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Spontaneous Swallow Frequency Compared with Clinical Screening in the Identification of Dysphagia in Acute Stroke

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Abstract

Background—The aim of this study was to compare spontaneous swallow frequency analysis (SFA) with clinical screening protocols for identification of dysphagia in acute stroke.

Methods—In all, 62 patients with acute stroke were evaluated for spontaneous swallow frequency rates using a validated acoustic analysis technique. Independent of SFA, these same patients received a routine nurse-administered clinical dysphagia screening as part of standard stroke care. Both screening tools were compared against a validated clinical assessment of dysphagia for acute stroke. In addition, psychometric properties of SFA were compared against published, validated clinical screening protocols.

Results—Spontaneous SFA differentiates patients with versus without dysphagia after acute stroke. Using a previously identified cut point based on swallows per minute, spontaneous SFA demonstrated superior ability to identify dysphagia cases compared with a nurse-administered clinical screening tool. In addition, spontaneous SFA demonstrated equal or superior psychometric properties to 4 validated, published clinical dysphagia screening tools.

Conclusions—Spontaneous SFA has high potential to identify dysphagia in acute stroke with psychometric properties equal or superior to clinical screening protocols.

Keywords

Dysphagia; acute stroke; screening; swallow frequency

Dysphagia screening poststroke is related to reduced morbidity and mortality[1–3]; specifically, pneumonia rates are lower among stroke patients who pass dysphagia screening.[3] Dysphagia screening poststroke is intended as a brief, valid, and reliable tool administered to all new stroke admissions that is both sensitive and specific to dysphagia risk in the acute poststroke period. Dysphagia screening is intended to be completed before the administration of any food, liquid, or medications by mouth.[4–6] As a result, dysphagia screening tools have been employed in the emergency department, on admission to acute

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care stroke units, and even on admission to rehabilitation hospitals.[7–9] Most dysphagia screening tools proposed for acute stroke incorporate some form of limited clinical examination plus/minus a test swallow of 1 or more materials.[4–6] As a result, clinical screening protocols for dysphagia require available, trained personnel and some degree of cooperation from the patient. Furthermore, many proposed clinically based screening protocols suffer from limited psychometric properties,[4,6] and no current consensus exists regarding which clinical items to include in dysphagia screening protocols.[5] Collectively, these limitations may contribute to a reported low adherence rate for dysphagia screening in acute stroke.[3,10] These practical considerations may have contributed to the action of the Joint Commission to retire dysphagia screening as a performance measure in 2010.[3]

An alternative to clinical dysphagia screening protocols may be the evaluation of spontaneous swallowing frequency. Spontaneous swallowing is one of a group of aerodigestive reflexes supporting airway protection.[11–15] Reduction in spontaneous swallowing frequency rate has been demonstrated as a sensitive index of dysphagia in various clinical populations including acute stroke.[16–19] The current study compared psychometric properties of spontaneous swallow frequency analysis (SFA) with a clinical dysphagia screening protocol completed as the standard of care by stroke nurses in the identification of dysphagia in patients with acute stroke. In addition, we compared psychometric properties of spontaneous SFA to 4 published, validated clinical dysphagia screening protocols highlighted in a recent systematic review.[6]

Methods

Subjects

Between May and July 2012, consecutive stroke admissions were monitored and those meeting inclusion criteria were recruited for inclusion in this study. Inclusion criteria were age of 21 years or older with confirmation of acute stroke by neurologic examination and imaging study. Exclusion criteria were trauma or anatomical alteration to the head–neck region, pre-existing conditions contributing to dysphagia, intubation at the time of recruitment, and patient/proxy refusal to participate in this study. Patients with recurrent stroke were included as long as they did not meet any of the exclusion criteria. Each participant received all stroke and swallowing clinical examinations including both dysphagia screening protocols. The local institutional review board (IRB) approved the study, and all patients or their approved proxy signed an IRB-approved consent form.

