Fisher's exact test was used for nominal dependent variables. Ordinal dependent variables were analyzed using the Wilcoxon Mann-Whitney exact test. Continuous dependent variables were analyzed using logistic regression. Using FEES as the gold standard, the positive likelihood ratio (LR) was determined for statistically significant demographic and physical exam variables. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operating characteristic curve (AUC) were determined for the swallowing trials, 3-WST, and overall BSE recommendations with 95% confidence intervals (95%CI).

Results

Of the 54 patients enrolled, 45 patients were included in the analysis. Seven patients did not complete both BSE and FEES for the following reasons: re-intubated prior to evaluation (n=3), refused FEES after consent (n=2), refused both BSE and FEES (n=1), and scheduling conflicts for FEES (n=1). One patient was excluded for <24 hours on mechanical ventilation, and one due to tracheostomy. Median age was 55 years with interquartile range (IQR) 47–65. Median duration of mechanical ventilation was 3.3 days (IQR=1.8–6.0). 67% were male. Median APACHE II score on admission was 22 (IQR=16–27). Median Charlson Comorbidity Index was 2 (IQR=1–3). 22% (n=10) of the patients had COPD as judged by chart review. 44% (n=20) of patients had a size 7.5 or lower endotracheal tube. 41% of

patients (n=19) received sedating medications in the 12 hours before the swallow evaluation. Eight patients had been mechanically ventilated more than once during that admission.

Not all patients completed testing for every consistency due to safety concerns of the clinician administering the BSE or FEES. On BSE, 5 patients did not undergo trials of ice chips, 5 did not trial puree, 15 did not trial nectar-thick liquid, and 9 did not trial solids. All patients trialed thin liquids. All but one patient underwent 3-WST. Similarly, on FEES 7 patients did not trial ice chips, 3 did not trial puree, 6 did not trial nectar-thick liquid, 13 did not trial solids, and 4 did not trial thin liquids. The median duration of FEES was 5.5 min (IQR=3.2–7.4). The duration of BSE was not recorded.

Using PAS 6 on FEES examination as the gold standard, 31% (n=14) of the patients aspirated on at least one consistency: 5 aspirated on ice chips, 9 on thin liquids, 2 on puree, 4 on nectar-thick liquids, and 1 on solids. Age, gender, race, Charlson Comorbidity Index, COPD, use of sedating medications, and multiple episodes of mechanical ventilation prior to testing were not associated with aspiration (Table 2, Figure 1). The following were associated with aspiration on FEES: endotracheal tube size <8.0 (LR=0.9 (95%CI=0.5–1.6), p=0.028), APACHE II score (p=0.007), and AM-PAC basic mobility score (p=0.018).

Components of the physical examination associated with aspiration included: reduced lip seal (LR=1.1 (95%CI=0.1–11.2), p=0.005), reduced lip ROM (LR=1.2 (95%CI=0.1–12.0), p=0.008), reduced tongue ROM (LR=1.1 (95%CI=0.1–11.2), p=0.005), abnormal pre-exam voice (LR=1.4 (95%CI=1.0–2.1), p=0.001), need for feeding assistance (LR=1.5 (95%CI=0.9–2.6), p=0.018), and abnormal dentition (LR=0.8 (95%CI=0.4–1.6), p=0.041). Reduced tongue strength and decreased cough strength were not associated with aspiration.

The accuracy of each consistency testing for overall FEES-documented aspiration is displayed in Table 3. Nectar-thick liquids maintained the best sensitivity at 73% (95%CI=43–90%). Puree maintained the best specificity at 93% (95%CI=77–98%). 3-WST had a sensitivity of 77% (95%CI=50–92%) and specificity of 65% (95%CI=47–79%). The accuracy of each consistency test for FEES-documented aspiration on that consistency is in Table 4. A pulse-ox change of >3% during BSE was associated with aspiration on FEES (negative LR=1.1 (95%CI=1.0–1.2), p=0.008).

Using the liberal definition of aspiration, 18 patients were recommended a normal diet after BSE, of whom 2 aspirated on FEES. Of the 27 patients recommended any altered diet after BSE, 12 aspirated on FEES. The dietary recommendation of “altered diet” had a sensitivity of 86% (95%CI=60–96%), specificity of 52% (95%CI=35–68%), PPV of 44% (95%CI=28–63%), NPV of 89% (95%CI=67–97%), and AUC of 0.69.

