Swallowing and Aspiration Risk: A Critical Review of Non Instrumental Bedside Screening Tests

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Background and Purpose The presence of dysphagia and aspiration in stroke patients is associated with increased mortality and morbidity. Early recognition and management of these two conditions via reliable, minimally invasive bedside procedures before complications arise remains challenging in everyday clinical practice. This study reviews the available bedside screening tools for detecting swallowing status and aspiration risk in acute stroke by qualitatively observing reference population study design, clinical flexibility, reliability and applicability to acute-care settings.

Methods The primary search was conducted using the PubMed, Embase, and Cochrane Library databases. The search was limited to papers on humans written in English and published from 1991 to 2016. Eligibility criteria included the consecutive enrollment of acute-stroke inpatients and the development of a protocol for screening aspiration risk during oral feeding in this population.

Results Of the 652 sources identified, 75 articles were reviewed in full however, only 12 fulfilled the selection criteria. Notable deficiencies in most of the bedside screening protocols included poor methodological designs and inadequate predictive values for aspiration risk which render clinicians to be more conservative in making dietary recommendations.

Conclusions The literature is dense with screening methods for assessing the presence of dysphagia but with low predictive value for aspiration risk after acute stroke. A standard, practical, and cost-effective screening tool that can be applied at the bedside and interpreted by a wide range of hospital personnel remains to be developed. This need is highlighted in settings where neither trained personnel in evaluating dysphagia nor clinical instrumentation procedures are available.

Key Words acute stroke, aspiration risk, oropharyngeal dysphagia, screening, swallowing.

INTRODUCTION

Stroke ranks as the third leading cause of death[1,2] and has a staggering human and economic toll.[3] There are 1.8 million new cases of stroke in the European Union annually.[4,5] The high prevalence of stroke might be at least partially attributable to continued record levels of cigarette smoking[6] and to the lack of unified prevention and treatment planning policies.

Dysphagia is commonly observed after a cerebrovascular accident (CVA),[7] and if not recognized early, it may lead to aspiration of saliva, food, and/or fluid entering the airway below the level of the vocal cords and into the trachea.[8] The incidence of oropharyngeal dysphagia exceeds 50% within the first 72 hours after stroke.[9] Dysphagia is transient and resolves spontaneously for many acute-stroke survivors,[10,11] while about 50% of patients with persisting dysphagia will show slower recovery and will typically resort to alternative methods of nutrition for some time following stroke.[12]

Despite the propensity for recovering after acute stroke, the presence of dysphagia car-

ries a 12-times greater risk of pulmonary complications such as aspiration pneumonia,[13] an infection that increases the catabolic condition of the patient[14] and is associated with the highest attributable mortality rate of all medical complications following a CVA.[2,15,16] Several studies have further revealed significant relationships between dysphagia, malnutrition, and dehydration, especially in patients who receive thickened liquids or modified diets.[17,18] The limited ability of patients to achieve a safe and adequate oral intake is linked to longer hospital stays[19] and an increased likelihood of being discharged to long-term care facilities, which further adversely affects patient outcome.[20]

Managing dysphagia early in the stroke care pathway is of international concern, and so worldwide clinical guidelines mandate systematic bedside swallowing screening within the first few hours of admission to the hospital and prior to offering any oral food, fluid, or medication.[21-23] The current lack of a universally acceptable and validated screening protocol has meant that various bedside methodologies are applied in clinical settings. When available, the use of diagnostic imaging methods for evaluating dysphagia and aspiration after stroke provides additional evidence for treatment planning. However, significant patient-specific limitations apply to instrumental diagnostic tests, such as the inability to comply with instructions due to poor medical or cognitive-communicative state, which render them inappropriate to use for all patients in the acute phase of stroke.[24] Moreover, many nursing homes and other facilities do not have access to diagnostic imaging for dysphagia. In several acute-care settings across the world, there are notable organizational and procedural limitations to applying these diagnostic tests, since clinical expertise is required to perform and interpret these tests and specialized equipment might not be readily available at all locations.[24,25] These conditions may delay assessments for days, having clear implications for patients associated with an increased likelihood of malnutrition and susceptibility to nosocomial infection and medical complications. Thus, a clinical bedside screening tool is needed for identifying the swallowing status and aspiration risk of the acute-stroke patient.