Stroke Assessments

The primary metric of stroke severity was the National Institutes of Health Stroke Scale.[20,21] The modified Rankin Scale[22,23] was used as a metric of stroke impairment, and the modified Barthel Index[24,25] was employed as a metric of functional impairment. Finally, the Glasgow Coma Scale[26] was used as an index of consciousness.

Swallowing/Dysphagia Assessments

The Mann Assessment of Swallowing Ability (MASA)[27] is a stroke-validated clinical assessment of swallowing. The MASA served as the criterion referent in this study. An

MASA score of 178 or less (from a total of 200 possible points) indicates the presence of dysphagia. A second index of dysphagia, the Functional Oral Intake Scale (FOIS),[28] is a stroke-validated metric of functional oral intake of food and liquid.

Spontaneous Swallow Frequency Analysis

A previously validated approach was used for spontaneous SFA.[29] This approach uses the acoustic signature of swallowing to calculate the rate of spontaneous swallowing over a fixed time period as swallows per minute. Spontaneous swallow frequency was measured with an acoustic recording obtained via a miniature microphone (VT506; Voice Technologies, Zurich, Switzerland) connected to a digital voice recorder (Olympus DS-40). The microphone was adhered to the skin of the anterolateral neck just below the lateral cricoid cartilage in the area identified by Takahashi[30,31] as optimal to record swallow sounds. Rycote was used to affix the microphone over the recording area (Rycote Microphone Windshields Ltd, Gloucestershire, UK). Recordings were obtained over a 30-minute interval with all patients resting quietly in bed. All recordings were analyzed off-line using an acoustic software program (TF 32; P. Milenkovic, Madison, WI), which displayed a visual trace of the recording simultaneously with the auditory signal. Two independent judges reviewed all recordings in 1-minute segments to identify the presence or absence of swallow activity. Judges were blinded to the clinical status of all acute stroke cases. Spontaneous swallowing frequency rate was calculated as swallows per minute for each 30-minute recording.

Independent Nurse Screening for Dysphagia in Acute Stroke

The care pathway for acute stroke in our facility incorporates a nurse-administered clinical screening for dysphagia. All stroke nurses in this certified primary stroke center have been trained to criterion on the use of this tool with adherence rates approaching 75% of all stroke admissions.[32] This tool has not been psychometrically validated but is reflective of many dysphagia screening protocols currently in use.[5,6] Clinical judgment of 6 items, alertness, voice, speech, coughing/choking, difficulty managing secretions, and patient/family report of present or prior dysphagia, is used to make a determination of dysphagia risk for each patient. Each item is presented as a yes/no question, and any “yes” response results in the patient being placed on no oral intake status and referred to the speech–language pathology (SLP) service for comprehensive swallowing evaluation. Thus, identification of dysphagia on this screening protocol was represented by a “yes” response to any item in the protocol with resulting referral to SLP for comprehensive dysphagia assessment.

Comparison of Swallow Frequency with Validated Clinical Dysphagia Screening Protocols

Schepp et al[6] reviewed 35 dysphagia screening protocols for acute stroke and concluded that only 4 met basic psychometric quality criteria. Basic psychometric characteristics (sensitivity, specificity, negative predictive value [NPV], and positive predictive value [PPV]) and likelihood ratios (LRs, ±) were descriptively compared between spontaneous SFA and each of these published, validated clinical dysphagia screening protocols.

Assessor Blinding

Assessors who completed spontaneous SFA from recorded samples were blinded to the clinical status of patients. Assessors who either collected or analyzed spontaneous swallow frequency data were blinded to the results of nurse clinical dysphagia screening. Finally, both nurses and SLPs were unaware of the collection of spontaneous swallow frequency data or the results of spontaneous SFA.

