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Wiley Blackwell

2024

Kuuskoski, J, Vanhatalo, J, Rekola, J, Aaltonen, L-M & Järvenpää, P 2024, 'The Water Swallow Test and EAT-10 as Screening Tools for Referral to Videofluoroscopy', Laryngoscope, vol. 134, no. 3, pp. 1349-1355. https://doi.org/10.1002/lary.31038

http://hdl.handle.net/10138/571813

10.1002/lary.31038

The Laryngoscope
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The Water Swallow Test and EAT-10 as Screening Tools for Referral to Videofluoroscopy

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Background: Videofluoroscopy (VFS) is the gold standard in evaluating dysphagia. Water swallow tests (WST) and the Eating Assessment Tool (EAT-10) are commonly used in dysphagia screening. We aimed to determine the feasibility of WST and EAT-10 as screening tools for referral to VFS.

Methods: Patients ($n = 150$, median age: 70.0 years, range: 19–92 years, 58.7% female) referred to VFS completed the WST and EAT-10 before the examination. In the WST, we evaluated both the qualitative parameters (coughing, possible change in voice) and quantitative parameters (average drinking bolus size, swallowing speed). Correlations of EAT-10 total scores and WST parameters to the VFS findings were analyzed both individually and combined.

Results: In the WST, the most specific (89.7%) predictor of normal VFS findings was the absence of coughing, and the most sensitive (79.1%) parameter to predict abnormal findings was a bolus size of ≤20 mL. Using a combination of coughing and a bolus size ≤20 mL (simplified WST), the sensitivity of predicting abnormal findings increased to 83.5%. The most sensitive (84.6%) predictor of penetration/aspiration was failing any parameter in the WST. Lack of coughing indicated an absence of penetration/aspiration with an 82.5% specificity. Swallowing speed or combining the EAT-10 results with the WST results did not enhance the sensitivity or specificity of the WST for predicting the VFS results.

Conclusions: Coughing and average drinking bolus size are the most important parameters in WST when screening for referral to VFS, whereas the swallowing speed does not seem to be useful. The WST is superior to EAT-10 in predicting VFS findings.

Key Words: deglutition, dysphagia screening, EAT-10, videofluoroscopy, water swallow test.
Level of Evidence: 4
***Laryngoscope*, 134:1349–1355, 2024**

INTRODUCTION

Dysphagia is a common symptom and is related to many diseases. Symptoms may vary from mild or transient sensations to life-threatening aspiration and choking and lead to malnutrition, dehydration, impaired quality of life, and even death. It is important to distinguish dysphagia from a globus symptom, which does not usually need instrumental examinations.[1,2] Problems in deglutition can be examined in many ways, mostly by videofluoroscopy (VFS) or fiberoptic endoscopic evaluation of swallowing (FEES),[3] but these resource-demanding examinations should be targeted correctly.

Quick and easy screening tools are needed for evaluating dysphagia. Patient-reported outcome measures (PROMs) can help in offering information about a patient's subjective symptoms. A 10-item questionnaire Eating Assessment Tool (EAT-10) has been widely utilized in dysphagia assessment in everyday practice.[4] EAT-10 has been translated and validated into many languages, and recently in Finnish.[5] It is presently distributed by Nestlé Nutrition Institute.[6] EAT-10 has been proven to be a sensitive method to detect dysphagia as was shown in a recent meta-analysis.[7] Some studies have introduced EAT-10 as a screening tool to predict aspiration.[8–10]

Quick and simple tools are also necessary for screening of swallowing. Water swallow test (WST) can be performed quickly, and the equipment is easily available. In the original 3 oz water test, only the qualitative parameters (drinking continuity, coughing during or 1 min interval after drinking, and possible wet–hoarse quality of voice after drinking) were observed.[11] More recently, the quantitative measures (count of swallows and time of drinking) have been observed and swallowing speed (mL/s) and average drinking bolus size (mL) counted

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Editor's Note: This Manuscript was accepted for publication on August 24, 2023.

This study was funded by the Finnish ORL-HNS Foundation, Turunmaa Duodecim Society, the Finnish Society for Laryngology, Turku University Foundation (Kosti Hämmärö Fund), Päivikki and Sakari Sohlberg Foundation, and Turku University Hospital Research Funds. The authors have no other funding, financial relationships, or conflict of interest to disclose.

