Delayed Swallowing Reflex is Overlooked in Swallowing Screening Among Acute Stroke Patients

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Background and Purpose: Dysphagia in the acute phase of stroke contributes significantly to poor outcomes and is associated with the development of aspiration pneumonia and malnutrition. Therefore, an accurate evaluation of swallowing is necessary before initiating oral food intake. The modified water swallow test (MWST) and the repetitive saliva swallow test (RSST) are commonly used as bedside screening methods for swallowing dysfunction, but it is unclear whether other factors contribute to dysphagia and consequent aspiration. The purpose of this study was to identify characteristics that might be overlooked in screening tests. *Methods:* Participants were prospectively selected from patients hospitalized for stroke at the Suiseikai Kajikawa Hospital between August 1, 2016 and June 30, 2018. Inclusion criteria were conscious and stable medical condition, and patients who were diagnosed with dementia were excluded. A videofluoroscopic (VF) swallowing study was carried out on all patients who met the inclusion/exclusion criteria and who passed both the MWST and the RSST. *Results:* Aspiration was observed in 16 of 172 patients (9.3%) when swallowing 3 ml of water. These aspirated patients showed significantly delayed swallowing reflex on VF. *Conclusions:* Swallowing evaluation using a combination of the MWST and the RSST is reasonably effective. However, patients who show a delayed swallowing reflex might be overlooked by this screening procedure.

Key Words: Swallowing—Dysphagia—Fluoroscopy—Stroke—Acute—Aspiration

Introduction

The number of deaths from stroke has been declining since the 1980's, however, stroke is still the most common cause of patients becoming bedridden, and stroke prevention and treatment are crucial issues to prolong healthy life in the aging Japanese population.[1]

Several studies have demonstrated that early rehabilitation for acute stroke facilitates functional recovery,[2,3] and

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complications in the early stages of rehabilitation can worsen the patient's prognosis.[4] Respiratory tract infection, urinary tract infection, falls, and skin damage are the most common complications during the early phases of stroke recovery. Swallowing dysfunction presents in approximately 55% of all acute stroke patients admitted to hospitals and is associated with the development of aspiration pneumonia as well as malnutrition. [5] Regardless of the severity or presence of aspiration, patients with swallowing dysfunction are 3 times more likely than patients without to develop pneumonia, which is significantly related to acute phase recovery outcomes.[6,7]

While videofluoroscopy (VF) and videoendoscopy examinations are the gold standard to diagnose swallowing dysfunction, bedside screening is usually used to assess whether a patient can receive oral food intake.[8,9] The modified waters wallow test (MWST)[10] and the repetitive saliva swallow test (RSST)[11,12] are often used in combination as a bedside screening test in Japan, but few studies have compared the validity of these screening tests with VF results.

Therefore, the aim of the present study was to identify the percentage of aspiration cases among acute stroke patients who are permitted oral intake following the combined MWST and RSST and to identify characteristics that might be overlooked in screening tests.

Methods

This study was carried out with the approval of the Suiseikai Kajikawa Hospital Ethics Committee (2016-1) and the Hiroshima University Graduate School of Biomedical and Health Sciences Ethics Committee (E-1151). All procedures were in accordance with institutional guidelines.