Statistical Analyses

Sample demographics were evaluated using descriptive statistics. Based on MASA threshold, dysphagia subgroups (6) were identified, and spontaneous swallow frequency rate was compared between subgroups. Accuracy of spontaneous SFA to identify patients with dysphagia was identified by comparison with the clinical evaluation method (MASA) and analyzed in terms of sensitivity (Se), specificity (Sp), PPV, and NPV. The 95% confidence intervals (CIs) of these measures were calculated using standard methods. The cut point of .40 or less swallows per minute identified in prior work in acute stroke[18] was used to discriminate between patients with and without dysphagia based on this method. Overall concordance between the swallow frequency measure and the standard clinical examination (MASA) was expressed as classification accuracy and computed from 2 × 2 tables. Reliability between and within raters was evaluated using intraclass correlation statistics. Using these same psychometric analysis procedures, we compared results of the independent nurse screening to the MASA clinical criterion referent. Furthermore, based on independent nurse screening results, we compared mean swallow frequency rates for cases referred to SLP versus not referred as part of a standard care pathway. All statistical analyses were completed using SPSS 21.0 and Medcalc 2.0.

Results

Sixty-two patients were enrolled and completed all study procedures during the recruitment period. Mean age was 60.13 (15.17) years; 32 patients were male. Both ischemic (n = 39) and hemorrhagic (n = 23) strokes were enrolled. The mean (standard deviation [SD]) interval between the onset of stroke symptoms and swallow frequency dysphagia screening was 4.6 days (4.1) with a mode of 48 hours. The prevalence of dysphagia based on the MASA was 42% (n = 26). No significant differences were identified in the stroke onset to dysphagia screening interval between dysphagia subgroups. The National Institutes of Health Stroke Scale mean scores were significantly higher for the dysphagia subgroup ($t = -4.72$, $P < .0001$) as were Rankin scores ($t = -6.561$, $P < .0001$). Barthel Index ($t = 7.39$, $P < .0001$) and Glasgow Coma Scale ($t = 2.45$, $P = .018$) scores were significantly lower in the dysphagia subgroup. Both dysphagia indices (MASA: $t = 9.93$, $P < .0001$; Functional Oral Intake Scale: $t = 8.84$, $P < .0001$) were significantly lower in the dysphagia subgroup (Table 1).

Spontaneous Swallow Frequency Analysis and Dysphagia

The mean (SD) swallow frequency rate for the subgroup of patients with dysphagia was .23 (.15) versus .55 (.30) for the subgroup without dysphagia ($t = 4.88$, $P < .0001$). Using the identified swallow frequency rate threshold of .40 or less for dysphagia from a prior study,[18]

psychometric properties of swallow frequency rate to identify dysphagia were calculated in comparison with the criterion referent MASA (≤178). Based on this comparison, swallow frequency rate (≤.40 swallows per minute) was 96% (95% CI, 80.3–99.4) sensitive and 67% (95% CI, 49.0–1.4) specific in the identification of clinically significant dysphagia. NPV was 96% (95% CI, 79.6–99.3), PPV 68% (95% CI, 50.2–82.0), 1LR 2.9, 2LR .06, and the overall classification accuracy was 79%.

Independent Nurse Clinical Screening and Dysphagia

Nurse-administered clinical screenings were completed an average of 1.74 (SD, 1.96) days (mode = 24 hours) before spontaneous swallowing frequency analysis and concomitant clinical dysphagia assessment (MASA). Comparing the results of the nurse screening to our criterion referent (MASA) revealed 88% sensitivity (95% CI, 69.8–97.4), 58% specificity (95% CI, 40.8–74.5), 88% NPV (95% CI, 67.6–97.2), 61% PPV (95% CI, 43.4–75.9), 1LR of 2.1, −LR of .20, and 71% overall classification accuracy (Table 2). Swallow frequency rate was significantly lower for patients referred to SLP (versus those cases not referred) based on results of nurse screening (.34 versus .53; $t = 2.61$, $P < .01$) (Fig 1).