There remains a need to find simple, valid, and clinically useful bedside screening procedures that will correctly estimate the presence of aspiration risk associated with post stroke dysphagia.[26] This is especially true in countries where stroke care is still evolving, instrumentation by a qualified speech language pathologist (SLP), otorhinolaryngologist (ENT), or radiology team is lacking, and judgements are made by clinicians without sufficient training to assess the swallowing status of patients and determine appropriate nutritional plans. A standard bedside assessment of aspiration risk may lead to more clinically focused treatment, improved patient outcomes, and a reduction

in unnecessary incurring costs.[27]

In this study we endeavored to review all bedside methodologies designed for clinical use by a range of health-care professionals and to critically evaluate already established practices for assessing aspiration risk following acute stroke.

METHODS

An electronic search was performed of the Medline (PubMed), Embase, and Cochrane databases from 1991 to 2016 for studies on humans reported in English for which the full text was available. The following search terms were applied to the medical subject headings: (stroke OR cerebrovascular accident) AND (dysphagia OR swallowing OR aspiration) AND (screening OR assessment). Other potentially relevant papers were identified for full-text review from the reference lists of selected articles and from online searches of the tables of contents during the same period. Two of the authors independently completed the full article reviews to verify their inclusion, with disagreements resolved by consensus-based discussion among the review authors.

Findings of the literature search

Of the 652 articles retrieved, 75 original articles pertained to screening oropharyngeal swallowing impairments and aspiration risk following an acute ischemic CVA (Fig. 1). The inclusion criteria were fulfilled by only 12 articles. Information on sample size, length of training, and overall administrative burden on the clinician were noted but not required for inclusion.

Selection criteria

Eligibility criteria included originally validated studies involving 1) the consecutive enrollment of acute-stroke patients with or without suspected dysphagia, 2) the specificity of the bedside tool for adult stroke survivors in an inpatient care unit, and 3) the combined use of subjective non-swallowing variables with subsequent food or liquid trials for estimating a patient's swallowing risk. Accordingly, papers were eliminated from full review if 1) the study did not have a prospective design, 2) the described assessment or screening protocols were administered to a heterogeneous sample of adults with confirmed or suspected dysphagia with different neurogenic etiologies, and 3) the bedside screening procedures did not entail some form of direct swallowing stimuli for determining swallowing integrity and predicting whether the patients had a high or low risk of aspiration during food and/or liquid intake.