Using the conservative definition of aspiration, 36 patients were allowed oral intake, of whom 7 aspirated on FEES. Of the 9 patients recommended NPO, 7 aspirated on FEES. The dietary recommendation of NPO had a sensitivity of 50% (95%CI=27–73%), specificity of 94% (95%CI=79–98%), PPV of 78% (95%CI=45–94%), NPV of 81% (95%CI=65–90%), and AUC of 0.72. The SLP recommended further testing with VFSS or FEES in 9 patients (20%), which was not associated with aspiration (p=0.132).

Discussion

In this study, we evaluated the accuracy of BSE and 3-WST for detecting aspiration. Using a recommendation of altered diet after BSE as a liberal definition of aspiration generated a sensitivity of 86% and specificity of 52% when compared to a gold standard FEES examination. Using a conservative definition of aspiration (recommendation of NPO after BSE) yielded better specificity at 94% but lower sensitivity at 50%. Prior studies of patients with stroke yielded similar results to our liberal definition when comparing a BSE to either FEES or VFSS. The sensitivity on these studies ranged from 80–91% and specificity from 30–68%[34–37]. In contrast, a study in patients with a spinal cord injury reported a higher sensitivity and specificity at 100% and 93% respectively. This study included 30 patients; over half had a tracheostomy and were receiving mechanical ventilation[38]. In survivors of ARF, one prior study compared BSE to FEES, however patients were randomized to FEES or BSE rather than having both; 14% aspirated on FEES and 6% had a positive BSE[4].

The 3-WST was not an accurate test for aspiration, with a sensitivity of 77%, a specificity of 65%. These numbers are similar to those reported on validation of the 3-WST in stroke patients, with a sensitivity of 76% and specificity of 59%[28]. Other blinded studies in stroke patients reported higher sensitivity for the 3-WST at 86%, but lower specificity at 50%[34, 35]. One study found 3-WST to be less sensitive and more specific, at 52% and 86% respectively in a blinded assessment of patients with various neurologic conditions[39]. Two large studies in heterogeneous populations found a higher sensitivity of the 3-WST for aspiration, at 96.5% and >98%. However, neither was blinded; the endoscopist performed 3-WST directly after FEES[30, 40]. This may have influenced the rating of the 3-WST. In one of these studies, nearly 10% of patients did not undergo 3-WST because FEES demonstrated high aspiration risk. This may have eliminated some patients at risk for silent aspiration[40].

We found that 14% of patients who aspirated on FEES had a negative BSE. This may underestimate silent aspiration in our population, as it excludes patients who aspirated silently on one consistency but had clinical signs of aspiration on another. 3-WST performed worse, with 23% of patients who aspirated on FEES having a negative 3-WST. Previously reported rates of post-extubation silent aspiration range from 17–25%[2, 5, 6]. Patients with silent aspiration suffer the same complications as those with overt aspiration[10, 41, 42]. Identification and treatment of these patients can decrease clinically significant aspiration[5, 43].

We did not find any consistency on BSE to be a good predictor of aspiration on FEES. Although puree had the highest specificity at 93%, sensitivity was low at 64%. No consistency was over 73% sensitive for detecting overall aspiration on FEES. Abnormal trials of some of these consistencies appeared better at predicting FEES-documented aspiration on the same consistency, however fewer patients were included in these analyses (the patients who aspirated on each consistency were a subset of the patients who aspirated overall). The low sensitivities of these trials suggest bedside screening tests using only one consistency may be inadequate.

Our study had some limitations. We had a relatively small sample size. Due to safety concerns, some of our patients did not receive every trial bolus on BSE and FEES. The small sample size and incomplete data set may have affected the accuracy of our measured sensitivity and specificity. We may have been unable to detect some predictors of aspiration on BSE. A larger sample would allow for more sophisticated analysis to develop a screening algorithm for aspiration, as well as further investigate the associations between the components of the BSE and aspiration on FEES. One example is cough strength, a subjective measurement on BSE. Development of a standardized way of measuring cough strength after extubation is one avenue for further study. AM-PAC scores were associated with aspiration, which may suggest that aspiration after extubation is part of a syndrome of ICU acquired weakness. Further investigation with prospectively collected data, including Medical Research Council sum scores and possibly electrophysiological testing may be useful.