Comparison of Spontaneous Swallow Frequency Analysis with Validated Clinical Dysphagia Screening Tools

The systematic review by Schepp et al[6] identified 4 dysphagia clinical screening protocols meeting basic quality criteria for reliability, validity, and feasibility.[8,9,33,34] Comparison of spontaneous SFA psychometric properties for dysphagia screening with each of these clinical protocols is depicted in Table 3. The prevalence of dysphagia in the present study is comparable with each of the published, clinical protocols. Reliability across studies was uniformly strong. A clinical examination (MASA in 3 of 4 comparisons) was used either in isolation or in combination with a fluoroscopic swallowing examination as the criterion referent in all studies. Comparison of psychometric properties in dysphagia case identification suggests that spontaneous SFA is equal to or slightly superior to the 4 validated clinical screening protocols.

Discussion

Spontaneous SFA has high potential to identify patients with acute stroke at risk for dysphagia. On the same cohort of acute stroke cases, SFA was superior to a nurse-administered dysphagia screening tool in the accurate identification of patients at risk for dysphagia. Furthermore, SFA is comparable with or exceeds the published psychometric properties of highly rated clinical dysphagia screening tools.

A primary goal of a screening tool is to accurately identify a high number of cases at risk for the disorder of interest (high sensitivity). High sensitivity serves to “rule out” cases not at risk.[35] Pertinent to dysphagia in acute stroke, high sensitivity helps the stroke team decide if oral intake of any food, liquid, or medication is appropriate. SFA was superior to the nurse-administered tool, in that it demonstrated only 4% missed cases (false negatives) compared with 12% with nurse-administered clinical screening tool in the same cohort of patients. This difference may translate into a higher level of confidence in decisions based on SFA to

provide food, liquid, or medicines by mouth during the acute phase of stroke. This difference also may indicate that an additional 8% of patients with acute stroke with dysphagia would not receive comprehensive dysphagia assessment and indicated treatment leading to potential reduction in dysphagia-related morbidity.[1,3,36]

A related attribute of a screening tool is to limit the percentage of cases falsely identified as demonstrating the disorder of interest (high specificity). High specificity serves to "rule in" cases at risk.[35] Thus, positive findings based on dysphagia screening tools with high specificity would result in further dysphagia evaluation and possibly other negative or time-consuming consequences. Both dysphagia screening tools (SFA and clinical) demonstrated fair specificity with false-positive rates of 33% (swallow frequency) versus 42% (nurse-administered clinical screener). As a result, both screening protocols (see Table 3) are likely to overestimate the risk for dysphagia in acute stroke. However, the primary consequence of overestimation is likely to be referral to SLP for comprehensive dysphagia evaluation. This consequence is viewed as conservative and one that may be in the best interest of the patient's overall health care.

One potential explanation for the difference in false-positive rates between SFA and the nurse-administered screening is the time difference between administration of the 2 screening protocols. On average, the nurse-administered dysphagia screening protocol was completed 1.74 days (mode = 24 hours) before swallow frequency dysphagia screening. One reason for this time difference is the informed consent time required for patient consent (24 hours). Given that dysphagia may resolve rapidly in acute stroke,[37] this 1-day window might have affected the accuracy of dysphagia identification with the respective screening tools. Moreover, because the criterion referent (MASA) was administered on the same day as swallow frequency screening, the nurse screening may have overestimated the number of cases positive for dysphagia (inflated false-positive rate) based on MASA score. However, this time delay is similar to study delay time reported in validation studies in 3 of the highly rated, validated clinical dysphagia screening protocols.[9,33,34] Finally, SFA was not significantly correlated with time poststroke onset in a prior study.[18] This observation combined with strong correlations to dysphagia and dysphagia severity[18] suggests that SFA may be a robust dysphagia screening tool at different time points poststroke onset. Despite these related observations, future comparisons between SFA and clinical screening protocols should ascertain that both screening protocols are administered at the same time as the criterion referent to ensure an accurate comparison. Moreover, SFA should be completed on sequential days during the acute phase of stroke to evaluate the temporal stability of the measure compared with the clinical status of patients.