The following exclusion criteria were applied: 1) failure to explicitly state an appraisal of swallowing status or aspira-
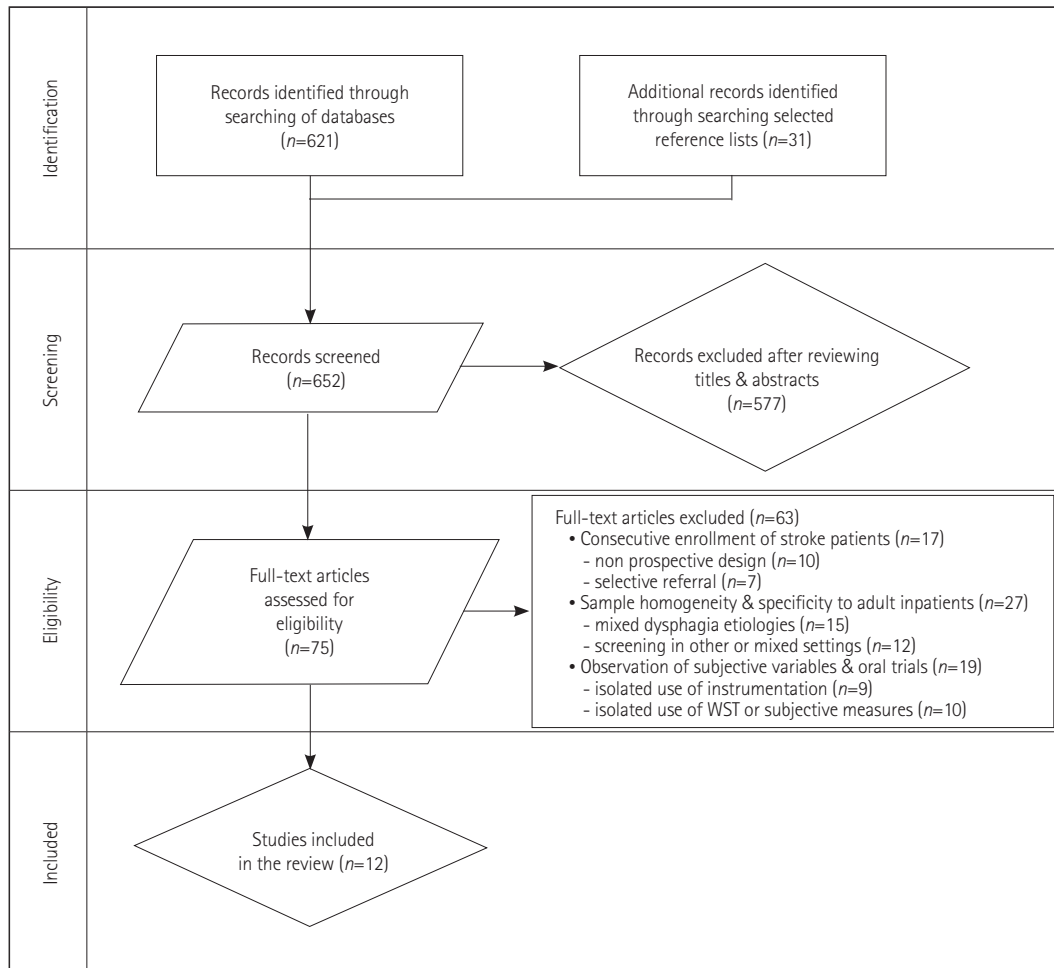
Fig. 1. Flow chart of study inclusion. WST: water swallowing test.

tion risk after the bedside screening protocol, 2) main outcome via the bedside screening test other than the early detection of a aspiration and/or dysphagia, 3) sole use of oral trials for determining aspiration risk without the use of other clinical identifiers, 4) sole use of subjective clinical indicators without subsequent bolus trials, 5) sole use of instrumental methods for detecting dysphagia and aspiration, 6) highly heterogeneous patient samples with other kinds of neurogenic etiologies besides confirmed stroke, and 7) samples drawn exclusively from a rehabilitation setting, nursing home setting, or mixed inpatient and outpatient setting, since these were not considered patients with an acute risk of aspiration.

Articles meeting the inclusion criteria were evaluated for methodological rigor (as presented in Table 1) using diagnostic study appraisal criteria from the Centre for Evidence-Based Medicine (http://www.cebm.net/critical-appraisal/) and the Quality Assessment for Diagnostic Accuracy of Studies-2 (QUADAS-2) tool, which are recommended by Cochrane.[28] These criteria were modified for consistency with the present study focusing on patients with stroke using clinical features associated with swallowing risk and a reference test. The criteria were rated as either 'yes' or 'no' if sufficient information was provided, or 'unclear' if the information was insufficient.

RESULTS

The results from the methodological appraisal of the included studies are presented in Table 1. None of the 12 articles were consistent with all ten quality-analysis measures. The need for informed consent and the ability to cooperate with bedside or instrumental assessment procedures resulted in a high rate of exclusion in some studies[29-31] and a bias toward patients with mild-to-moderate strokes. Five of the studies [32-36] conformed with nine of the methodological-rigor measures, while a study involving the hyper-acute stroke phase and emergency-room physicians[30] conformed to only three of them. The procedures in two studies[30,31] were not described in sufficient detail or with sufficient clarity to allow their replication.

