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REVIEW

Bedside Diagnosis of Dysphagia: A Systematic Review

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Dysphagia is associated with aspiration, pneumonia, and malnutrition, but remains challenging to identify at the bedside. A variety of exam protocols and maneuvers are commonly used, but the efficacy of these maneuvers is highly variable. We conducted a comprehensive search of 7 databases, including MEDLINE, Embase, and Scopus, from each database's earliest inception through June 9, 2014. Studies reporting diagnostic performance of a bedside examination maneuver compared to a reference gold standard (videofluoroscopic swallow study or flexible endoscopic evaluation of swallowing with sensory testing) were included for analysis. From each study, data were abstracted based on the type of diagnostic method and reference standard study population and inclusion/exclusion characteristics, design, and prediction of aspiration. The search strategy identified 38 articles meeting inclusion criteria. Overall, most bedside examinations lacked sufficient sensitivity to be used for screening purposes across all patient populations examined. Individual studies found dysphonia assessments, abnormal pharyngeal sensation assessments, dual axis accelerometry, and 1 description of water swallow testing to be sensitive tools, but none were reported as consistently sensitive. A preponderance of identified studies was in poststroke adults, limiting the generalizability of results. No bedside screening protocol has been shown to provide adequate predictive value for presence of aspiration. Several individual exam maneuvers demonstrated reasonable sensitivity, but reproducibility and consistency of these protocols was not established. More research is needed to design an optimal protocol for dysphagia detection. *Journal of Hospital Medicine* 2015;10:256–265. © 2015 Society of Hospital Medicine

Dysphagia is a serious medical condition that can lead to aspiration pneumonia, malnutrition, and dehydration.[1] Dysphagia is the result of a variety of medical etiologies, including stroke, traumatic brain injury, progressive neurologic conditions, head and neck cancers, and general deconditioning. Prevalence estimates for dysphagia vary depending upon the etiology and patient age, but estimates as high as 38% for lifetime prevalence have been reported in those over age 65 years.[2]

To avoid adverse health outcomes, early detection of dysphagia is essential. In hospitalized patients, early detection has been associated with reduced risk of pneumonia, decreased length of hospital stay, and improved cost-effectiveness resulting from a reduction in hospital days due to fewer cases of aspiration pneumonia.[3–5] Stroke guidelines in the United States recommend screening for dysphagia for all patients admitted with stroke.[6] Consequently, the majority of screening procedures have been designed for and tested in this population.[7–10]

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The videofluoroscopic swallow study (VFSS) is a commonly accepted, reference standard, instrumental evaluation technique for dysphagia, as it provides the most comprehensive information regarding anatomic and physiologic function for swallowing diagnosis and treatment. Flexible endoscopic evaluation of swallowing (FEES) is also available, as are several less commonly used techniques (scintigraphy, manometry, and ultrasound). Due to availability, patient compliance, and expertise needed, it is not possible to perform instrumental examination on every patient with suspected dysphagia. Therefore, a number of minimally invasive bedside screening procedures for dysphagia have been developed.

The value of any diagnostic screening test centers on performance characteristics, which under ideal circumstances include a positive result for all those who have dysphagia (sensitivity) and negative result for all those who do not have dysphagia (specificity). Such an ideal screening procedure would reduce unnecessary referrals and testing, thus resulting in cost savings, more effective utilization of speech-language pathology consultation services, and less unnecessary radiation exposure. In addition, an effective screen would detect all those at risk for aspiration pneumonia in need of intervention. However, most available bedside screening tools are lacking in some or all of these desirable attributes.[11,12] We undertook a systematic review and meta-analysis of bedside procedures to screen for dysphagia.

METHODS

Data Sources and Searches

We conducted a comprehensive search of 7 databases, including MEDLINE, Embase, and Scopus, from each database's earliest inception through June 9, 2014 for English-language articles and abstracts. The search strategy was designed and conducted by an experienced librarian with input from 1 researcher (J.C.O.). Controlled vocabulary supplemented with keywords was used to search for comparative studies of bedside screening tests for predicting dysphagia (see Supporting Information, Appendix 1, in the online version of this article for the full strategy).

All abstracts were screened, and potentially relevant articles were identified for full-text review. Those references were manually inspected to identify all relevant studies.

Study Selection

A study was eligible for inclusion if it tested a diagnostic swallow study of any variety against an acceptable reference standard (VFSS or flexible endoscopic evaluation of swallowing with sensory testing [FEEST]).