We were unable to look for differences in outcomes such as pneumonia or mortality between FEES and BSE. Although VFSS is more widely available, we used FEES as our gold standard instrumental exam[18]. Prior studies have demonstrated excellent agreement between VFSS and FEES as well as good inter- and intra-rater reliability for both, however FEES is more sensitive for penetration and aspiration[44–49]. VFSS requires transportation to fluoroscopy, which can be challenging in critically ill patients, whereas FEES can be performed at the bedside. Introducing access to FEES may increase the chance that patients will get an instrumental assessment of swallowing, despite pre-existing availability of VFSS[43]. Our patients received 0.2 mL of intranasal lidocaine at the SLP's discretion. The use of topical lidocaine at this dose during FEES can improve patient comfort and does not increase the risk of penetration or aspiration[50–52].

Conclusion

Clinical swallowing evaluations are frequently used following mechanical ventilation to guide dietary recommendations. We found that 11% of patients recommended a regular diet based on a clinical swallowing exam aspirate on FEES. 48% of the patients with abnormal BSE and 6% of the patients kept NPO had no aspiration on FEES. The 3-WST was neither sensitive nor specific for aspiration. The optimal test for aspiration in ARF survivors remains uncertain and requires further investigation.

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YTL had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. YTL also drafted the submitted article. Marc Moss made substantial contributions to the conception and design and analysis of data. Madison Macht made substantial contributions to the conception and design and acquisition of data. BJC made substantial contributions to the conception and design and analysis of data. SDW, HT, and TW all made substantial contributions to the acquisition of data and design. All authors reviewed the article critically for intellectual content.

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Abbreviations list

3–WST 3-ounce water swallowing test

95%CI	95% confidence interval
ARF	acute respiratory failure
AUC	area under the receiver operating characteristic curve
BSE	bedside swallowing evaluation
FEES	Flexible endoscopic assessment of swallowing
IQR	interquartile range
LR	likelihood ratio
NPV	negative predictive value
PAS	penetration aspiration scale
PPV	positive predictive value
SLP	Speech language pathologist
VFSS	videofluoroscopic swallow study

References

1. Wunsch H, Linde-Zwirble WT, Angus DC, Hartman ME, Milbrandt EB, Kahn JM. The epidemiology of mechanical ventilation use in the United States. *Critical Care Medicine*. 2010; 38(10):1947. [PubMed: 20639743]
2. Leder SB, Cohn SM, Moller BA. Fiberoptic endoscopic documentation of the high incidence of aspiration following extubation in critically ill trauma patients. *Dysphagia*. 1998; 13(4):208. [PubMed: 9716751]
3. Brown CVR, Hejl K, Mandaville AD, Chaney PE, Stevenson G, Smith C. Swallowing dysfunction after mechanical ventilation in trauma patients. *Journal of Critical Care*. 2011; 26(1):108.e9.
4. Barquist E, Brown M, Cohn S, Lundy D, Jackowski J. Postextubation fiberoptic endoscopic evaluation of swallowing after prolonged endotracheal intubation: a randomized, prospective trial. *Critical Care Medicine*. 2001; 29(9):1710. [PubMed: 11546969]
5. Ajemian MS, Nirmul GB, Anderson MT, Zirlen DM, Kwasnik EM. Routine fiberoptic endoscopic evaluation of swallowing following prolonged intubation: implications for management. *Archives of Surgery (Chicago, Ill: 1960)*. 2001; 136(4):434.
6. Hafner G, Neuhuber A, Hirtenfelder S, Schmedler B, Eckel HE. Fiberoptic endoscopic evaluation of swallowing in intensive care unit patients. *European archives of oto-rhino- laryngology: official journal of the European Federation of Oto-Rhino-Laryngological Societies (EUFOS): affiliated with the German Society for Oto-Rhino-Laryngology – Head and Neck Surgery*. 2008; 265(4):441.
7. El Solh A, Okada M, Bhat A, Pietrantonio C. Swallowing disorders post orotracheal intubation in the elderly. *Intensive Care Medicine*. 2003; 29(9):1451. [PubMed: 12904855]
8. Scheel R, Pisegna JM, McNally E, Noordzij JP, Langmore SE. Endoscopic Assessment of Swallowing After Prolonged Intubation in the ICU Setting. *The Annals of Otolaryngology, Rhinology, and Laryngology*. 2016; 125(1):43.
9. Hogue CW, Lappas GD, Creswell LL, Ferguson TB, Sample M, Pugh D, et al. Swallowing dysfunction after cardiac operations. Associated adverse outcomes and risk factors including intraoperative transesophageal echocardiography. *The Journal of Thoracic and Cardiovascular Surgery*. 1995; 110(2):517. [PubMed: 7637370]