Bedside evaluation tools included different non-swallow-

Table 1. Quality assessment measures in the studies reviewed

Study	Was selection bias minimized?	Did the study avoid inappropriate exclusions?	Was an index clinical test used?	Did all patients complete a reference standard test?	Was an appropriate protocol used?	Was there an acceptable interval between the index and reference tests?	Were the reference test results interpreted while blinded to those of the clinical test?	Were psychometric analysis data adequately reported?	Were accuracy measures adequately interpreted?	Was the description of the study protocol sufficient to allow replication?	Number of criteria met
Leigh et al.[41]	1	1	1	0	1	0	0	1	0	1	6
Edmiaston et al.[33]	1	1	1	1	1	1	1	1	0	1	9
Antonios et al.[36]	1	1	1	1	0	1	1	1	1	1	9
Turner-Lawrence et al.[30]	U	0	1	0	U	1	1	0	0	0	3
Trapl et al.[32]	1	U	1	1	1	1	1	1	1	1	9
Ramsey et al.[29]	0	0	1	1	1	U	1	1	0	1	6
Nishiwaki et al.[40]	0	1	1	1	1	1	U	1	0	1	7
Leder & Espinosa[35]	1	1	1	1	1	1	1	1	0	1	9
Lim et al.[34]	1	1	1	1	1	1	1	1	0	1	9
Smith et al.[31]	1	0	1	1	U	0	1	1	1	0	6
Daniels et al.[38]	1	1	1	1	1	U	1	1	0	1	8
Smithard et al.[37]	1	1	1	1	0	1	1	1	0	1	8

1 indicates criteria met, 0 indicates criterion not met, U indicates unclear whether the criterion was met (assigned a final score of 0).

ing stimuli, such as medical history information, subjective variables,[33,35-37] oral motor measures,[29,35-40] oxygen desaturation recordings,[30,31,34] and scores on neurological scales such as the National Institutes of Health Stroke Severity Scale or the Glasgow Coma Scale.[33] For the purposes of this review, all of the bedside tools that were investigated in detail utilized some form of direct oral trial such as either a water swallowing test (WST) and/or a bolus swallowing test (BST) with multiple or alternative oral (per os) intake consistencies administered in varied volumes. Almost half of the included studies (42%)[32,36,37,40,41] incorporated a preliminary assessment of patient's dry (saliva) swallowing ability prior to administering swallowing trials involving boluses with other textures or specifically measured for swallowing reflex ability. One study used small aliquots of diluted radiopaque contrast agent and looked for signs of aspirated contrast in chest radiography.[29]

Four of the reviewed studies involved drinking water in gradually increasing volumes ranging from 3 mL to a 90-mL sequential drinking task based on the patient's initial tolerance to smaller volumes.[32,37,39,41] Each subtest was typically terminated if a patient exhibited any overt sign of swallowing difficulty, aspiration, or voice-quality compromise. Seven studies (58%) utilized a single volume of water in combination with other subjective clinical data in order to determine the swallowing integrity, aspiration, or dysphagia risk of each patient[30,31,33,34,36,40,41] and their eligibility to receive oral nutrition at the time of assessment. One study[35] incorporated single sips of water boluses administered via a straw, and two studies[32,38] added swallowing of different bolus types: semisolids, solids, and liquids.

The clinical bedside screening test was completed before the diagnostic reference test in all studies. More than half of the studies (58%) used videofluoroscopy (VFSS) as the reference diagnostic test,[29,31,33,37,38,40,41] while 25%[32,34,35] used videoendoscopy [fiberoptic endoscopic evaluation of swallowing (FEES)]. In the study conducted by Antonios and colleagues,[36] subsequent validation was conducted by an SLP who performed the Mann Assessment of Swallowing Ability[42] while the results from the Emergency Physician Screening tool[30] were compared with those from an unspecified standardized dysphagia assessment performed by an expert SLP. Blinding of clinical results from the health-care professional completing the diagnostic reference test was reported for all studies except for that conducted by Leigh and colleagues.[41] The time frame between the two assessments was reported for all of the studies, but four studies used instrumental techniques with a delay of >1 day between the bedside screening and the diagnostic test (ranging from a few days to several weeks poststroke).[31,38,40,41]

Across all of the included studies (as listed in Table 2),

the sensitivities of the procedures described for detecting dysphagia ranged from as low as 54.6%[41] to as high as 100%,[32] while their specificities exhibited less variability, ranging from 66%[33] to 86.3%.[36] The sensitivities of the tests for identifying aspiration risk ranged from 65.2%[41] to 100%,[32] and their specificities ranged from 30%[35] to 84.4%.[38] Eight studies used aspiration or the risk of aspiration as the outcome measure,[29,31,32,34,35,37,38,40] one study solely used dysphagia as the outcome measure,[30] and the remaining studies used both aspiration and dysphagia measures.[33,36,41]