Data Extraction and Quality Assessment

The primary outcome of the study was aspiration, as predicted by a bedside exam, compared to gold-standard visualization of aspirated material entering below the vocal cords. From each study, data were abstracted based on the type of diagnostic method and reference standard study population and inclusion/exclusion characteristics, design, and prediction of aspiration. Prediction of aspiration was compared against the reference standard to yield true positives, true negatives, false positives, and false negatives. Additional potential confounding variables were abstracted using a standard form based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis[13] (see Supporting Information, Appendix 2, in the online version of this article for the full abstraction template).

Data Synthesis and Analysis

Sensitivity and specificity for each test that identified the presence of dysphagia was calculated for each study. These were used to generate positive and negative likelihood ratios (LRs), which were plotted on a likelihood matrix, a graphic depiction of the logarithm of the $^{+}$LR on the ordinate versus the logarithm of the $^{-}$LR on the abscissa, dividing the graphic into quadrants such that the right upper quadrant is tests that can be used for confirmation, right lower quadrant neither confirmation nor exclusion, left lower quadrant exclusion only, and left upper quadrant an ideal test with both exclusionary and confirmatory properties.[14] A good screening test would thus be on the left half of the graphic to effectively rule out dysphagia, and the ideal test with both good sensitivity and specificity would be found in the left upper quadrant. Graphics were constructed using the Stata MIDAS package (Stata Corp., College Station, TX).[15]

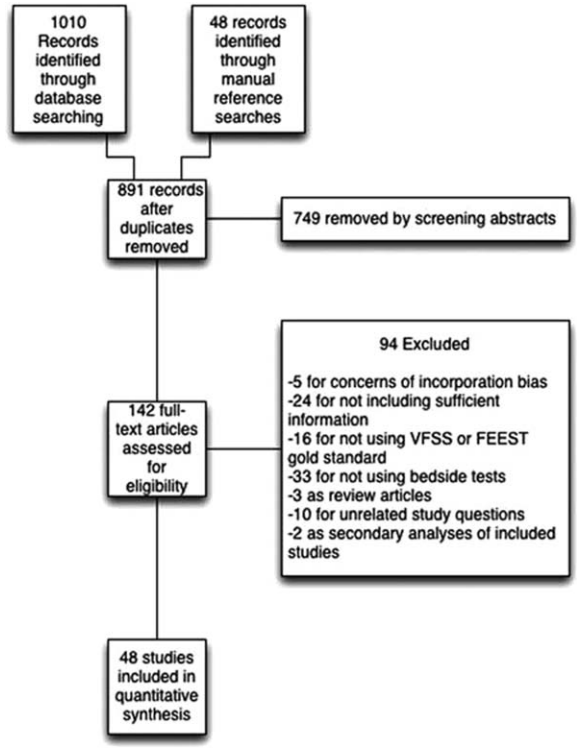

FIG. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram. Abbreviations: FEEST, flexible endoscopic evaluation of swallowing with sensory testing; VFSS, videofluoroscopic swallow study.

RESULTS

We identified 891 distinct articles. Of these, 749 were excluded based on abstract review. After reviewing the remaining 142 full-text articles, 48 articles were determined to meet inclusion criteria, which included 10,437 observations across 7414 patients (Figure 1). We initially intended to conduct a meta-analysis on each type, but heterogeneity in design and statistical heterogeneity in aggregate measures precluded pooling of results.

Characteristics of Included Studies

Of the 48 included studies, the majority (n = 42) were prospective observational studies,[7,8,14,16–53] whereas 2 were randomized trials,[9,54] 2 studies were double-blind observational,[9,16] 1 was a case-control design,[55] and 1 was a retrospective case series.[56] The majority of studies were exclusively inpatient,[7–9,14,17–19,21,22,24–26,31–33,35,36,38,41,43–47,49,51–53,55,57] with 5 in mixed in and outpatient populations,[20,27,40,55,58] 2 in outpatient populations,[23,41] and the remainder not reporting the setting from which they drew their study populations.

The indications for swallow evaluations fit broadly into 4 categories: stroke,[7–9,14,21,22,24–26,31,33–35,38,40–43,45,48,52,56,58] other neurologic disorders,[17,18,23,28,39,47] all causes,[16,20,27,29,30,36,37,44,46,49,51–54,58] and

postsurgical.[19,32,34] Most used VFSS as a reference standard,[7–9,14,16–19,21–23,25–30,34,36–47,50–54,56–58] with 8 using FEEST,[20,24,31–33,35,49,55] and 1 accepting either videofluoroscopic evaluation of swallow or FEEST.[48]

Studies were placed into 1 or more of the following 4 categories: subjective bedside examination,[8,9,18,19,31,34,48] questionnaire-based tools,[17,23,46,53] protocolized multi-item evaluations,[20–22,25,30,33,34,37,39,44,45,52,53,57,58] and single-item exam maneuvers, symptoms, or signs.[7,9,14,16,24,26–32,34–43,47–51,56,58,59] The characteristics of all studies are detailed in Table 1.