Psychometric properties of SFA are comparable with 4 highly rated, published, validated clinical protocols for dysphagia screening in acute stroke. This observation is strengthened by the fact that all 4 published protocols used a clinical dysphagia examination as all or part of the criterion referent and that 3 of the 4 used the same criterion referent (MASA). Clinical screening tools require trained, available personnel for completion. For example, the Toronto Bedside Screening Test requires 4 hours of nurse training to reliably administer.[9] Edmiaston et al[8] reported that initial training on their clinical screening protocol required only 10 minutes, however, to establish reliability; 50 nurses watched a video and scored patient

performance. Two weeks later, 15 of the original 50 nurses reviewed the video and rescored patient performance to establish test–retest reliability. As such, this additional time should be included as part of the required training component of their protocol. Conversely, Antonios et al[33] and Turner-Lawrence et al[34] reported minimal training for their clinical screening protocols (eg, an explanation of the screening tool provided to examine physicians). Thus, although some training or orientation is required for all clinical screening protocols, extensive variability is reported across validation studies for the respective protocols. In addition to any training period, specialized personnel must be available on a 24-hour daily basis to provide dysphagia screening. Finally, clinically based screening protocols are language dependent and require some degree of participation on the part of the patient. Perhaps, in consideration of these attributes, clinically based screening tests demonstrate low adherence. For example, Hinchey et al[10] reported a mean adherence rate of 62% (range 17%–99%) across 17 participating hospitals. Moreover, based on the data from the Paul Coverdell National Acute Stroke Registry, Lakshminarayan et al[3] reported a range of adherence between 56% and 63%. Their results suggested that patients were selectively screened in consideration of stroke severity.[3] Furthermore, their results indicated that unscreened patients had higher pneumonia rates than patients who had passed a dysphagia screening protocol. They interpret their findings in support of Hinchey et al[1] who concluded that screening all stroke cases contributed to a reduction in poststroke pneumonia rates.

This study is limited to a cross-sectional identification of dysphagia cases from a cohort of patients with acute stroke. Consistent with all dysphagia screening protocols, future studies must address the longer term implication of passing or failing the screening protocol. For example, Lakshminarayan et al[3] reported that patients who passed a dysphagia screening had lower pneumonia rates. Additional questions might be posed to address patients who fail the screening protocol and are identified as at risk for dysphagia. These questions should include both false and true positive cases in reference to utilization of health care resources. Prior studies have demonstrated that stroke patients with dysphagia have a longer length of hospital stay, more morbidity, and are more likely to be discharged to institutional settings.[36–38] True benefit from a screening protocol should demonstrate enhanced long-term outcomes, which will require a high level of sustained patient surveillance. Larger samples with a longer surveillance period will be required to address these questions. Finally, though the present study suggests that spontaneous SFA is superior to a nurse-administered clinical screening protocol in a head-to-head comparison and equal to other published clinical screening protocols, these data do not indicate whether SFA combined with a nurse-administered clinical screening might produce the strongest screening outcomes.

Conclusions

SFA has high potential to be developed into a simple, rapid, and sensitive dysphagia screening tool for acute stroke. Psychometric performance of SFA is equal or superior to clinically based dysphagia screening protocols in acute stroke.

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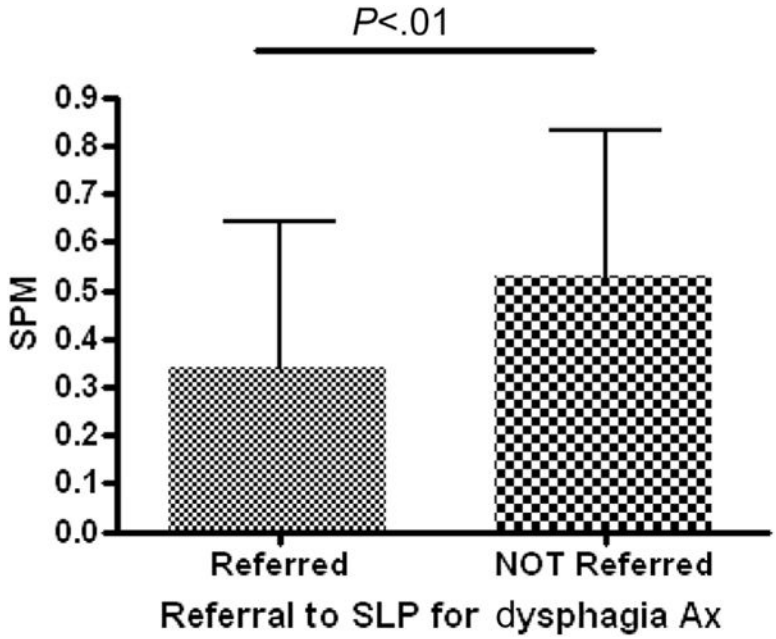