10. Pikus L, Levine MS, Yang Y-X, Rubesin SE, Katzka DA, Laufer I, et al. Videofluoroscopic studies of swallowing dysfunction and the relative risk of pneumonia. *AJR American journal of roentgenology*. 2003; 180(6):1613. [PubMed: 12760930]
11. Odderson IR, Keaton JC, McKenna BS. Swallow management in patients on an acute stroke pathway: quality is cost effective. *Archives of Physical Medicine and Rehabilitation*. 1995; 76(12): 1130. [PubMed: 8540789]
12. Martino R, Foley N, Bhogal S, Diamant N, Speechley M, Teasell R. Dysphagia after stroke: incidence, diagnosis, and pulmonary complications. *Stroke; a Journal of Cerebral Circulation*. 2005; 36(12):2756.
13. Macht M, Wimbish T, Clark BJ, Benson AB, Burnham EL, Williams A, et al. Postextubation dysphagia is persistent and associated with poor outcomes in survivors of critical illness. *Critical Care (London, England)*. 2011; 15(5)
14. Macht M, King CJ, Wimbish T, Clark BJ, Benson AB, Burnham EL, et al. Postextubation dysphagia is associated with longer hospitalization in survivors of critical illness with neurologic impairment. *Critical Care (London, England)*. 2013; 17(3)
15. Altman KW, Yu G-P, Schaefer SD. Consequence of dysphagia in the hospitalized patient: impact on prognosis and hospital resources. *Archives of Otolaryngology–Head & Neck Surgery*. 2010; 136(8):784. [PubMed: 20713754]
16. Barker J, Martino R, Reichardt B, Hickey EJ, Ralph-Edwards A. Incidence and impact of dysphagia in patients receiving prolonged endotracheal intubation after cardiac surgery. *Canadian Journal of Surgery Journal Canadien De Chirurgie*. 2009; 52(2):119. [PubMed: 19399206]
17. de Aguilar-Nascimento JE, Kudsk KA. Clinical costs of feeding tube placement. *JPEN Journal of parenteral and enteral nutrition*. 2007; 31(4):269. [PubMed: 17595433]
18. Macht M, Wimbish T, Clark BJ, Benson AB, Burnham EL, Williams A, et al. Diagnosis and treatment of post-extubation dysphagia: results from a national survey. *Journal of Critical Care*. 2012; 27(6):578. [PubMed: 23084136]
19. Ponfick M, Linden R, Nowak DA. Dysphagia—a common, transient symptom in critical illness polyneuropathy: a fiberoptic endoscopic evaluation of swallowing study*. *Critical Care Medicine*. 2015; 43(2):365. [PubMed: 25377021]
20. Hardemark Cedborg AI, Sundman E, Boden K, Hedstrom HW, Kuylensstierna R, Ekberg O, et al. Effects of morphine and midazolam on pharyngeal function, airway protection, and coordination of breathing and swallowing in healthy adults. *Anesthesiology*. 2015; 122(6):1253. [PubMed: 25853450]
21. Colice GL, Stukel TA, Dain B. Laryngeal complications of prolonged intubation. *Chest*. 1989; 96(4):877. [PubMed: 2791687]
22. Megarbane B, Be Hong T, Kania R, Herman P, Baud FJ. Early laryngeal injury and complications because of endotracheal intubation in acutely poisoned patients: a prospective observational study. *Clinical Toxicology (Philadelphia, Pa)*. 2010; 48(4):331.
23. Colton House J, Noordzij JP, Murgia B, Langmore S. Laryngeal injury from prolonged intubation: a prospective analysis of contributing factors. *The Laryngoscope*. 2011; 121(3):596. [PubMed: 21344442]
24. Hutcheson KA, Lewin JS, Barringer DA, Lisec A, Gunn GB, Moore MWS, et al. Late dysphagia after radiotherapy-based treatment of head and neck cancer. *Cancer*. 2012; 118(23):5793. [PubMed: 23640737]
25. Lee S-Y, Kim BH, Park YH. Analysis of Dysphagia Patterns Using a Modified Barium Swallowing Test Following Treatment of Head and Neck Cancer. *Yonsei Medical Journal*. 2015; 56(5):1221. [PubMed: 26256963]
26. Lee SJ, Lee KW, Kim SB, Lee JH, Park MK. Voluntary Cough and Swallowing Function Characteristics of Acute Stroke Patients Based on Lesion Type. *Archives of Physical Medicine and Rehabilitation*. 2015; 96(10):1866. [PubMed: 26184890]
27. Gallas S, Moiriot P, Debono G, Navarre I, Denis P, Marie JP, et al. Mylohyoid motor- evoked potentials relate to swallowing function after chronic stroke dysphagia. *Neurogastroenterol Motil*. 2007; 19(6):453–8. [PubMed: 17564626]