Subjective Clinical Exam

Seven studies reported the sensitivity and specificity of subjective assessments of nurses and speech-language pathologists in observing swallowing and predicting aspiration.[8,9,18,19,31,34,48] The overall distribution of studies is summarized in the likelihood matrix in Figure 2. Two studies, Chong et al.[31] and Shem et al.,[18] were on the left side of the matrix, indicating a sensitive rule-out test. However, both were small studies, and only Chong et al. reported reasonable sensitivity with incorporation bias from knowledge of a desaturation study outcome. Overall, subjective exams did not appear reliable in ruling out dysphagia.

Questionnaire-Based Tools

Only 4 studies used questionnaire-based tools filled out by the patient, asking about subjective assessment of dysphagia symptoms and frequency.[17,23,46,53] Yamamoto et al. reported results of using the swallow dysphagia questionnaire in patients with Parkinson's disease.[17] Rofes et al. looked at the Eating Assessment Tool (EAT-10) questionnaire among all referred patients and a small population of healthy volunteers.[53] Each was administered the questionnaire before undergoing a videofluoroscopic study. Overall, sensitivity and specificity were 77.8% and 84.6%, respectively. Cox et al. studied a different questionnaire in a group of patients with inclusion body myositis, finding 70% sensitivity and 44% specificity.[23] Cohen and Manor examined the swallow dysphagia questionnaire across several different causes of dysphagia, finding at optimum, the test is 78% specific and 73% sensitive.[46] Rofes et al. had an 86% sensitivity and 68% specificity for the EAT-10 tool.[53]

Multi-Item Exam Protocols

Sixteen studies reported multistep protocols for determining a patient's risk for aspiration.[9,20–22,25,30,33,34,37,39,44,45,52,53,57,58] Each involved a combination of physical exam maneuvers and history elements, detailed in Table 1. This is shown in the likelihood matrix in Figure 3. Only 2 of these studies were in the left lower quadrant, Edmiaston et al. 2011[21] and 2014.[52] Both studies were restricted to stroke populations, but found reasonable sensitivity and specificity in identifying dysphagia.

Individual Exam Maneuvers

Thirty studies reported the diagnostic performance of individual exam maneuvers and signs.[7,9,14,16,24,26–32,34–43,47–51,54,56,58] Each is depicted in Figure 4 as a likelihood matrix demonstrating the $^{+}$LR and $^{-}$LR for individual maneuvers as seen in the figure; most fall into the right lower quadrant, where they are not diagnostically useful tests. Studies in the left lower quadrant demonstrating the ability to exclude aspiration desirable in a screening test were dysphonia in McCullough et al.,[34] dual-axis accelerometry in Steele et al.,[16] and the water swallow test in DePippo et al.[43] and Suiter and Leder.[49]

McCullough et al. found dysphonia to be the most discriminatory sign or symptom assessed, with an area under the curve (AUC) of 0.818. Dysphonia was judged by a sustained/a/and had 100% sensitivity but only 27% specificity. "Wet voice" within the same study was slightly less informative, with an AUC of 0.77 (sensitivity 50% and specificity 84%).[34]

Kidd et al. verified the diagnosis of stroke, and then assessed several neurologic parameters, including speech, muscle strength, and sensation. Pharyngeal sensation was assessed by touching each side of the pharyngeal wall and asking patients if they felt sensation that differed from each side. Patient report of abnormal sensation during this maneuver was 80% sensitive and 86% specific as a predictor of aspiration on VFSS.[42]

Steele et al. described the technique of dual axis accelerometry, where an accelerometer was placed at the midline of the neck over the cricoid cartilage during VFSS. The movement of the cricoid cartilage was captured for analysis in a computer algorithm to identify abnormal pharyngeal swallow behavior. Sensitivity was 100%, and specificity was 54%. Although the study was small (n = 40), this novel method demonstrated good discrimination.[58]

DePippo et al. evaluated a 3-oz water swallow in stroke patients. This protocol called for patients to drink the bolus of water without interruption, and be observed for 1 minute after for cough or wet-hoarse voice. Presence of either sign was considered abnormal. Overall, sensitivity was 94% and specificity 30% looking for the presence of either sign.[43] Suiter and Leder used a similar protocol, with sensitivity of 97% and specificity of 49%.[49]