DISCUSSION

Dysphagia with or without aspiration is highly prevalent after stroke and is associated with increased nutritional deficits and pneumonia risk. Worldwide stroke guidelines advise the early recognition and management of dysphagia in hospitalized patients in order to reduce its devastating sequelae. Initial bedside swallowing screening remains the cornerstone of routine clinical practice, but the heterogeneity of the existing screening protocols reflects that a consensus has yet to be established.

The quality of the articles included in the methodological analysis varied. Although all quality measures are important for developing a highly valid and reliable tool that can detect the swallowing status and aspiration risk following acute stroke, the exact relevance of specific quality criteria such as a short interval between assessments and the ability to replicate administration protocols may vary according to the needs of the facilities developing swallowing screening tests. Aspiration or aspiration risk was the primary outcome in the vast majority of the studies. However, a patient may present with significant dysphagia without aspiration[43] that may also lead to a reduced nutritional status and lower quality of life.[44] One study[34] also followed up on the hospital stay of the patients for evidence of aspiration pneumonia, which was not performed in any of the other studies. It appears that a screening tool needs to be able to detect both the swallowing status and aspiration risk with high sensitivity and specificity, and be correlated with clinical outcomes such as pneumonia. In addition, the tool should be sufficiently simple to allow it to be implemented by the hospital personnel assigned to assess and care for stroke patients.

Significant variability also existed in the components used to screen for swallowing and aspiration risk across the studies. Non-swallowing measures included medical history items such as the presence of pneumonia, assessment of mental status, speech and language deficits, and oral motor categorical items such as unilateral jaw weakness, tongue strength, gag reflex, secretion management, and volitional cough. However,

Table 2. Validity measures in the included studies

Research study and protocol name (index test)	Descriptive measures and test components	Criterion standard	Main outcome	Psychometric analysis data
Leigh et al.[41]	Check mental status and ability to open the mouth	VFSS	Dysphagia	Sensitivity=54.6% Specificity=80.9% PPV=75.7% NPV=62.1% +LR (95% CI)=2.86%
Bedside swallowing screening test	Dry and wet swallowing tests (20-mL WST) Descriptive three-point scale classifying the aspiration risk		Aspiration risk	Sensitivity=65.2% Specificity=71.4% PPV=42.9% NPV=86.2% +LR (95% CI)=2.28%
Edmiaston et al.[33]	Four screening items: mental status (Glasgow Coma Scale score <13), and presence of facial, tongue, or palatal asymmetry or weakness	VFSS	Dysphagia	Sensitivity=94% Specificity=66% PPV=71% NPV=93%
Barnes Jewish Hospital Stroke Dysphagia Screen	Subjective signs of aspiration on 90-mL WST		Aspiration	Sensitivity=95% Specificity=50% PPV=41% NPV=96%
Antonios et al.[36]	Physician-weighted screening of 12 items: alertness, cooperation, respiration, expressive dysphasia, auditory comprehension, dysarthria, saliva, tongue movement, tongue strength, gag reflex, voluntary cough, and palate movement	Evaluation of dysphagia by SLPs using the MASA[42]	Dysphagia	Sensitivity=92.6% Specificity=86.3% PPV=79% NPV=95%
Modified MASA	(maximum score=100)		Aspiration	Sensitivity=93% Specificity=53%
Turner-Lawrence et al.[30]	Two-tier bedside assessment: 1) voice quality, swallowing complaints, facial asymmetry, and aphasia; and	Formal swallowing evaluation by SLP	Dysphagia	Sensitivity=96% Specificity=56% +LR=2.2%
Emergency Physician Swallowing Screen	2) Signs of aspiration on WST and observation of pulse oximetry desaturation (≥2%)			

Table 2. Validity measures in the included studies (continued)