Participants were prospectively selected from 539 patients hospitalized for stroke at the Suiseikai Kajikawa Hospital between August 1, 2016 and June 30, 2018. We included the first attack stroke patients with both ischemic and hemorrhagic stroke who were admitted within 1 week from onset, were aged ≥20 years, and consented to this study (if the patient was not able to consent to the study, consent was obtained from relatives). We excluded patients who had histories of stroke and dementia. Dementia was diagnosed using the 10th revision of the International Statistical Classification of Diseases and Related Health Problems. We also excluded patients who had altered mental status due to severe stroke (in the best eye response score in the Glasgow coma scale was 3 or less). In addition, patients were excluded if they showed any medulla oblongata lesions. Those who had more than 4 points on the MWST (Fig 1) and were able to swallow 3 or more times in 30 seconds on the RSST were deemed to meet the selection criteria. VF was carried out on these patients within 14 days of the stroke event. An x-ray imaging system (BV Pulsera, Royal Philips, Amsterdam, Netherland) was used, and the tests were carried out in a seated position. The test food was 3 ml of water with 50% iodine contrast medium (Oypalomin 370®, Fuji Pharma Co. Ltd, Tokyo), which the patients were instructed to swallow after it was delivered via syringe to the floor of the mouth. The x-ray system imaged forward toward the lips, back to the pharynx wall, up to the nasal cavity and downward to the upper esophageal sphincter, taking a side VF recording of 30 frames per second and recording this data on a DVD. Two blinded dentists (TN and MYoshida) with specialized experience evaluating videofluorographic records evaluated 1) the presence or absence of aspiration viewable in natural light, 2) the presence or absence of swallowing reflex delay, defined as liquid remaining in the pyriform sinus for more than 0.1 seconds (3 frames) before swallowing, and 3) clear oral cavity residue, epiglottic valleculae residue, or pyriform sinus residue after one swallow.

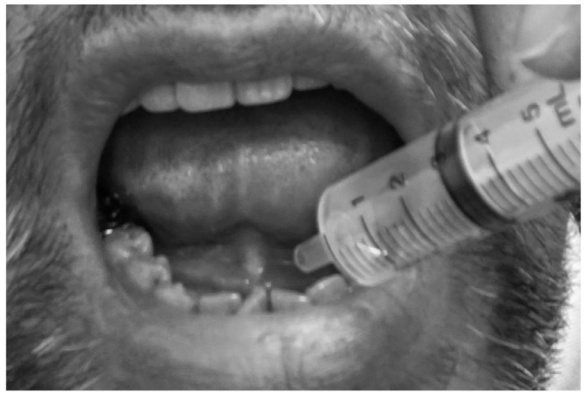

Fig. 1. ***Modified water swallow test (MWST). [Procedure]:*** *The patient is given 3 mL of cold water in the oral vestibule and is then instructed to swallow the water. If possible, this procedure is repeated 2 more times, and the worst swallowing result is used for analysis. If the patient meets Criteria 1 through 4, a maximum of 2 additional attempts (a total of 3 attempts) should be made, and the worst assessment should be recorded as the final result.* ***[Assessment criteria]:*** *1. Failed to swallow with choking and/or changes in breathing. 2. Swallowed successfully without choking, but with changes in breathing or wet hoarseness. 3. Swallowed successfully, but with choking and/or wet hoarseness. 4. Swallowed successfully with no choking or wet hoarseness. 5. Criteria 4 is met, and 2 successful swallows are performed within 30 s.*

Additionally, stroke type (hemorrhagic/ischemic), affected area (left/right, supra/subtentorial), stroke severity (NIHSS score),[13] body mass index (BMI), and comorbidities (hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation) were obtained from patient medical records. Hypertension was defined as the use of antihypertensive medication before admission or a confirmed blood pressure ≥140/90 mm Hg at rest measured 2 weeks after the onset of stroke. Diabetes mellitus was defined as a glycated hemoglobin level ≥6.5%, fasting blood glucose level ≥126 mg/dL, or use of anti-diabetes medication. Dyslipidemia was defined as total cholesterol level ≥220 mg/dL, low-density lipoprotein cholesterol level ≥140 mg/dL, high-density lipoprotein cholesterol level <40 mg/dL, triglyceride levels ≥150 mg/dL, or use of

Table 1. *Relationship between each evaluated item and presence or absence of aspiration.*