DISCUSSION

Our results show that most bedside swallow examinations lack the sensitivity to be used as a screening test for dysphagia across all patient populations examined. This is unfortunate as the ability to determine which patients require formal speech language pathology consultation or imaging as part of their diagnostic evaluation early in the hospital stay would lead to improved allocation of resources, cost reductions, and earlier implementation of effective therapy approaches. Furthermore, although radiation doses received during

TABLE 1. Characteristics of Included Studies

Study	Location	Design	Mean Age (SD)	Reason(s) for Dysphagia	Indx Test	Description	Reference Standard	Sample Size, No. of Patients	Sample Size, No. of Observations
Splaingard et al., 1988[44]	Milwaukee, WI, USA	Prospective observational study	NR	Multiple	Clinical bedside swallow exam	Combination of scored comprehensive physical exam, history, and observed swallow.	VFSS	107	107
DePippo et al., 1992[43]	White Plains, NY, USA	Prospective observational study	71 (10)	Stroke	WST	Observation of swallow.	VFSS		44
Horner et al., 1993[56]	Durham, NC, USA	Retrospective case series	64*	Stroke	Clinical bedside swallow evaluation		VFSS	38	114
Kidd et al., 1993[42]	Belfast, UK	Prospective observational study	72 (10)	Stroke	Bedside 50-mL swallow evaluation	Patient swallows 50 mL of water in 5-mL aliquots, with therapist assessing for choking, coughing, or change in vocal quality after each swallow.	VFSS	60	240
Collins and Bakheit, 1997[41]	Southampton, UK	Prospective observational study	65*	Stroke	Desaturation	Desaturation of at least 2% during videofluoroscopic study.	VFSS	54	54
Daniels et al., 1997[40]	New Orleans, LA, USA	Prospective observational study	66 (11)	Stroke	Clinical bedside examination	6 individual bedside assessments (dysphonia, dysphagia, cough before/after swallow, gag reflex and voice change) examined as predictors for aspiration risk.	VFSS	59	354
Mari et al., 1997[39]	Ancona, Italy	Prospective observational study	60 (16)	Mixed neurologic diseases	Combined history and exam	Assessed symptoms of dysphagia, cough, and 3-oz water swallow.	VFSS	93	372
Daniels et al., 1998[7]	New Orleans, LA, USA	Prospective observational study	66 (11)	Stroke	Clinical bedside swallow evaluation	Describes sensitivity and specificity of several component physical exam maneuvers comprising the bedside exam.	VFSS	55	330
Smithard et al., 1998[8]	Ashford, UK	Prospective observational study	79*	Stroke	Clinical bedside swallow evaluation	Not described.	VFSS	83	249
Addington et al., 1999[38]	Kansas City, MO, USA	Prospective observational study	80*	Stroke	NR	Reflex cough.	VFSS	40	40
Logemann et al., 1999[37]	Evanston, IL, USA	Prospective observational study	65†	Multiple	Northwestern Dysphagia Check Sheet	28-item screening procedure including history, observed swallow, and physical exam.	VFSS	200	1400
Smith et al., 2000[9]	Manchester, UK	Double blind observational	69†	Stroke	Clinical bedside swallow evaluation, pulse oximetry evaluation	After eating/drinking, patient is evaluated for signs of aspiration including coughing, choking, or "wet voice." Procedure is repeated with several consistencies. Also evaluated if patient desaturates by at least 2% during evaluation.	VFSS	53	53
Warms et al., 2000[36]	Melbourne, Australia	Prospective observational study	67†	Multiple	Wet voice	Voice was recorded and analyzed with Sony digital audio tape during videofluoroscopy.	VFSS	23	708
Lim et al., 2001[35]	Singapore, Singapore	Prospective observational study	NR	Stroke	Water swallow test, desaturation during swallow	50-mL swallow done in 5-mL aliquots with assessment of phonation/choking afterward; desaturation >2% during swallow,	FEEST	50	100
McCullough et al., 2001[34]	Nashville, TN, USA	Prospective observational study	60 (10)	Stroke	Clinical bedside swallow evaluation	15-item physical exam with observed swallow.	VFSS	2040	60