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DOI: 10.1002/lary.31038

("Timed test").[12] The use of the qualitative and quantitative elements of WST varies in publications.[13,14]

In this study, we tested the ability of EAT-10 and WST to predict findings in VFS separately and combined. We also aimed to investigate which parameters in WST were useful for evaluating the necessity to perform VFS.

MATERIALS AND METHODS

Adult Finnish-speaking patients who were referred for VFS in Turku University Hospital were recruited for 1 year. Patients were referred by several health care providers, and the referring physician's medical discipline was also recorded. The inclusion criteria were an age between 18 and 99 years, not having any significant cognitive or psychiatric diseases, and being able to complete questionnaires independently (assisted writing was accepted). We collected information about age, gender, body mass index (BMI), diagnosed diseases, performed surgeries, medication, smoking habits, and alcohol consumption. The etiology of the dysphagia was evaluated from medical records. Patients validated Finnish version of EAT-10[5] was completed by interviewing, and a WST was performed on the same visit just before the VFS by a single researcher (JK).

A 100 mL WST

Patients were asked to drink 100 mL of water as quickly as possible without interruption. The number of swallows was observed, and then the average bolus size was counted by dividing 100 mL with a number of swallows. The interpretation >20 mL (100 mL completed with less than five swallows) was considered normal.[15] Time from onset of swallowing to completing the drinking process (when the larynx was decreased back to a resting position after the last swallow) was measured in seconds (s), and the swallowing speed (mL/s) was calculated by dividing 100 mL with the drinking time (s).[14] Over 10 mL/s was considered normal.[12] The WST was considered passed if the patient did not cough during drinking, 1 min after drinking or interrupted drinking (removing the glass from the lips). If a patient coughed during drinking, the time measurement was interrupted immediately, and the swallowing speed was calculated using the amount of water the patient drank before coughing. The parameters of the water test (coughing during drinking, coughing after drinking, possible wet–hoarse voice after drinking, average drinking bolus size, and swallowing speed) were recorded and compared to the VFS results.

Videofluoroscopy

All subjects underwent VFS using multipurpose twin robotic x-ray system (Multitom Rax, Siemens Healthcare GmbH, Erlangen, Germany) with a tube voltage of 73 kV and Cu Filter of 0.2 mm. Imaging was generally done in 15 pulses/s according to the local "as low as reasonably achievable" (ALARA) principles to avoid exposure to unnecessary radiation, and 30 pulses/s continuous mode was used if needed for clarification. Oral iohexol contrast media was used (Omnipaque 300 mg/mL, GE Healthcare, Princeton, NJ). An iodine contrast agent was preferred as it has a better safety profile if aspirated compared to barium and leaves fewer persistent residues.

VFS was started with a 10 mL thickened iodine bolus instructed to drink at once if possible, and the imaging projections were lateral, oblique, and anterior–posterior (AP) views. A liquid iodine contrast was thickened using xanthan gum-based thickener (Resource ThickenUP Clear, Nestlé Health Science, Vevey, Switzerland) to achieve an IDDSI 3 (International Dysphagia Diet Standardisation Initiative Framework[16,17]) consistency level. The thoracic esophagography was included in the oblique and AP view. The imaging was continued with a 10 mL of liquid iodine bolus (IDDSI 0) instructed to drink at once if possible and the imaging continued with lateral and AP views. Lastly, patients were instructed to take a spoonful of iodine-coated cookie mixture, and this was imaged in the lateral and AP view. A 20 mL liquid bolus was also tested in 76 patients and compared for possible penetration/aspiration findings to those with the 10 mL liquid bolus. If contrast media residues from previous swallows were present, the throat was cleaned with water sips before continuing. All images were saved to the imaging server of Turku University Hospital (Philips Vue PACS).