28. DePippo KL, Holas MA, Reding MJ. Validation of the 3-oz water swallow test for aspiration following stroke. *Archives of Neurology*. 1992; 49(12):1259. [PubMed: 1449405]
29. Leder SB, Suiter DM, Warner HL, Acton LM, Siegel MD. Safe initiation of oral diets in hospitalized patients based on passing a 3-ounce (90 cc) water swallow challenge protocol. *QJM: monthly journal of the Association of Physicians*. 2012; 105(3):257. [PubMed: 22006561]
30. Suiter DM, Leder SB. Clinical utility of the 3-ounce water swallow test. *Dysphagia*. 2008; 23(3): 244. [PubMed: 18058175]
31. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. *Dysphagia*. 1996; 11(2):93. [PubMed: 8721066]
32. Jette DU, Stilphen M, Ranganathan VK, Passek SD, Frost FS, Jette AM. AM-PAC “6- Clicks” functional assessment scores predict acute care hospital discharge destination. *Phys Ther*. 2014; 94(9):1252–61. [PubMed: 24764073]
33. Jette DU, Stilphen M, Ranganathan VK, Passek S, Frost FS, Jette AM. Interrater Reliability of AM-PAC “6-Clicks” Basic Mobility and Daily Activity Short Forms. *Phys Ther*. 2015; 95(5):758–66. [PubMed: 25504489]
34. McCullough GH, Wertz RT, Rosenbek JC. Sensitivity and specificity of clinical/bedside examination signs for detecting aspiration in adults subsequent to stroke. *Journal of Communication Disorders*. 2001; 34(1–2):55. [PubMed: 11322570]
35. Rosenbek JC, McCullough GH, Wertz RT. Is the information about a test important? Applying the methods of evidence-based medicine to the clinical examination of swallowing. *Journal of Communication Disorders*. 2004; 37(5):437. [PubMed: 15231424]
36. Leder SB, Espinosa JF. Aspiration risk after acute stroke: comparison of clinical examination and fiberoptic endoscopic evaluation of swallowing. *Dysphagia*. 2002; 17(3):214. [PubMed: 12140648]
37. Smith HA, Lee SH, O'Neill PA, Connolly MJ. The combination of bedside swallowing assessment and oxygen saturation monitoring of swallowing in acute stroke: a safe and humane screening tool. *Age and Ageing*. 2000; 29(6):495. [PubMed: 11191240]
38. Shem KL, Castillo K, Wong SL, Chang J, Kao M-C, Kolakowsky-Hayner SA. Diagnostic accuracy of bedside swallow evaluation versus videofluoroscopy to assess dysphagia in individuals with tetraplegia. *PM & R: the journal of injury, function, and rehabilitation*. 2012; 4(4):283.
39. Mari F, Matei M, Ceravolo MG, Pisani A, Montesi A, Provinciali L. Predictive value of clinical indices in detecting aspiration in patients with neurological disorders. *Journal of Neurology, Neurosurgery, and Psychiatry*. 1997; 63(4):456.
40. Leder SB, Suiter DM, Green BG. Silent aspiration risk is volume-dependent. *Dysphagia*. 2011; 26(3):304. [PubMed: 21063732]
41. Meguro K, Yamagauchi S, Doi C, Nakamura T, Sekizawa K, Sasaki H. Prevention of respiratory infections in elderly bed-bound nursing home patients. *The Tohoku Journal of Experimental Medicine*. 1992; 167(2):135. [PubMed: 1475786]
42. Kikuchi R, Watabe N, Konno T, Mishina N, Sekizawa K, Sasaki H. High incidence of silent aspiration in elderly patients with community-acquired pneumonia. *American Journal of Respiratory and Critical Care Medicine*. 1994; 150(1):251. [PubMed: 8025758]
43. Bax L, McFarlane M, Green E, Miles A. Speech-language pathologist-led fiberoptic endoscopic evaluation of swallowing: functional outcomes for patients after stroke. *Journal of Stroke and Cerebrovascular Diseases: The Official Journal of National Stroke Association*. 2014; 23(3):e195. [PubMed: 24361193]
44. Kelly AM, Leslie P, Beale T, Payten C, Drinnan MJ. Fibreoptic endoscopic evaluation of swallowing and videofluoroscopy: does examination type influence perception of pharyngeal residue severity? *Clinical otolaryngology: official journal of ENT-UK; official journal of Netherlands Society for Oto-Rhino-Laryngology & Cervico-Facial Surgery*. 2006; 31(5):425.
45. Kelly AM, Drinnan MJ, Leslie P. Assessing penetration and aspiration: how do videofluoroscopy and fiberoptic endoscopic evaluation of swallowing compare? *The Laryngoscope*. 2007; 117(10): 1723. [PubMed: 17906496]

