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ORIGINAL ARTICLE

Diagnostic accuracy of the Dysphagia Trained Nurse Assessment tool in acute stroke

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Abstract

Background and purpose: Comprehensive swallow screening assessments to identify dysphagia and make early eating and drinking recommendations can be used by trained nurses. This study aimed to validate the Dysphagia Trained Nurse Assessment (DTNAx) tool in acute stroke patients.

Methods: Participants with diagnosed stroke were prospectively and consecutively recruited from an acute stroke unit. Following a baseline DTNAx on admission, participants underwent a speech and language therapist (SLT) bedside assessment of swallowing (speech and language therapist assessment [SLTAx]), videofluoroscopy (VFS) and a further DTNAx by the same or a different nurse.

Results: Forty-seven participants were recruited, of whom 22 had dysphagia. Compared to SLTAx in the identification of dysphagia, DTNAx had a sensitivity of 96.9% (95% confidence interval [CI] 83.8–99.9) and specificity of 89.5% (95% CI 75.2–97.1). Compared to VFS in the identification of aspiration, DTNAx had a sensitivity of 77.8% (95% CI 40.0–97.2) and a specificity of 81.6% (95% CI 65.7–92.3). Over 81% of the diet and fluid recommendations made by the dysphagia trained nurses were in absolute agreement compared to SLTAx. Both DTNAx and SLTAx had low diagnostic accuracy compared to the VFS-based definition of dysphagia.

Conclusions: Nurses trained in DTNAx showed good diagnostic accuracy in identifying dysphagia compared to SLTAx and in identifying aspiration compared to VFS. They made appropriate diet and fluid recommendations in line with SLTs in the early management of dysphagia.

KEYWORDS
stroke, dysphagia, swallowing, screening, assessment, nurses

INTRODUCTION

Post-stroke dysphagia is common, and negative health impacts, such as stroke-associated pneumonia,[1,2] can be reduced by early swallow screening and dysphagia assessment.[3] In the United Kingdom, speech and language therapists (SLTs) are the main professionals assessing and managing dysphagia. It is essential that patients admitted to acute stroke units (ASUs) who have dysphagia are effectively identified. In the United Kingdom, guidelines recommend that acute stroke patients remain "nil by mouth" until screened using a validated

tool within 4 h of admission.[4] Trained nurses are essential to screen for dysphagia given that SLTs are not commissioned to provide 24-h cover. If nurses could also make recommendations to commence safe oral feeding for nutrition, hydration and medication administration it would benefit acute stroke patients whilst waiting for SLT input. Acute stroke SLTs aim to see patients with dysphagia within 72 h of admission to provide specialist assessment and ongoing management including adaptations, strategies, education and rehabilitation. Water swallow tests carried out by nurses have good sensitivity but lower specificity,[5] resulting in many patients with no or mild to moderate dysphagia remaining nil by mouth while awaiting SLT assessment. Comprehensive screening assessments not only screen for dysphagia but allow the assessor to recommend modified oral intake in those with mild to moderate dysphagia. Modified diet and fluids are commonly used to compensate for swallowing impairment and to improve safety and efficiency.[6,7] A systematic review and meta-analysis found only a handful of published comprehensive screening assessment tools, and fewer have been validated with pooled accuracy similar to that of water swallow tests.[8] The Gugging Swallow Screening (GUSS),[9] Volume Viscosity Swallowing Test (VVST)[10] and Bedside Swallow Screening Test (BESST)[11] have been validated. Due to questions over methodological rigour, most studies were at high risk of bias and demonstrated low applicability to new stroke admissions.[8] Furthermore, there are concerns that the assessment outcome recommendations of these tests include several levels of modified diet and fluid that are not directly tested in the assessment.[8]

The Dysphagia Trained Nurse Assessment (DTNAx) and training package were developed to address the demand on SLT services for assessing and managing dysphagia.[12,13] Dysphagia trained nurses (DTNs) complete 1 day of theory and practical training and are assessed for competency using the tool. The DTNAx includes an oromotor screen, but unlike the GUSS and many water swallow tests where impairment results in a fail, the DTNAx continues to assess several trials of a range of diet and fluid consistencies, making recommendations where indicated. This could prevent many patients unnecessarily waiting nil by mouth until SLT assessment.[14] In addition, the DTNAx only allows recommendations of the specific diet and fluid consistencies deemed safe and efficient on direct testing using the tool.