Figure 1.
Swallow frequency analysis rate for SLP referred versus not referred. Abbreviations: Ax, assessment; SLP, speech–language pathology; SPM, swallows per minute.

Table 1

Demographic characteristics of the total cohort and the dysphagia subgroups

Variable	Total cohort	Dysphagia subgroup	No dysphagia subgroup
Age	60.1 (15.2)	65.2 (17.1)	56.5 (12.7) *
Male/female	32/30	12/14	20/16
Type stroke (n)			
Ischemic	39	16	23
Hemorrhagic	23	10	13
Interval stroke symptoms to assessment			
Mean (SD), d	4.6 (4.23)	5.23 (4.99)	4.11 (3.58)
Mode, h	48	24	24
Median, d	3.0	3.5	3.0
NIHSS		10.9 (6.02)	4.4 (3.42) *
Rankin		4.2 (1.08)	2.1 (1.32) *
Barthel Index		5.9 (6.39)	16.3 (4.55) *
GCS		13.4 (2.94)	14.8 (.05) *
MASA		144.7 (28.6)	192.9 (4.9) *
FOIS		3.5 (2.21)	6.9 (.46) *

Abbreviations: FOIS, Functional Oral Intake Scale; GCS, Glasgow Coma Scale; MASA, Mann Assessment of Swallowing Ability; NIHSS, National Institutes of Health Stroke Scale.

Mean and SDs are reported unless otherwise noted.

* Variables that differ significantly between dysphagia subgroups ($P < .05$).

Table 2

Comparison of SFA to nurse-administered clinical screening

Test	Sensitivity %	Specificity %	NPV (%)	PPV (%)	+LR	−LR	Classification accuracy (%)
SFA	96	67	96	68	2.9	.06	79
Nurse, clinical	88	58	88	61	2.1	.20	71

Abbreviations: LR, likelihood ratio; −, negative; NPV, negative predictive value; +, positive; PPV, positive predictive value; SFA, swallow frequency analysis.

All values except LR expressed at %.

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Table 3

Comparison of spontaneous swallow frequency properties to 4 validated clinical dvsphagia protocols for acute stroke

Screening protocol	Sample size	Setting	Prevalence (%)	Reliability	Ciiteiion referent	+LR	−LR	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Swallow frequency	62	Acute stroke unit	42	ICC = .95	MASA	2.8	.06	96	67	68	96
Bames Jewish[28]	300	Acute stroke unit	29	κ = .94	MASA	3.5	.12	91	74	54	95
MMASA[29]	150	Acute stroke unit	36	κ = .76	MASA	6.8	.09	93	86	79	95
Emergency MD[30]	84	Emergency department	57	κ = .90	SLP clinical examination	2.2	.08	96	56	74	91
TOR-BSST[31]	59	Acute stroke unit (n = 24) Rehabilitation unit (n = 35)	39	ICC = .92	Fluoroscopy and MASA	2.7	.10	96	64	77	93

Abbreviations: ICC, intraclass correlation; LR, likelihood ratio; −, negative; MASA, Mann Assessment of Swallowing Ability; MMASA, modified Mann Assessment of Swallowing Ability; NPV, negative predictive value; +, positive; PPV, positive predictive value; SLP, speech–language pathology; TOR-BSST, Toronto Bedside Swallowing Screening Test.