TABLE 1. *Continued*

Study	Location	Design	Mean Age (SD)	Reason(s) for Dysphagia	Indx Test	Description	Reference Standard	Sample Size, No. of Patients	Sample Size, No. of Observations
Rosen et al., 2001[74]	Newark, NJ, USA	Prospective observational study	60†	Head and Neck cancer	Wet voice	Observation of swallow.	VFSS	26	26
Leder and Espinosa, 2002[33]	New Haven, CT, USA	Prospective observational study	70*	Stroke	Clinical exam	Checklist evaluation of cough and voice change after swallow, volitional cough, dysphonia, dysarthria, and abnormal gag.	FEEST	49	49
Belafsky et al., 2003[32]	San Francisco, CA, USA	Prospective observational study	65 (11)	Post-tracheostomy patients	Modified Evans Blue Dye Test	3 boluses of dye-impregnated ice are given to patient. Tracheal secretions are suctioned, and evaluated for the presence of dye.	FEES	30	30
Chong et al., 2003[31]	Jalan Tan Tock Seng, Singapore	Prospective observational study	75 (7)	Stroke	Water swallow test, desaturation during, clinical exam	Subjective exam, drinking 50 mL of water in 10-mL aliquots, and evaluating for desaturation >2% during FEES.	FEEST	50	150
Tohara et al., 2003[30]	Tokyo, Japan	Prospective observational study	63 (17)	Multiple	Food/water swallow tests, and a combination of the 2	Protocolized observation of sequential food and water swallows with scored outcomes.	VFSS	63	63
Rosenbek et al., 2004[14]	Gainesville, FL, USA	Prospective observational study	68*	Stroke	Clinical bedside swallow evaluation	Describes 5 parameters of voice quality and 15 physical examination maneuvers used.	VFSS	60	1200
Ryu et al., 2004[29]	Seoul, South Korea	Prospective observational study	64 (14)	Multiple	Voice analysis parameters	Analysis of the/a/vowel sound with Visi-Pitch II 3300.	VFSS	93	372
Shaw et al., 2004[28]	Sheffield, UK	Prospective observational study	71†	Neurologic disease	Bronchial auscultation	Auscultation over the right main bronchus during trial feeding to listen for sounds of aspiration.	VFSS	105	105
Wu et al., 2004[27]	Taipei, Taiwan	Prospective observational study	72 (11)	Multiple	100-mL swallow test	Patient lifts a glass of 100 mL of water and drinks as quickly as possible, and is assessed for signs of choking, coughing, or wet voice, and is timed for speed of drinking.	VFSS	54	54
Nishiwaki et al., 2005[26]	Shizuoaka, Japan	Prospective observational study	70*	Stroke	Clinical bedside swallow evaluation	Describes sensitivity and specificity of several component physical exam maneuvers comprising the bedside exam.	VFSS	31	248
Wang et al., 2005[54]	Taipei, Taiwan	Prospective double-blind study	41*	Multiple	Desaturation	Desaturation of at least 2% during videofluoroscopic study.	VFSS	60	60
Ramsey et al., 2006[25]	Kent, UK	Prospective observational study	71 (10)	Stroke	BSA	Assessment of lip seal, tongue movement, voice quality, cough, and observed 5-mL swallow.	VFSS	54	54
Trapl et al., 2007[24]	Krems, Austria	Prospective observational study	76 (2)	Stroke	Gugging Swallow Screen	Progressive observed swallow trials with saliva, then with 3–50 mL liquid, then dry bread.	FEEST	49	49
Suiter and Leder, 2008[49]	Several centers across the USA	Prospective observational study	68.3	Multiple	3-oz water swallow test	Observation of swallow.	FEEST	3000	3000
Wagasugi et al., 2008[50]	Tokyo, Japan	Prospective observational study	NR	Multiple	Cough test	Acoustic analysis of cough.	VFSS	204	204