The aim of the present study was to validate the DTNAx tool against clinical SLT assessment (SLTAx) and the "gold standard" videofluoroscopy (VFS) for identification of dysphagia and aspiration in acute stroke, and to explore the accuracy of diet and fluid recommendations by DTNs using the tool.

METHODS

Participants

New admissions to the ASU at University Hospitals of Derby and Burton NHS Trust were screened prospectively and consecutively between January 2018 and March 2020. Participants were approached and recruited if they were aged over 18 years with a new clinical diagnosis of stroke. Participants were excluded if they had a history of dysphagia, had a degenerative neurological condition, were medically unwell (determined by the clinical team), or were pregnant. Initially, inability to attend VFS was an exclusion criterion, but this was amended as it skewed recruitment towards milder stroke patients. Participants were given written study information and provided written consent where able. Advice was sought from a consultee for those who were unable to consent to ensure full representation of stroke severity.

Study protocol

The study was approved by the West Midlands – Coventry and Warwickshire Research Ethics Committee (REC ref: 17/WM/0209). It was registered on ClinicalTrials.gov (identifier: NCT03700853). The protocol and statistical analysis plan were published prior to recruitment end.[15] The study used the Standards for the Reporting of Diagnostic Accuracy Studies 2015 checklist[16] (Supplementary Material I).

Dysphagia Trained Nurse Assessment tool

All participants had their swallowing assessed as part of usual care using the DTNAx tool by one of 23 clinical DTNs on shift in the ASU. The DTNAx (Supplementary Material II) consists of preliminary checks, ruling out those unsuitable for assessment. An oromotor assessment alerts the assessor to neuromuscular weakness. Oral trials are commenced cautiously, with half teaspoons of water, increasing volumes and/or viscosity of fluids, indicated by the proforma. International Dysphagia Diet Standardization Initiative (IDDSI)[17] Level 4 through to 7 diets are then assessed. There are a series of checkbox signs to identify safety or efficiency concerns. Demonstrating good content validity, the DTNAx includes components[18-21] and swallow tasks[22] found in previous studies to be highly predictive of aspiration (Supplementary Material III). Its content is also comparable to textbook descriptions of methods to identify dysphagia on bedside assessment.[23] Dysphagia was defined by the presence of safety or efficiency concerns on any of the sections of the assessment.

Speech and language therapy assessment

The DTNAx tool was validated against usual SLTAx, obtained by a pool of 13 blinded SLTs from the acute hospital with experience in dysphagia ranging from 1 month to over 10 years. Their assessments included an oromotor examination and assessment of oral trials. Dysphagia was defined clinically as an impaired swallow requiring modification, adaptation or strategies and SLT input. To reduce bias, signage behind the bed and clues as to current swallowing

recommendations were hidden. However, this could not be fully controlled (e.g., if a nasogastric tube was *in situ*).

Videofluoroscopy

The DTNAx tool was validated against VFS, a gold standard assessment for swallowing, which was performed within 24 h of the DTNAx. VFS was carried out by a blinded SLT, radiographer and/or radiologist. Data were acquired from continuous screening and recorded onto DVD at 25 frames per second using a Philips system. IDDSI-tested recipes were used, containing 40% barium sulphate solution concentration. The assessment protocol (Supplementary Material IV, Table I) was adapted from the Modified Barium Swallow Impairment Profile (MBSImP),[24] matching the oral trials received in the DTNAx. The VFSs were anonymized and later analysed by a blinded SLT (J.B.) trained in using the standardized and reliability-tested MBSImP. J.B. and a second trained blinded SLT (G.W.) analysed different sets of 60 boluses from a random five VFSs for intra- and interrater reliability, respectively. Aspiration was defined as a Penetration Aspiration Scale (PAS)[25] score of >5. Dysphagia was defined by MBSImP cut-off criteria (Supplementary Material IV, Table II). Safe and efficient fluid and diet consistencies were predefined by a combination of MBSImP criteria, PAS score and number of swallows (Supplementary Material IV, Table III).

Reliability

To assess for intra- and interrater reliability, a second DTNAx was carried out by the same or a different DTN, respectively, blinded to the outcome of the other assessments. Agreement on presence of dysphagia and specific recommendations was explored.