46. Wu CH, Hsiao TY, Chen JC, Chang YC, Lee SY. Evaluation of swallowing safety with fiberoptic endoscope: comparison with videofluoroscopic technique. *The Laryngoscope*. 1997; 107(3):396. [PubMed: 9121321]
47. Madden C, Fenton J, Hughes J, Timon C. Comparison between videofluoroscopy and milk-swallow endoscopy in the assessment of swallowing function. *Clinical Otolaryngology and Allied Sciences*. 2000; 25(6):504. [PubMed: 11122289]
48. Colodny N. Interjudge and intrajudge reliabilities in fiberoptic endoscopic evaluation of swallowing (fees) using the penetration-aspiration scale: a replication study. *Dysphagia*. 2002; 17(4):308. [PubMed: 12355146]
49. Hey C, Pluschinski P, Pajunk R, Almahameed A, Girth L, Sader R, et al. Penetration- Aspiration: Is Their Detection in FEES ® Reliable Without Video Recording? *Dysphagia*. 2015; 30(4):418. [PubMed: 25943296]
50. Fife TA, Butler SG, Langmore SE, Lester S, Wright SC, Kemp S, et al. Use of topical nasal anesthesia during flexible endoscopic evaluation of swallowing in dysphagic patients. *The Annals of Otolary, Rhinology, and Laryngology*. 2015; 124(3):206.
51. Kamarunas EE, McCullough GH, Guidry TJ, Mennemeier M, Schluterman K. Effects of topical nasal anesthetic on fiberoptic endoscopic examination of swallowing with sensory testing (FEESST). *Dysphagia*. 2014; 29(1):33. [PubMed: 23828313]
52. O'Dea MB, Langmore SE, Krisciunas GP, Walsh M, Zanchetti LL, Scheel R, et al. Effect of Lidocaine on Swallowing During FEES in Patients With Dysphagia. *The Annals of Otolary, Rhinology, and Laryngology*. 2015; 124(7):537.

Highlights

Dysphagia with subsequent aspiration occurs in up to 60% of acute respiratory failure (ARF) survivors. In this prospective study, the accuracy of the bedside swallowing evaluation (BSE) and its components for detecting aspiration was determined. Within three days of extubation, patients underwent comprehensive BSE including 3-ounce water swallowing test (3-WST), followed by a gold standard test for aspiration, flexible endoscopic evaluation of swallowing (FEES). A total of 45 patients were included in the analysis, and 31% aspirated on the FEES. The BSE and its components, including the 3-WST, demonstrated variable accuracy for aspiration in survivors of ARF.