TABLE 1. *Continued*

Study	Location	Design	Mean Age (SD)	Reason(s) for Dysphagia	Indx Test	Description	Reference Standard	Sample Size, No. of Patients	Sample Size, No. of Observations
Baylow et al., 2009[45]	New York, NY, USA	Prospective observational study	NR	Stroke	Northwestern Dysphagia Check Sheet	28-item screening procedure including history, observed swallow, and physical exam.	VFSS	15	30
Cox et al., 2009[23]	Leiden, the Netherlands	Prospective observational study	68 (8)	Inclusion body myositis	Dysphagia questionnaire	Questionnaire assessing symptoms of dysphagia.	VFSS	57	57
Kagaya et al., 2010[51]	Tokyo, Japan	Prospective observational study	NR	Multiple	Simple Swallow Provocation Test	Injection of 1-2 mL of water through nasal tube directed at the suprapharynx.	VFSS	46	46
Martino et al., 2009[57]	Toronto, Canada	Randomized trial	69 (14)	Stroke	Toronto Bedside Swallow Screening Test	4-item physical assessment including Kidd water swallow test, pharyngeal sensation, tongue movement, and dysphonia (before and after water swallow).	VFSS	59	59
Santamato et al., 2009[55]	Bari, Italy	Case control	NR	Multiple	Acoustic analysis, postswallow apnea	Acoustic analysis of cough.	VFSS	15	15
Smith Hammond et al., 2009[48]	Durham, NC, USA	Prospective observational study	67.7 (1.2)	Multiple	Cough, expiratory phase peak flow	Acoustic analysis of cough.	VFSS or FEES	96	288
Leigh et al., 2010[22]	Seoul, South Korea	Prospective observational study	NR	Stroke	Clinical bedside swallow evaluation	Not described.	VFSS	167	167
Pitts et al., 2010[47]	Gainesville, FL, USA	Prospective observational study	NR	Parkinson	Cough compression phase duration	Acoustic analysis of cough.	VFSS	58	232
Cohen and Manor, 2011[46]	Tel Aviv, Israel	Prospective observational Study	NR	Multiple	Swallow Disturbance Questionnaire	15-item questionnaire.	FEES	100	100
Edmiaston et al., 2011[21]	St. Louis, MO, USA	Prospective observational study	63*	Stroke	SWALLOW-3D Acute Stroke Dysphagia Screen	5-item screen including mental status; asymmetry or weakness of face, tongue, or palate; and subjective signs of aspiration when drinking 3 oz water.	VFSS	225	225
Mandysova et al., 2011[20]	Pardubice, Czech Republic	Prospective observational study	69 (13)	Multiple	Brief Bedside Dysphagia Screening Test	8-item physician exam including ability to clench teeth; symmetry/strength of tongue, facial, and shoulder muscles; dysarthria; and choking, coughing, or dripping of food after taking thick liquid.	FEES	87	87
Steele et al., 2011[58]	Toronto, Canada	Double blind observational	67†	Stroke	4-item bedside exam	Tongue lateralization, cough, throat clear, and voice quality.	VFSS	400	40
Yamamoto et al., 2011[17]	Kodaira, Japan	Prospective observational study	67 (9)	Parkinson's Disease	Swallowing Disturbance Questionnaire	15-item questionnaire.	VFSS	61	61
Bhama et al., 2012[19]	Pittsburgh, PA, USA	Prospective observational study	57 (14)	Post-lung transplant	Clinical bedside swallow evaluation	Not described.	VFSS	128	128
Shem et al., 2012[18]	San Jose, CA, USA	Prospective observational study	42 (17)	Spinal cord injuries resulting in tetraplegia	Clinical bedside swallow evaluation	After eating/drinking, patient is evaluated for signs of aspiration including coughing, choking, or "wet voice." Procedure is repeated with several consistencies.	VFSS	26	26
Steele et al., 2013[16]	Toronto, Canada	Prospective observational study	67 (14)	Multiple	Dual-axis accelerometry	Computed accelerometry of swallow.	VFSS	37	37
Edmiaston et al., 2014[52]	St. Louis, MO, USA	Prospective observational study	63 (15)	Stroke	Barnes Jewish Stroke Dysphagia Screen	5-item screen including mental status; asymmetry or weakness of face, tongue, or palate; and subjective signs of aspiration when drinking 3 oz water.	VFSS	225	225

TABLE 1. *Continued*

Study	Location	Design	Mean Age (SD)	Reason(s) for Dysphagia	Indx Test	Description	Reference Standard	Sample Size, No. of Patients	Sample Size, No. of Observations
Rofes et al., 2014[53]	Barcelona, Spain	Prospective observational study	74 (12)	Mixed	EAT-10 questionnaire and variable viscosity swallow test	Symptom-based questionnaire (EAT-10) and repeated observations and measurements of swallow with different thickness liquids.	VFS	134	134

NOTE: Abbreviations: BSA, bedside assessment; EAT-10, Eating Assessment Tool; FEES, flexible endoscopic evaluation of swallowing; FEEST, flexible endoscopic evaluation of swallowing with sensory testing; NR, not reported; SD, standard deviation; VFSS, videofluoroscopic swallow study; WST, Water swallow test. *SD not available. †Median provided instead of mean.

VFSS are not high when compared with other radiologic exams like computed tomography scans,[60] increasing awareness about the long-term malignancy risks associated with medical imaging makes it desirable to reduce any test involving ionizing radiation.