Statistics

The findings were evaluated using IBM SPSS Statistics 26. Groups were compared using *t*-tests, Mann–Whitney *U*-tests and chi-squared tests as appropriate. For diagnostic accuracy, the sensitivity, specificity, positive predictive values (PPVs) and negative predictive values (NPVs) and their confidence intervals (CIs) were calculated. Inter- and intrarater reliability data were analysed using intraclass correlation coefficients (ICCs) for continuous data, kappa for dichotomized data and weighted kappa for ordinal data.

Sample size

The planned sample size was rounded to 50 participants. For primary analyses, to achieve 90% sensitivity (95% CI 75–100) and a 60% specificity (95% CI 45–75) the sample size needed was 41.

RESULTS

Forty-seven participants were recruited. Table 1 shows participants' baseline characteristics. Participants with and without dysphagia were equal in age, sex, premorbid disability (modified Rankin scale), previous stroke and stroke type. Participants with dysphagia had significantly more severe stroke, with a National Institutes of Health Stroke Scale score of 9.6 (6.5) versus 4.0 (3.9) for the participants with no dysphagia (p = 0.001). The recruitment rate of participants with no dysphagia was notably quicker than for those with dysphagia, therefore, to ensure a representative sample[1], without the knowledge of DTNs and once 25 participants were enrolled, recruitment continued with only those who had dysphagia identified on the DTNAx.

Timing of assessments

Forty-seven participants underwent baseline DTNAx evaluation, of whom 46 had SLTAx, 30 a VFS, 21 a repeat DTNAx by a different assessor and four had another DTNAx by the same assessor (Table 2). The mean (SD) time between the index DTNAx and SLTAx was 14.7 (7.5) h and between index DTNAx and VFS it was 15.5 (6.3) h. The mean time between the index DTNAx and the second DTNAx by a different nurse was 19.6 (6.6) h (Table 2).

Dysphagia severity

Dysphagia was defined by clinical SLTAx and was present in 22 participants (46.8%) with a median (interquartile range) severity of 6 (4) on the 0–12-point Dysphagia Severity Rating Scale (DSRS).[26] The scores ranged from 1 to 12, suggesting a range of dysphagia severities. A further seven participants were identified by SLTs as having very mild dysphagia, which did not require intervention, adaptation or modification, scoring 0 on the DSRS. Consistently across the recruitment period SLTs were blinded to the results of the other assessments in the majority of cases (69.6%).

Diagnostic accuracy for dysphagia

Of the 47 participants recruited, 46 had a DTNAx and a SLTAx, 24 of these had a further DTNAx by the same or a different nurse; these data were pooled to calculate diagnostic accuracy. For identification of dysphagia the sensitivity, specificity, PPVs and NPVs were 96.9% (95% CI 83.8–99.9), 89.5% (95% CI 75.2–97.1), 88.6% (95% CI 75.4–95.2) and 97.1% (95% CI 83.1–99.6), respectively (Table 3).

The DTNAx and VFS were carried out in 30 participants. Reasons for no VFS were not being able to sit out of bed (8/17), no VFS available (6/17), being unwell (2/17) or technical problems (1/17). Of those participants who underwent VFS, a further 17 had another DTNAx; therefore, a total of 47 DTNAx results could be compared

TABLE 1 Baseline characteristics of participants

	Participants (*n* = 47)	No dysphagia (*n* = 25)	Dysphagia (*n* = 22)	*p*
Age, years	73.0 (13.3)	71.5 (12.7)	74.8 (14.1)	0.410
Sex: female, *n* (%)	24 (51.1)	11 (44.0)	13 (59.1)	0.302
Premorbid mRS score (/6)	0 (4)	0 (4)	0 (4)	0.897
Stroke type, *n* (%)				
Haemorrhagic	4 (8.5)	1 (4.0)	3 (13.6)	0.237
Ischaemic or normal CT	43 (91.5)	24 (96.0)	19 (86.4)	
Stroke syndrome, *n* (%)				
TACS	4 (8.5)	1 (4.0)	3 (13.6)	0.070
PACS	19 (40.4)	8 (32.0)	11 (50.0)	
POCS	7 (14.9)	7 (28.0)	0 (0.0)	
LACS	14 (29.8)	7 (28.0)	7 (31.8)	
Unconfirmed stroke	3 (6.4)	2 (8.0)	1 (4.5)	
NIHSS score on admission (/42)	6.8 (6.0)	4.0 (3.9)	9.6 (6.5)	0.001
Time from stroke to recruitment, h	32.8 (22.5)	32.2 (20.5)	33.5 (25.0)	0.856
Previous stroke, *n* (%)	20 (42.6)	11 (44.0)	9 (40.9)	0.831

Note: Data are median (interquartile range), or mean (SD), unless otherwise indicated.