		Aspiration present (16 cases)	Aspiration absent (156 cases)	*p* value
Males (%)		6 (37.5)	93 (59.6)	0.11
Median age (IQR)		72.0 (63.0,79.8)	72.0 (65.0, 87.0)	0.41
Ischemic stroke (%)		9 (56.3)	76 (48.7)	0.61
Left-side lesions (%)		7 (46.7)	74 (48.1)	1.00
Supratentorial lesions (%)		16 (100)	139 (90.3)	0.37
Median BMI (IQR)		23.2 (21.0, 25.3)	23.1 (22.2, 26.4)	0.41
NIHSS median score (IQR)		3.0 (2.0, 5.0)	3.5 (2.0, 6.8)	0.39
Hypertension (%)		12 (75.0)	130 (83.3)	0.49
Diabetes (%)		5 (31.3)	42 (26.9)	0.77
Dyslipidemia (%)		9 (56.3)	75 (48.1)	0.61
Atrial fibrillation (%)		0 (0)	21 (13.5)	0.22
Presence of molar occlusion (%)		11 (68.8)	128 (83.7)	0.17
Maximum median tongue pressure (IQR)		27.3 (20.0, 34.8)	29.2 (20.1, 33.4)	0.86
VF	Oral residue (%)	9 (56.3)	80 (51.3)	0.80
	Epiglottal valleculae residue (%)	4 (25.0)	35 (22.4)	0.76
	Pyriform sinus residue (%)	3 (18.8)	20 (12.8)	0.45
	Delayed swallowing reflex (%)	5 (31.3)	17 (10.9)	0.04*

*$p < 0.05$, IQR: interquartile range

anti-hyperlipidemia medication. Atrial fibrillation was defined as follows: (1) a history of sustained or paroxysmal atrial fibrillation, or (2) atrial fibrillation detection on arrival or during admission.

Oral function was evaluated in the absence or presence of molar occlusion (including dentures), and maximum tongue strength (MTS) was measured using a tongue pressure measurement device (TPM-01; JMS Co Ltd., Hiroshima, Japan). According to the standard method written by Hayashi et al,[14] participants were instructed to push their tongue as hard as they could against the palate for 5–7 s to compress a balloon. The largest pressure value from three trials was recorded and used to represent the MTS (kPa).

Statistical analysis

Analysis was carried out using IBM SPSS ver. 25 (IBM, Tokyo). In order to reveal which factors were significantly associated with aspiration, data were analyzed using non-parametric methods, either the Mann-Whitney U test or the Chi-square test. The same tests were used to detect relationships between any significant results and the other variables. A logistic regression analysis was conducted using all significant variables as $p < 0.10$. Continuous variables are presented as the median (interquartile range), and a p value of less than 0.05 was used to indicate statistical significance.

Results

A total of 172 subjects were analyzed in the present study (99 males; 73 females; median age, 72.0 years). Of these subjects, 16 patients (6 males; 10 females; median age, 72.0 years) were confirmed for aspiration by VF. A comparison of confirmed aspiration and non-aspiration cases is presented in Table 1. Swallowing reflex delay was the only variable that was significantly associated with the presence of aspiration ($p < 0.05$), so that multiple analysis was not done.

We then evaluated which items were significantly different between patients who did or did not show a swallowing reflex delay. Stroke severity, the presence or absence of molar occlusion, MTS, and oral residue were found to be statistically different between these two groups (all $p < 0.05$; Table 2). A logistic regression analysis using these factors as the independent variables revealed that swallowing reflex delay was significantly related to the presence or absence of molar occlusion and oral residue after one swallow ($p < 0.05$; Table 3).

Discussion

The results of the current study indicate that only 9.3% of patients who were judged as being able to receive oral food intake according to the combined MWST/RSST bedside swallowing screening method was classified as showing aspiration by VF. Therefore, the combined MWST/RSST appears to be a reasonably effective method for bedside screening.