There were several categories of screening procedures identified during this review process. Those classified as subjective bedside exams and protocolized multi-item evaluations were found to have high heterogeneity in their sensitivity and specificity, though a few exam protocols did have a reasonable sensitivity and specificity.[21,31,52] The following individual exam maneuvers were found to demonstrate high sensitivity and an ability to exclude aspiration: a test for dysphonia through production of a sustained/a/[34] and use of dual-axis accelerometry.[16] Two other tests, the 3-oz water swallow test[43] and testing of abnormal pharyngeal sensation,[42] were each found effective in a single study, with conflicting results from other studies.

Our results extend the findings from previous systematic reviews on this subject, most of which focused only on stroke patients.[5,12,61,62] Martino and colleagues[5] conducted a review focused on screening for adults poststroke. From 13 identified articles, it was concluded that evidence to support inclusion or exclusion of screening was poor. Daniels et al. conducted a systematic review of swallowing screening tools specific to patients with acute or chronic stroke.[12] Based on 16 articles, the authors concluded that a combination of swallowing and nonswallowing features may be necessary for development of a valid screening tool. The generalizability of these reviews is limited given that all were conducted in patients poststroke, and therefore results and recommendations may not be generalizable to other patients.

Wilkinson et al.[62] conducted a recent systematic review that focused on screening techniques for inpatients 65 years or older that excluded patients with stroke or Parkinson's disease. The purpose of that review was to examine sensitivity and specificity of bedside screening tests as well as ability to accurately predict pneumonia. The authors concluded that existing evidence is not sufficient to recommend the use of bedside tests in a general older population.[62]

Specific screening tools identified by Martino and colleagues[5] to have good predictive value in detecting aspiration as a diagnostic marker of dysphagia were an abnormal test of pharyngeal sensation[42] and the 50-mL water swallow test. Daniels et al. identified a water swallow test as an important component of a screen.[7] These results were consistent with those of this review in that the abnormal test of pharyngeal sensation[42] was identified for high levels of sensitivity. However, the 3-oz water swallow test,[43,49] rather than the 50-mL water swallow test,[42] was identified in this review as the version of the water swallow test with the best predictive value in ruling out aspiration. Results of our review identified 2 additional individual items, dual-axis accelerometry[16] and dysphonia,[34] that may be important to

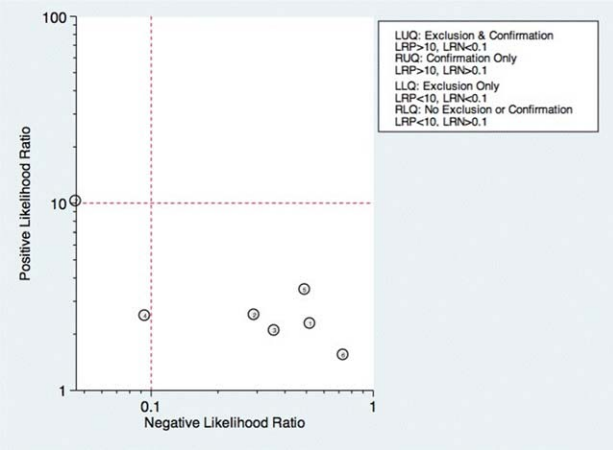

FIG. 2. Likelihood matrix for curve for subjective clinical exam. Each point corresponds to a study as follows: 1 = Smithard et al., 1998; 2 = Smith et al., 2000; 3 = McCullough et al., 2001; 4 = Chong et al., 2003; 5 = Smith-Hammond et al., 2009; 6 = Bhama et al., 2012; 7 = Shem et al., 2012. LUQ = Left upper quadrant, LRP = Positive likelihood ratio, RUQ = Right upper quadrant, LLQ = Left lower quadrant, RLQ = Right lower quadrant, LRN = Negative likelihood ratio.

include in a comprehensive screening tool. In the absence of better tools, the 3 oz swallow test, properly executed, seems to be the best currently available tool validated in more than 1 study.

Several studies in the current review included an assessment of oral tongue movement that is not described thoroughly and varies between studies. Tongue movement as an individual item on a screening protocol was not found to yield high sensitivity or specificity. However, tongue movement or range of motion is only 1 aspect of oral tongue function; pressures produced by the tongue reflecting strength also may be important and warrant evaluation. Multiple studies