Abbreviation: LACS, lacuna stroke; mRS, modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; PACS, partial anterior circulatory stroke; POCS, posterior circulatory stroke; TACS, total anterior circulatory stroke.

Dysphagia is defined by a speech and language therapist (Dysphagia Severity Rating Scale [DSRS][22] > 0) and excludes those with dysphagia not requiring SLT intervention or dietary modification (DSRS = 0). In the case of missing data (*n* = 1), videofluoroscopy was used to determine presence of dysphagia.

TABLE 2 Number of participants that completed each assessment and time between assessments

	Reference Assessments			
	Second DTNAx	Repeat DTNAx	SLTAx	VFS
Index Assessment: first DTNAx (*n* = 47)				
Number	21	4	46	30
Mean time between assessments, h	19.6 (6.6)	11.5 (8.4)	14.7 (7.5)	15.5 (6.3)
All DTN assessments: first DTNAx (*n* = 47), second DTNAx2 (*n* = 21), repeat DTNAx (*n* = 4) All DTNAx (*n* = 72)				
Number	n/a	n/a	70	47
Mean time between assessments, (h)	n/a	n/a	11.3 (8.3)	11.5 (7.7)

Note: Data are number, or mean (SD).

Abbreviations: DTNAx, Dysphagia Trained Nurse Assessment; SLTAx, speech and language therapy assessment.VFS, videofluoroscopy.

to VFS results. Using the original MBSImP cut-offs, as predefined in the protocol, *all* participants achieved the threshold for dysphagia on VFS. Given that this was questionable, the data are presented for those with dysphagia requiring modifications to their diet or fluids as per the prespecified VFS criteria. For DTNAx identification of dysphagia versus VFS identification, diagnostic accuracy was considerably lower; sensitivity, specificity, PPV and NPV were 45.7% (95% CI 28.8–63.4), 83.3% (95% CI 51.6–97.9), 88.9% (95% CI 68.2–96.8) and 34.5% (95% CI 26.17–43.87), respectively (Table 4). There were no differences in the results when comparing only the first DTNAx and SLTAx or VFS. In further exploratory analyses, SLTAx had a sensitivity, specificity, PPV and NPV of 38.1% (95% CI 18.1–61.6), 85.7% (95% CI 42.1–99.6), 88.9% (95% CI 54.6–98.2) and 31.6% (95% CI 22.7–42.0), respectively, compared to VFS for identification of dysphagia (Supplementary Material V, Table I). The mean (SD) time between SLTAx and VFS was 1.9 (1.3) h.

TABLE 3 A 2×2 table comparing dysphagia trained nurse assessment index tests to usual clinical speech and language therapy assessment

Validation Clinical SLTAx (*N* = 70)	SLTAx – Dysphagia	SLTAx – No dysphagia		Value, %	95% CIs
			Sensitivity	**96.9**	**83.8–99.9**
			Specificity	**89.5**	**75.2–97.1**
DTNAx – Dysphagia	31	4	PPV	88.6	75.4–95.2
			NPV	97.1	83.1–99.6
DTNAx – No dysphagia	1	34	Prevalence	46.67	
			Accuracy	92.9	84.1–97.6

Abbreviations: CI, confidence interval; DTNAx, Dysphagia Trained Nurse Assessment; NPV, negative predictive value; PPV, positive predictive value; SLTAx, speech and language therapy assessment.