According to a recent review of bedside screening tests for swallowing dysfunction in acute phase stroke patients,[15] the sensitivity to determine aspiration ranges from 65.2% to 100%, whereas the specificity ranges only from 30% to 84.4%. Therefore, the water-drinking test is efficacious as a screening procedure, but usage in combination with other tests is necessary to further increase the sensitivity and specificity. The results of the current study may identify the overlooked characteristics in these screening tests. [16]

Table 2. *Relationship between the presence or absence of swallowing reflex delay and each evaluated item.*

		Delay Present (22 cases)	Delay Absent (150 cases)	*p* value
Males (%)		11 (50.0)	88 (58.7)	0.49
Median age (IQR)		76.0 (61.8, 83.0)	72.0 (63.0, 79.3)	0.35
Ischemic stroke (%)		11 (50.0)	74 (48.7)	1.00
Left-side lesions (%)		9 (42.9)	72 (48.6)	0.65
Supratentorial lesions (%)		20 (95.2)	135 (90.6)	0.70
Median BMI (IQR)		22.7 (19.2, 24.7)	23.3 (21.2, 25.4)	0.59
NIHSS median score (IQR)		4.5 (2.8, 10.5)	3.0 (1.0, 5.0)	0.02*
Hypertension (%)		20 (90.9)	122 (81.3)	0.37
Diabetes (%)		6 (27.3)	41 (27.3)	1.00
Dyslipidemia (%)		13 (59.1)	71 (47.3)	0.36
Atrial fibrillation (%)		1 (4.5)	20 (13.3)	0.48
Presence of molar occlusion (%)		14 (63.6)	125 (85.0)	0.03*
Maximum median tongue pressure (IQR)		24.5 (17.8, 30.8)	28.1 (21.9, 34.8)	0.04*
VF	Oral residue (%)	17 (77.3)	72 (48.0)	0.01*
	Epiglottal valleculae residue (%)	8 (36.4)	31 (20.7)	0.11
	Pyriform sinus residue (%)	5 (22.7)	18 (12.0)	0.18

*$p < 0.05$, IQR: interquartile range

Table 3. *Results of logistic regression analysis predicting swallowing reflex delay.*

Items	B	Standard Error	Wald	Degree of freedom	*p* value	Exp (B)
NIHSS score	0.107	0.059	3.307	1	0.069	1.113
Maximum tongue pressure	-0.004	0.021	0.035	1	0.852	0.996
Presence of molar occlusion	1.447	0.569	6.465	1	0.011	4.249
Oral residue observed by VF	-1.534	0.581	6.978	1	0.008	0.216
Constant	-2.122	0.822	6.670	1	0.010	0.120

The current study used VF to report that delayed swallowing reflex is significantly associated with aspiration following bedside screening. Delayed swallowing reflex describes a situation where food bolus remains in the pyriform sinus before swallowing begins. The residual bolus can be lifted by laryngeal elevation and enter the larynx, leading to aspiration. This swallowing reflex delay has been shown to cause diminished pharyngeal sensation,[17] which might be related to silent aspiration. This in turn may be the reason why aspiration cases with delayed swallowing reflex were able to pass the bedside screening methods. Power et al.[18] reported that delayed start of laryngeal elevation, laryngeal closure time, and pharyngeal transit time serve as temporal indicators to discriminate aspiration using VF, but it remains unclear how to incorporate these perspectives into the screening procedure. The results of that study agree with those of the current study: that physicians should seek to incorporate items related to swallowing reflex delay into swallowing dysfunction screening. This is a future challenge and we are preparing the next study.

Multivariate analysis in the current study revealed that the presence or absence of molar occlusion and VF evidence of oral residue after one swallow were significantly related to swallowing reflex delay. The reasons for this are unclear, however, a study by Yamamoto et al.[19] reported that the tip of the food bolus extending deep within the pharynx elicited the swallowing reflex among the healthy edentulous elderly subjects when they removed their upper and lower complete dentures, indicating that reduced transit capability is related to the delayed occurrence of the swallowing reflex. Also, Yoshikawa et al.[20] demonstrated that tongue activity was not stable for edentulous elderly without dentures, which may cause improper transit of the bolus and thus delay the initiation of swallowing. Furthermore, palatal augmentation prostheses, made by thickening the palate of maxillary dentures, have been shown to improve swallowing reflex time in rehabilitation hospital inpatients.[21] These results suggest that using molar stability to alter bolus transit speed might help to control the swallowing reflex.