Research study and protocol name (index test)	Descriptive measures and test components	Criterion standard	Main outcome	Psychometric analysis data
Trapl et al.[32]	Preliminary assessment/ indirect swallowing test: vigilance, throat clearing, and SST	FEES (using the Penetration Aspiration Scale)	Aspiration risk (grouped according to the Penetration Aspiration Scale)[48]	First group (*n*=19) Sensitivity=100% Specificity=50% PPV=81% NPV=100%
The Gugging Swallowing Screen	Subsequent direct swallowing trials with three bolus types: semisolids, liquids, and solids			Second group (*n*=30) Sensitivity=100% Specificity=69% PPV=74% NPV=100%
Ramsey et al.[29]	Oral motor function examination Observation after three 5-mL aliquots of diluted radiopaque contrast agent	VFSS	Aspiration/unsafe swallowing	Failed MBSA±oxygen desaturation >2% Sensitivity=60% Specificity=41% PPV=28% NPV=73%
Modified bedside swallowing test	Simultaneous 10-min desaturation recordings			Failed MBSA±oxygen desaturation >5% Sensitivity=53% Specificity=67% PPV=38% NPV=79%
Nishiwaki et al.[40]	Six oral motor items: lip closure, tongue movement, palatal elevation, gag reflex, voice quality, and motor speech function	VFSS	Aspiration	Sensitivity=72% Specificity=67% (for cough/voice change in WST)
Modified screening tool	Two swallowing screening tests: SST and 30-mL WST			
Leder & Espinosa[35]	Bedside evaluation with six clinical identifiers: dysphonia, dysarthria, abnormal gag reflex, abnormal volitional cough, and voice change after swallowing	FEES	Aspiration risk	Sensitivity=86% Specificity=30% PPV=50% NPV=73%
Clinical bedside examination	Per-os trials of single sips of water boluses via straw			
Lim et al.[34]	50-mL WST (in 10-mL aliquots) and pulse oximetry recordings before and after each 10-mL WST (≥2% desaturation was clinically significant)	FEES	Aspiration	WST and oxygen desaturation test combined: Sensitivity=100% Specificity=70.8% PPV=78.8% NPV=100%
Bedside aspiration test	Monitoring for evidence of aspiration pneumonia		Aspiration pneumonia risk	RR if evidence of aspiration on FEES=1.24 (1.03<RR<1.49)

Table 2. Validity measures in the included studies (continued)

Research study and protocol name (index test)	Descriptive measures and test components	Criterion standard	Main outcome	Psychometric analysis data
Smith et al.[31] *Clinical bedside examination*	Subjective evaluation of swallowing physiology at rest and on swallowing various quantities and consistencies (not clearly outlined)	VFSS	Aspiration risk	Bedside examination and oxygen desaturation ≥2% Sensitivity=73% Specificity=76% PPV=55% NPV=88%
Daniels et al.[38] *Bedside swallowing examination*	Oral motor examination 70-mL WST in small ordinal aliquots and clinical swallowing trial with semisolids and solids	VFSS	Aspiration risk	Stepwise logistic regression highlighted two of six predictor variables: abnormal volitional cough and cough with swallowing combined Sensitivity=69.6% Specificity=84.4%
Smithard et al.[37]	Medical bedside assessment: consciousness level, head and trunk control, breathing pattern, lip closure, palate movement, laryngeal function, gag reflex, and voluntary cough Signs of aspiration during WST (three 5-mL aliquots followed by 60-mL challenge if passed) Clinical judgement by SLP	VFSS	Aspiration	Multiple logistic regression analysis revealed two independent predictors of aspiration: impairment of consciousness level and weak voluntary cough Sensitivity=75% Specificity=72% PPV=41% NPV=91%

CI: confidence interval, FEES: fiberoptic endoscopic evaluation of swallowing, MASA: Mann Assessment of Swallowing Ability, MBSA: modified bedside swallowing assessment, NPV: negative predictive value, PPV: positive predictive value, RR: relative risk, SLP: speech language pathologist, SST: saliva swallowing test, VFSS, videofluoroscopy, WST, water swallowing test, +LR: positive likelihood ratio.

not all of these items have been demonstrated to be strong predictors of aspiration. McCullough et al.[39] examined the utility of non-swallowing bedside indicators and trial swallowing measures in detecting aspiration. Sound methodology and lengthy statistical recording for each measure were noted, but they reported low sensitivities for each measure individually, leading a clinician to the conclusion that the presence of two measures is much more meaningful than their absence. Regression analysis demonstrated that the best factors in the model for detecting aspiration overall were the failure of the 90-mL WST and dysphonia.