TABLE 4 Accuracy of the dysphagia trained nurse assessment tool versus gold standard videofluoroscopy for the identification of dysphagia and aspiration

Accuracy DTN vs VFS (*N* = 47)	VFS Dysphagia	VFS – No dysphagia		Value, %	95% CI
			Sensitivity	**45.7**	**28.8–63.4**
			Specificity	**83.3**	**51.6–97.9**
DTNAx Dysphagia	16	2	PPV	88.9	68.2–96.8
			NPV	34.5	26.2–43.9
DTNAx No dysphagia	19	10	Prevalence	74.5	
			Accuracy	55.3	40.1–69.8
	VFS Aspiration	VFS – No aspiration	Sensitivity	77.8	40.0–97.2
			Specificity	81.6	65.7–92.3
DTNAx Aspiration	7	7	PPV	50.0	32.0–68.0
			NPV	93.9	81.9%–98.2%
DTNAx No aspiration	2	31	Prevalence	19.1	
			Accuracy	80.9	66.7%–90.9%

Abbreviations: CI, confidence interval; DTNAx, Dysphagia Trained Nurse Assessment; NPV, negative predictive value; PPV, positive predictive value; VFS, videofluoroscopy.

Diagnostic accuracy for aspiration

Comparing DTNAx with VFS for the identification of aspiration, the sensitivity, specificity, PPV and NPV were 77.8% (95% CI 40.0–97.2), 81.6% (95% CI 65.7–92.3), 50.0% (95% CI 32.0–68.0) and 93.9% (95% CI 81.9–98.2), respectively (Table 4). Of the seven false-positives, six demonstrated airway penetration (PAS score 2–5) on VFS. For SLTAx identification of aspiration the diagnostic values were 80.0% (95% CI 28.4–99.5), 87.5% (95% CI 67.6–97.3), 57.1% (95% CI 29.8–80.7) and 95.5% (95% CI 78.3–99.2), respectively (Supplementary Material V Table II).

Accuracy of recommendations

There was moderate to strong agreement between the DTN and SLT recommendations (Table 5). In addition, 81.4% of the DTN fluid recommendations and 81.2% of the diet recommendations were in absolute agreement with the SLT recommendations. Agreement between DTNs and recommendations based on VFS was minimal to weak (Table 5). Supplementary Material VI, Tables I and II show DTN compared to SLT and VFS-based recommendations, respectively.

Reliability

Interrater reliability for identification of dysphagia on DTNAx was moderate κ = 0.62 (Table 6), with 81.0% absolute agreement. There was a trend for the first DTNAx to lead to more modified recommendations than the second DTNAx (Supplementary Material VII). To explore whether time between assessments was a factor, the DTNAx data were grouped into 0–20 h between assessments and >20 h, and agreement recalculated. Agreement was better when assessments were closer together in time (κ = 0.72 [95% CIs 0.24–1.0] versus k = 0.50 [95% CIs 0.02–0.98]).

Due to the limited number of reassessments by the same nurse (*n* = 4) there were insufficient data to explore agreement statistics, however, there was 100% agreement on presence of dysphagia and fluid and diet recommendations.

Videofluoroscopy reliability

Interrater reliability was excellent for PAS scoring (ICC = 0.93 95% CI 0.87–0.96), and moderate for MBSImP scores (κ = 0.500, 95% CI

TABLE 5 Agreement between dysphagia trained nurse assessment outcome, speech and language therapy assessment and videofluoroscopy

Recommendations	Absolute agreement, % (*n*)	Weighted κ (95% CI)	Interpretation McHugh 2012 [43]
DTNAx and SLTAx			
Fluids (*N* = 70)	81.4 (57)	0.73 (0.59–0.87)	Moderate
Diet (*N* = 69)	81.2 (56)	0.83 (0.73–0.93)	Strong
DTNAx and VFS			
Fluids (*N* = 47)	59.6 (28)	0.37 (0.14–0.59)	Minimal
Diet (*N* = 43)	55.8 (24)	0.47 (0.26–0.67)	Weak

Abbreviations: CI, confidence interval; DTNAx, Dysphagia Trained Nurse Assessment; SLTAx, speech and language therapy assessment; VFS, videofluoroscopy.

TABLE 6 Interrater reliability between dysphagia trained nurses for presence of dysphagia, and fluid and diet recommendations

	Comparison	Outcome	κ/ weighted κ (95% CI)	Interpretation
Interrater	*n* = 21	Dysphagia	0.62 (0.28–0.95)	Moderate
	n = 21	Fluids	0.29 (0.08–0.50)	Minimal
	N = 20	Diet	0.50 (0.24–0.77)	Weak

Abbreviation: CI, confidence interval.