It has been shown that conscious mastication quickens the swallowing reflex.[22] Therefore, delayed start of swallowing and oral residue might also be associated with the diminished sensation in the oropharyngeal area often experienced by stroke patients.[23] However, further studies will be needed to compare swallowing reflex times among different forms and temperatures of food.

There were several limitations in this study. It has been reported that an NIHSS score of more than 5 is predictive of dysphagia, but our subjects in this study had a median NIHSS score of 3 (2-5).[24] Therefore, a future study that

includes patients with more severe strokes is needed to confirm our results. Unfortunately, there is a time-lag between conducted screening test and VF study. This time lag can't be helped because it is a routine clinical study. Our subjects in this study were persons who did not have any problem in the bedside screening test, so that they can start oral feeding in clinical course. However, we evaluate MWST and RSST again at VF test. Also, our findings that these subjects showed small amount of aspiration by the later VF test may indicate that we pay attention pharyngeal residue symptom such as pharyngeal residual sound in daily observation. Moreover, this study was unable to assess the sensitivity and specificity of the MWST/RSST due to the nature of our study design. That is, VF examinations were not applied for patients who were judged to be at risk of aspiration due to MWST and RSST screening, so the percentage of false positives was not calculated. Additionally, we were unable to elucidate any increases in sensitivity and specificity caused by including the presence or absence of molar occlusion to the screening items. We are now preparing a future study that includes more severe patients to further investigate the results of the present study.

Conclusion

The combination of MWST and RSST as a bedside swallowing assessment appears to be reasonably effective. However, our results suggest that patients who show delayed swallowing reflex can be overlooked by screening tests.

Declaration of Competing Interest

H. Maruyama obtained speaker fees from Eisai, Pfizer, Takeda Pharmaceutical, Otsuka Pharmaceutical, Nihon Pharmaceutical, Teijin Pharma, Fuji Film, Boehringer Ingelheim, Sumitomo Dainippon Pharma, Nihon Medi-Physics, Bayer, MSD, Daiichi Sankyo, Kyowa Hakko Kirin, Sanofi, Novartis, Kowa Pharmaceutical, Astellas Pharma, Japan Blood Products Organization, Mitsubishi Tanabe Pharma, Ono pharmaceutical, Biogen, and Bristol-Myers Squibb, and research support from Eisai, Pfizer, Takeda Pharmaceutical, Otsuka Pharmaceutical, Nihon Pharmaceutical, Shionogi, Teijin Pharma, Fuji Film, Boehringer Ingelheim, Sumitomo Dainippon Pharma, Nihon Medi-Physics, Bayer, MSD, Daiichi Sankyo, Kyowa Hakko Kirin, Sanofi, Novartis, Kowa Pharmaceutical, Astellas Pharma, Tsumura, Japan Blood Products Organization, Mitsubishi Tanabe Pharma, Mylan.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Authors contributions

C. Takada contributed to study conception, data acquisition and manuscript drafting. M. Yoshida contributed to data analysis and interpretation. M. Nakamori contributed to data acquisition, and data interpretation. N Hosomi contributed to study conception, data interpretation, and manuscript drafting. T. Nagasaki contributed to data analysis and interpretation. M. Yoshikawa contributed to data acquisition and interpretation. J. Kayashita contributed to study design, data acquisition, and critically revised the manuscript. S. Masuda contributed to study design, data interpretation, and critically revised the manuscript. H. Maruyama a contributed to data interpretation and critically revised the manuscript. K. Tsuga contributed to data interpretation and critically revised the manuscript.

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