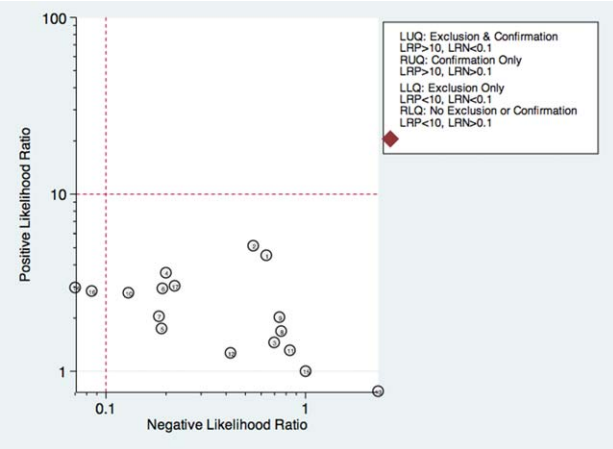

FIG. 3. Likelihood matrix of multi-item protocols. 1 = Splaingard et al., 1988; 2 = Mari et al., 1997; 3 = Logemann et al., 1999; 4 = Smith et al., 2000; 5 = McCullough et al., 2001; 6 = Leder et al., 2002; 7 = Tohara et al., 2003; 8 = Ramsey et al., 2006; 9 = Baylow et al., 2009; 10 = Martino et al., 2009; 11 = Leigh et al., 2010; 12 = Mandysova et al., 2011; 13 = Steele et al., 2011 (speech language pathology assessment); 14 = Edmiaston et al., 2011; 15 = Steele et al. (nurse assessment); 16 = Edmiaston et al., 2014; 17 = Rofes et al., 2014. LUQ = Left upper quadrant, LRP = Positive likelihood ratio, RUQ = Right upper quadrant, LLQ = Left lower quadrant, RLQ = Right lower quadrant, LRN = Negative likelihood ratio.

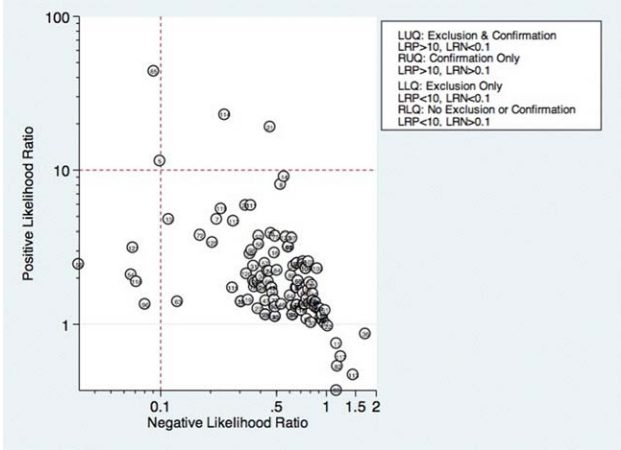

FIG. 4. Likelihood matrix of individual exam maneuvers. Studies in the LLQ demonstrating the ability to exclude aspiration were 56 = Kidd et al., 1993 (abnormal pharyngeal sensation); 96 = McCullogh et al., 2001 (dysphonia); 54 = Steele et al., 2013 (dual axis accelerometry); 121 = DePippo et al., 1992 (water swallow test); and 118 = Suiter and Leder et al., 2008 (water swallow test). (See Supporting Information, Appendix 3, in the online version of this article for the key to other tests). LUQ = Left upper quadrant, LRP = Positive likelihood ratio, RUQ = Right upper quadrant, LLQ = Left lower quadrant, RLQ = Right lower quadrant, LRN = Negative likelihood ratio.

have shown patients with dysphagia resulting from a variety of etiologies to produce lower than normal maximum isometric lingual pressures,[63–68] or pressures produced when the tongue is pushed as hard as possible against the hard palate. Tongue strengthening protocols that result in higher maximum isometric lingual pressures have been shown to carry over to positive changes in swallow function.[69–73] Inclusion of tongue pressure measurement in a comprehensive screening tool may help to improve predictive capabilities.

We believe our results have implications for practicing clinicians, and serve as a call to action for development of an easy-to-perform, accurate tool for dysphagia screening. Future prospective studies should focus on practical tools that can be deployed at the bedside, and correlate the results with not only gold-standard VFSS and FEES, but with clinical outcomes such as pneumonia and aspiration events leading to prolonged length of stay.

There were several limitations to this review. High levels of heterogeneity were reported in the screening tests present in the literature, precluding meaningful meta-analysis. In addition, the majority of studies included were in poststroke adults, which limits the generalizability of results.

In conclusion, no screening protocol has been shown to provide adequate predictive value for presence of aspiration. Several individual exam maneuvers demonstrate high sensitivity; however, the most effective combination of screening protocol components is unknown. There is a need for future research focused on the development of a comprehensive screening tool that can be applied across patient populations for accurate detection of dysphagia as well as prediction of other adverse health outcomes, including pneumonia.

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