0.44–0.56). There was 100% agreement on presence of dysphagia and aspiration.

Intrarater reliability was also excellent for PAS scoring (ICC = 0.92, 95% CI 0.87–0.96) and moderate for MBSImP scores (κ = 0.76, 95% CI 0.73–0.80).

DISCUSSION

This study investigated the diagnostic accuracy of the DTNAx in the identification of dysphagia and aspiration in acute stroke patients.

The DTNAx tool demonstrated excellent diagnostic accuracy in identification of dysphagia compared to usual SLTAx, and the recommendations from the DTNAx and SLTAx were closely aligned. This implies that nurses trained to use the DTNAx tool can accurately identify patients who have dysphagia from acute stroke admissions around the clock and make appropriate oral intake recommendations prior to a specialist SLTAx. The SLTs can subsequently adjust and update diet and fluid recommendations, provide education and rehabilitation.

The DTNAx tool and SLTAx also demonstrated good accuracy in the identification of aspiration on VFS. The PPV was lower for both DTNAx and SLTAx, suggesting assessors are oversensitive (or cautious) in identifying aspiration, which is not uncommon in bedside assessments.[27] However, six of seven false-positive cases from the DTNAx were found to show airway penetration on VFS. The DTNAx was not validated for penetration and/or aspiration because minor and shallow penetration (PAS score 2) is relatively common in normal swallowing, and thus is not seen as an impairment or risk.[28] However, penetration, when deeper, in increased amounts and uncleared from the laryngeal vestibule, is uncommon in healthy adults and can be a safety concern.[28,29] In addition, penetration does not always result in a sensorimotor response such as cough,[29] therefore, all cases of penetration are unlikely to be identified on bedside assessment. With this in mind, the low PPV is not unexpected and an overcautious approach by both DTNAx and SLTAx is safer in terms of avoiding stroke-associated pneumonia. Indeed, an accompanying high NPV for aspiration (94%) means few false-negatives, an encouraging result.

A meta-analysis of water swallow tests found a pooled sensitivity and specificity of 72% (95% CI 64–79) and 72% (95% CI 61–81), respectively,[30] suggesting that the DTNAx tool is superior to water swallow tests in the accurate identification of aspiration. Pooled sensitivity and specificity for aspiration for GUSS[9] were found to be 96.0% (95% CI 90–99) and 65% (95% CI 47–79), respectively, but this should be interpreted cautiously as discussed below.[8] The GUSS, VVST[10] and BESST[11] have also been validated for identification of dysphagia. The DTNAx tool showed more favourable sensitivity and specificity than the BESST (89.7% and 81.6%, respectively) [11] and the GUSS (95.3–98.5% and <53.3–72.2%, respectively).[14,31] The VVST demonstrated similarly high sensitivity and specificity to those of DTNAx. However, the accuracy of DTNAx for dysphagia cannot be likened directly to the GUSS and VVST as DTNAx uses SLTAx as the comparator rather than instrumental assessment. On the other hand, significant quality issues have been identified with the VVST and GUSS studies; for example, experts conducted the index tests, participants were already suspected to have dysphagia, and assessors were not blinded. In contrast, the present study used clinical DTNs for the index test, participants in this study were representative of an acute stroke population, and the VFS, DTNAx and 69% of SLTAx assessors were blinded. Bedside tests that subsequently

recommend consistencies of food and drink that have not been evaluated during the assessment are open to criticism as the safety and efficiency of swallowing differs among consistencies.[32] The DTNAx tool is distinct, only allowing recommendations for consistencies directly tested and deemed safe and efficient.

According to the VFS MBSImP thresholds for normal versus impaired swallowing, *all* participants in this study had a diagnosis of dysphagia. Thus, for purposes of validation in this study, dysphagia was redefined as dysphagia requiring adaptation/modification. The definition of what constituted a safe consistency was prespecified by the research team based on the PAS score and key subsections of the MBSImP that are known to impact on safety and efficiency of the swallow. Despite this, the accuracy of bedside DTNAx and SLTAx in identifying dysphagia according to VFS remained low. Increasing age and comorbidities will also contribute to changes in swallowing,[33,34] which may explain half of the 14 false-negatives that were identified by SLTs as very mild dysphagia (DSRS score 0), but this does not explain the remaining half. Another explanation is that the thresholds for dysphagia were too conservative and there is in fact a greater degree of variation in swallowing in the normal population than is accounted for by the MBSImP. To date, there have been no normative data published regarding MBSImP. However, studies using MBSImP that included healthy participants have shown that up to 95% scored above the MBSImP thresholds on component scores.[33,35] Further research gathering normative data for MBSImP across different demographics is warranted.