The ability to sustain adequate alertness level for a short period of time appears to be a prerequisite for direct oral trials. Furthermore, testing that a patient can actually swallow should be included in any screening tool, but the optimal method of assessment still requires investigation. Most of the studies included a WST, but the volumes administered varied over a very wide range (from 3 mL to 90 mL), and the number of trials also varied in some studies. Research has shown that silent aspiration is volume-dependent,[45] and thus one concern with the bedside administration of small bolus volumes for determining aspiration risk is that the absence of overt behavioral signs such as a reflexive cough can lead to high false-negative rates. Meanwhile, there is a need to determine the optimal trade-off between assessing the swallowing ability of patients and their swallowing safety. The safety of requiring an acute-stroke patient to self-administer 90 mL of water without stopping is questionable when research has shown poor awareness of swallowing deficits in the acute phases of stroke, with most patients consuming

larger volumes of water more rapidly.[46]

Several of the investigators used pulse oximetry in conjunction with bedside swallowing trials to determine the presence of an aspiration risk[25, 30, 31,34] but there are conflicting data of its usefulness.[29,47] Lim and colleagues[34] measured oxygen desaturation 10 minutes after applying a modified WST that involved small equal aliquots. A bedside procedure that simultaneously applies a sequential drinking task and pulse oximetry measurements may provide more meaningful results while maintaining the test–retest reliability. Equally controversial findings from small subject groups were found by Smith and colleagues[31] Although they used a combination of bedside screening and oxygen desaturation testing, they did not clearly report on their bedside assessment procedure, making it almost impossible to utilize their research in clinical practice.

Most of the studies used an instrumental reference test (VFSS or FEES) to objectively confirm the presence of dysphagia or aspiration. There is support in the literature for the need to routinely assess the swallowing function of patient in the acute phase of stroke using a diagnostic test (when this is readily available) and when the patient is able to sit up and cooperate with the procedure. However, few studies applied the reference standard test and the clinical index screening test within a few days of each other, which represents an unacceptable delay in this patient population given that the spontaneous recovery typically occurs rapidly.

The necessity for identifying post-stroke dysphagia and aspiration early in the care pathway of a patient indicates that frontline medical professionals who are the first to make contact with the patient after a CVA need to apply swallowing screening. Several studies have highlighted interdisciplinary dysphagia screening,[30,32-34] but this had limitations associated with the poorly defined screening procedures making it difficult to integrate them into clinical practice. It is clear from the existing literature that the reported statistical data can be influenced by whether patients are selectively referred due to probable dysphagia or whether they are consecutively recruited into a research study. The selection of different swallowing and non-swallowing features in the evaluation process and their perceived importance in identifying dysphagia and aspiration as well as the significant variability in the volumes and consistencies of boluses applied as direct swallowing stimuli at the bedside can further lead to discrepant assumptions.

Consistent empirical evidence is required to achieve best practice for swallowing screens. The absence of a consensus on the best screening methodology should not be interpreted as "no screening should be performed" or that it is a "one fits all" process. Broader patient-specific and facility-specific factors should be taken into account before making any recommendation regarding oral nourishment.

CONCLUSION

Stroke is the leading cause of neurogenic dysphagia and medical professionals in the acute situation rely on a bedside screening test to determine the swallowing status. How instrumental examinations are organized may present logistics problems at locations worldwide where their routine use is not possible. Screening for dysphagia and aspiration is important to reduce negative outcomes, decrease hospital re-admissions for pneumonia, and to expedite the safe nutritional management of patients in the acute phase of recovery. Although numerous screening tools have been developed, no present screening protocol provides high specificity and sensitivity for predicting the risk of aspiration. It appears that a cluster of swallowing and non-swallowing features may achieve both high sensitivity and specificity at the bedside.

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