VFS findings were analyzed by an experienced radiologist (JV) blinded from EAT-10 and WST results in both real time and later in slow motion/frame by frame. VFS finding classification was modified from Group for Learning Useful and Performant Swallowing (GLUPS) score.[18] The findings were categorized into: oral findings (lip closure, tongue movement, possible premature pharyngeal spillage, and possible oral residue), pharyngeal findings (swallow onset, velopharyngeal closure, epiglottal retroflexion, laryngeal elevation, possible vallecular residue, possible pyriform sinus residue, and penetration/aspiration), and esophageal findings (upper esophageal sphincter opening, peristalsis of esophagus, possible stasis of esophagus, and lower esophageal sphincter function); each of these 15 criteria was classified as normal or abnormal. Possible penetration or aspiration was also scored using the Penetration Aspiration Scale (PAS), PAS 2–5 meaning penetration, and PAS 6–8 aspiration.[19]

Ethical Considerations

Recruited patients were given both oral and written information before participation in the study and were required to sign a written consent. The Ethics Committee of the Hospital District of Southwest Finland approved the study protocol, and permission for the research was granted by the Hospital District of Southwest Finland. This study was conducted in accordance with the Declaration of Helsinki (The World Medical Association 2013).

Sample Size and Statistic Methods

The aim was to examine whether EAT-10 (PROM), and the WST (swallow performance screener), could predict normal or abnormal findings and penetration/aspiration in VFS. The sample size calculations were performed using different options for sensitivity and specificity and using an estimate of an 80% prevalence of dysphagia (or findings in VFS) and a 0.70 specificity with a 0.20 margin of error (95% confidence interval maximum 0.50–0.90), and the result was 101 participants. With a possible 10%–20% dropout rate, the sample size was estimated to be 120. This also covered the sensitivity demands (with 0.80 sensitivity and a 0.10 margin of error, the sample size would be 77).

The EAT-10 scores were reported as means (standard deviation, SD) for clarity and better comparison to other studies even though the results were not normally distributed. The EAT-10 total score correlations to the VFS findings were calculated with Spearman's correlation. The relationships between the WST and VFS findings were analyzed with a chi-square test or a Fisher's exact test, and sensitivities, specificities, positive (LR+), and negative likelihood ratios (LR−) were calculated. The correlation between age and EAT-10 scores was assessed with Spearman's rho and correlations between age and VFS and WST findings with a Mann–Whitney *U*-test. Comparisons of the EAT-10 total score findings to findings in the WST or VFS were assessed with the Mann–Whitney *U*-test. The possible effect of gender on the findings in the VFS or WST was assessed with a chi-square test.

An experienced statistician was consulted regarding the statistical analysis. All statistical analyses were performed with the IBM SPSS Statistics for Windows (version 26.0; IBM Corp., Armonk, NY, USA).

RESULTS

A cohort of 151 consecutive patients was collected over 1 year from June 2021 to June 2022 in Turku University Hospital, which is a tertiary care unit for approximately 868,000 inhabitants (population on December 31, 2019). One patient refused to drink or eat and was excluded from the study, but all the other patients ($n = 150$) had completed EAT-10, WST, and VFS records. The median age was 70.0 years (range 19–92 years) and 58.5% were female. The median BMI was 26.4 (range 17.0–52.4), and only 2.6% of the patients were underweight (BMI < 18.5). EAT-10 total scores varied considerably according to the etiology of the dysphagia (Table I). Patients were referred to VFS from various medical disciplines, mostly from otorhinolaryngology/phoniatrics ($n = 63$), gastroenterology ($n = 34$), gastrointestinal surgery ($n = 23$), and neurology ($n = 12$).

In the WST, 98 patients passed, and 52 patients failed. VFS was normal in 39 patients and abnormal in 111 patients. The relation between normal or abnormal WST results (without swallowing speed) and normal or abnormal VFS findings was statistically significant with a sensitivity of 40.5% and a specificity of 82.1%, (LR+ 2.368, LR− 0.725, $p = 0.011$). The most sensitive WST parameter to predict abnormal VFS findings was a small (≤20 mL) average drinking bolus size with a 79.1% sensitivity (LR+ 1.341, LR− 0.510, $p = 0.014$). The most specific predictor of normal VFS findings was the absence of coughing either during or after drinking with an 89.7% specificity (LR+ 2.534, LR− 0.824). Swallowing speed did not enhance the sensitivity or specificity of the WST. The results of the parameters in the WST and their connections to the VFS findings are shown in Table II. If only coughing (during or after drinking) and a small bolus size (≤20 mL) were considered (simplified WST, sWST), the sensitivity of predicting abnormal VFS findings increased to 83.8% but the specificity of predicting normal findings decreased to 38.5% (LR+ 1.363, LR− 0.421, $p = 0.005$).