Although we found moderate to strong agreement between the DTN and SLT recommendations, the accuracy of recommendations compared to VFS was poor. Clinical bedside assessments are limited in detecting silent aspiration,[36] describing physiological impairments accurately[37,38] and judging the effectiveness of compensatory strategies.[39] However, recommendations for oral intake are often made from bedside assessment as instrumental assessments are not always available, may be impractical and are unlikely to be cost-effective for making all management decisions. Furthermore, decisions on severity and suitable swallowing recommendations in clinical VFS are made on the basis of the VFS result in conjunction with patient reports, bedside assessments, and the impact on the patient's health and quality of life. Considering this, it is not surprising that the SLT and DTN recommendations do not agree with VFS outcomes alone. Despite moderate to strong agreement in recommendations between DTNAx and SLTAx there were a small number of participants with fewer modifications made by DTNs compared to SLTs. Differences may be explained by variability in patients from one assessment to the other due to factors such as fatigue. However, it is possible that DTNs miss subtle impairments, which might have clinical implications such as increased risk of aspiration pneumonia. Further research into the clinical effectiveness of this pathway is indicated.

Interrater reliability among DTNs was moderate. Due to clinical practicalities, assessments were on average 19.6 h apart with spontaneous swallow recovery in the early post-stroke phase,[40] leading to lower levels of agreement; the data support this with better agreement between closer assessments. In addition, recommendations from the first DTNAx were more modified compared to the second, suggesting an improvement in dysphagia over time. This may indicate a change in the patient's clinical picture rather than lack of reliability, and highlights the challenge of establishing test-retest reliability in clinical measures where function can be changing rapidly.

The present study has a few limitations. First, VFS was not always possible due to availability, and many participants with severe stroke symptoms were unable to tolerate the assessment; it was vital, however, to include more severe strokes to validate the DTNAx. Second, numbers were smaller for the second DTNAx causing less precision in the results, and in the case of intrarater reliability, data were too few to analyse. Third, the SLTs did not use a validated bedside assessment to identify dysphagia; however, this is representative of usual care and SLTs undergo in-depth training and competency assessments to become specialists in dysphagia. Lastly, the MBSImP was chosen due to its standardized protocol, analysis and training, favourable reliability[24] and lack of superior psychometrically sound VFS analysis tools.[41] However, due to the lack of normative data on which to define dysphagia, the use of the MBSImP has been limited in this study and highlights the need for more research defining dysphagia from VFS.

In conclusion, the DTNAx is comparable to SLT assessment in identifying dysphagia and making early oral intake recommendations in an ASU. Acute stroke patients with dysphagia admitted 'out of hours' can be accurately assessed and commenced on oral intake by DTNs when an SLT is not available. The DTNAx and SLTAx demonstrated good accuracy in identifying aspiration on VFS. Both the DTN and SLT assessments underdiagnosed dysphagia compared to the VFS, but this may be attributable to the methods for defining dysphagia on VFS. A good tool must demonstrate clinical and cost-effectiveness in addition to diagnostic accuracy; therefore, further research is needed to look at the outcomes of DTN-assessed patients and its cost-effectiveness against other pathways.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Jacqueline K. Benfield: Conceptualization (lead); Data curation (lead); Formal analysis (lead); Investigation (lead); Methodology (lead); Project administration (lead); Writing – original draft (lead); Writing – review and editing (lead). **Gwenllian Wilkinson:** Formal analysis (supporting); Writing – review and editing (supporting). **Lisa F. Everton:** Conceptualization (supporting); Methodology (supporting); Writing

– review and editing (supporting). **Philip Bath:** Conceptualization (supporting); Methodology (supporting); Writing – original draft (supporting); Writing – review and editing (supporting). **Timothy England:** Conceptualization (supporting); Methodology (supporting); Writing – original draft (supporting); Writing – review and editing (supporting).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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