Figure 1.
Aspiration Frequency by Duration of Mechanical Ventilation

Table 1

Penetration-Aspiration Scale

1	Material does not enter airway
2	Material enters the airway, remains above the vocal folds, and is ejected from the airway.
3	Material enters the airway, remains above the vocal folds, and is not ejected from the airway.
4	Material enters the airway, contacts the vocal folds, and is ejected from the airway.
5	Material enters the airway, contacts the vocal folds, and is not ejected from the airway.
6	Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway.
7	Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort.
8	Material enters the airway, passes below the vocal folds, and no effort is made to eject.

Adapted with permission from Rosenbek et al. (31).

Table 2

Demographic variables

	Aspiration N=14	No aspiration N=31	p-value
Age (median, IQR)	57 (47–65)	53 (46–66)	0.938
Gender (n, % male)	10 (71%)	20 (65%)	0.649
Race			0.664
	White	23 (74%)	
	Black	5 (16%)	
	Other	3 (10%)	
APACHE II (median, IQR)	21 (16–36)	22 (15–25)	0.007
Charlson Comorbidity Index (n, %)	0	5 (16%)	0.644
	1–2	15 (48%)	
	3	11 (35%)	
Duration of mechanical ventilation in days (median, IQR)	3.3 (1.7–6.1)	3.3 (1.9–6.2)	0.628
Reintubation ^a (n, %)	4 (29%)	4 (13%)	0.109
Duration of 1 st intubation in days (median, IQR)	2.4 (0.4–4.7)	1.6 (0.8–2.3)	
Duration of 2 nd intubation in hours (median, IQR)	6.4 (5.2–7.8)	2.3 (1.6–3.3)	
Duration of 3 rd intubation in hours (median, IQR)	n/a	3	
Endotracheal tube size 8.0 mm (n, %)	7 (50%)	18 (58%)	0.028
History of COPD	5 (35%)	5 (16%)	0.285
Sedative medications within 12 hours of swallow study	5 (36%)	13 (42%)	0.394
Positive Confusion Assessment Method for the ICU (CAM-ICU) score ^b	2 (20%)	3 (10%)	0.132
Activity Measure for Post-Acute Care (AM-PAC) score (median, IQR)	13 (8–20.3)	17 (14–19)	0.018

^aRequired >1 episode of mechanical ventilation prior to swallowing assessment.

^bFor the 6 patients without a CAM–ICU charted, all were noted to be Glasgow Coma Scale 14 or greater.

Table 3

Sensitivity, specificity, positive, and negative predictive value of the various consistencies used in the BSE^a and the 3-WST^{bc}

Consistency	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)	AUC
Ice	62% (36–82%)	85% (68–94%)	67% (39–86%)	82% (64–92%)	0.73
Puree	64% (39–84%)	93% (77–98%)	82% (52–95%)	83% (66–93%)	0.78
Nectar-thick	73% (43–90%)	74% (51–88%)	62% (36–82%)	82% (59–94%)	0.73
Thin	64% (39–84%)	68% (50–81%)	47% (27–68%)	81% (62–92%)	0.66
Solid	25% (7–59%)	82% (64–92%)	29% (8–64%)	79% (62–90%)	0.54
3-WST	77% (50–92%)	65% (47–79%)	48% (28–68%)	87% (68–96%)	0.71

^a BSE = bedside swallowing evaluation

^b 3-WST = 3-ounce water swallowing test

^c Flexible endoscopic evaluation of swallowing (FEES) was used as the gold standard

Table 4Analysis of abnormal bolus testing on BSE^a and aspiration on the same consistency on FEES^b

Consistency	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
Ice	25% (5–70%)	77% (60–89%)	13% (2–47%)	89% (72–96%)
Puree	100% (34–100%)	78% (62–88%)	20% (6–51%)	100% (88–100%)
Nectar-thick	75% (30–95%)	61% (41–78%)	25% (9–53%)	93% (70–99%)
Thin	56% (27–81%)	66% (48–80%)	31% (14–56%)	84% (65–94%)
Solid	n/a ^c	n/a ^c	n/a ^c	n/a ^c

^aBSE = bedside swallowing evaluation^bFEES = flexible endoscopic evaluation of swallowing^cThe one patient who aspirated on solids on FEES did not get a BSE trial of solids