The connections of the WST result to penetration/aspiration in VFS are shown in Table III. The most specific indicator to predict the absence of penetration/aspiration in VFS was the absence of coughing in the WST with an 82.5% specificity (LR+ 3.954, LR− 0.373). The most sensitive predictor of penetration/aspiration in VFS was failing any parameter in the WST with an 84.6% sensitivity. The swallowing speed measurement did not enhance sensitivity, but the specificity decreased from 70.1% without the swallowing speed to 43.8% with the swallowing speed (LR+ 2.829 and LR− 0.220, and LR+ 1.505, LR− 0.352, respectively). sWST with only coughing and an average drinking bolus size did not reach statistical significance when detecting penetration/aspiration in VFS (LR+ 1.318, LR− 0 $p = 0.073$).

With 76 patients, both a 10 and a 20 mL liquid bolus (IDDSI 0) were tested in VFS. Six patients had penetration/aspiration when swallowing a 10 mL bolus, and 12 patients had penetration/aspiration when swallowing 20 mL bolus. Among these 12 patients, nine (11.8% from whole 76 patients) did not have visible penetration/aspiration with the smaller bolus ($p = 0.005$).

The EAT-10 total scores were higher for those patients who did not pass the WST ($p = 0.004$); had a slow swallowing speed (<10 mL/s; $p = 0.009$); or if their oral ($p = 0.004$), pharyngeal ($p = 0.042$), or esophageal phase ($p = 0.032$) was abnormal in VFS. Moreover, patients who failed any parameter in the WST had higher EAT-10 scores than those whose WST was considered normal, but the difference did not reach statistical significance. The test result correlations of the WST and VFS to disease-specific EAT-10 total scores were not statistically significant (data not shown).

The EAT-10 total score was <16 for 95 patients and ≥ 16 for 55 patients. An EAT-10 total score of <16 predicted an absence of penetration/aspiration in the VFS with a 67.4% specificity, and an EAT-10 ≥ 16 predicted penetration/aspiration with an 84.6% sensitivity (LR+ 2.595, LR− 0.228, $p < 0.001$). If the EAT-10 cut-off ≥16 was combined with the WST test result, 68 patients passed (normal WST and EAT-10 < 16) and 82 patients failed either one or both tests. There was also a significant relationship between the combined test results and the penetration/aspiration findings ($p = 0.004$). If the EAT-10 score was <16 and the WST was normal, there was no penetration/aspiration in the VFS with a 48.9% specificity. However, if either one of the tests was positive, penetration/aspiration was shown with a 92.3% sensitivity (LR+ 1.806, LR− 0.157). Consequently, combining the

TABLE I.
The Etiology of Dysphagia and Correlations With Mean Eating Assessment Tool (EAT-10) Total Scores.

Etiology of Dysphagia	*n* (%)	EAT-10 Mean (SD) Range
Esophageal (reflux, motility disorders, and esophagitis)	47 (31.1)	14 (9) 0–36
Cricopharyngeal problem or Zenker's diverticulum	26 (17.2)	13 (7) 1–26
Dry mouth/throat	20 (13.2)	11 (7) 4–30
Neurological	17 (11.3)	16 (7) 3–32
Functional or globus	11 (7.3)	16 (8) 6–31
Presbyphagia	9 (6.0)	13 (8) 5–30
Sensation of dysphagia but swallowing is normal	6 (4.0)	5 (5) 1–15
Compression (osteophyte, scar tissue, and tonsillar hypertrophy	6 (4.0)	12 (9) 4–28
H&N or esophageal cancer	3 (2.0)	16 (7) 11–24
Gastric (pyloric stenosis, gastroparesis, and gastric banding)	3 (2.0)	8 (9) 0–18
Other (scleroderma, operated cleft palate, and sialolith)	3 (2.0)	20 (16) 2–33

H&N = head and neck.

TABLE II.
Water Swallow Test (WST) Parameters and Their Connections to Videofluoroscopy (VFS) Findings.

		VFS Normal *n*/%	VFS Abnormal *n*/%	Oral Phase Normal *n*/%	Oral Phase Abnormal *n*/%	Pharyngeal Phase Normal *n*/%	Pharyngeal Phase Abnormal *n*/%	Esophageal Phase Normal *n*/%	Esophageal Phase Abnormal *n*/%
Coughing during drinking	No	*39/100%*	*103/92.8%*	123/**96.9**%*	19/82.6%*	96/**99.0**%*	46/86.8%*	*58/98.3%*	*84/92.3%*
	Yes	*0*	*8/7.2%*	4/3.1%*	4/17.4%*	1/1.0%*	7/13.2%*	*1/1.7%*	*7/7.7%*
p-value			*0.112*		0.020*		0.003*		*0.148*
Coughing after drinking	No	*35 /89.7%*	*85/76.6%*	*103/81.1%*	*17/73.9%*	86/**88.7**%*	34/64.2%*	*48/81.4%*	*72/79.1%*
	Yes	*4/10.3%*	*26 /23.4%*	*24/18.9%*	*6/26.1%*	11/11.3%*	19/35.8%*	*11/18.6%*	*19/20.9%*
p-value			*0.077*		*0.408*		<0.001*		*0.738*
Coughing both	No	35/**89.7**%*	82/73.9%*	*102/80.3%*	*15/65.2%*	85/**87.6**%*	32/60.4%*	*48/81.4%*	*69/75.8%*
	Yes	4/10.3%*	29 /26.1%*	*25/19.7%*	*8/34.8%*	12/12.4%*	21/39.6%*	*11/18.6%*	*22/24.2%*
p-value			0.040*		*0.108*		<0.001*		*0.424*
Wet–hoarse voice	No	*39 /100%*	*109/98.2%*	*126/99.2%*	*22/95.7%*	*96/99.0%*	*52/98.1%*	*58/98.3%*	*90/98.9%*
	Yes	*0*	*2/1.8%*	*1/0.8%*	*1/4.3%*	*1/1.0%*	*1/1.9%*	*1/1.7%*	*1/1.1%*
p-value			*1.000*		*0.284*		*1.000*		*1.000*
Average drinking bolus size	>20 mL	16/41.0%*	23/20.9%*	38/29.9%*	1 /4.5%*	*29/29.9%*	*10/19.2%*	21/36.2%*	18/19.8%*
	≤20 mL	23/59.0%*	87/**79.1**%*	89/70.1%*	21/**95.5**%*	*68/70.1%*	*42/80.8%*	37/63.8%*	73/**80.2**%*
p-value			0.014*		0.012*		*0.158*		0.026*
Swallowing speed (SS)	>10 mL/s	27/69.2%*	47/42.3%*	71/55.9%*	3/13.0%*	*52/53.6%*	*22/41.5%*	39/66.1%*	35/38.5%*
	<10 mL/s	12/30.8%*	64/57.7%*	56/44.1%*	20/**87.0**%*	*45/46.4%*	*31/58.5%*	20/33.9%*	56/61.5%*
p-value			0.004*		<0.001*		*0.157*		0.001*
WST normal (without SS)	Yes	32/**82.1**%*	66/59.5%*	90/70.9%*	8/34.8%*	74/76.3%*	24/45.3%*	*42/71.2%*	*56/61.5%*
	No	7/17.9%*	45/40.5%*	37/29.1%*	15/65.2%*	23/23.7%*	29/54.7%*	*17/28.8%*	*35/38.5%*
p-value			0.011*		0.001*		<0.001*		*0.225*
WST normal with SS	Yes	23/59.0%*	39/35.1%*	59/46.5%*	3/13.0%*	*45/46.4%*	*17/32.1%*	31/52.5%*	31/34.1%*
	No	16/41.0%*	72/64.9%*	68/53.5%*	20/**87.0**%*	*52/53.6%*	*36/67.9%*	28/47.5%*	60/65.9%*
p-value			0.009*		0.003*		*0.089*		0.025*
Simplified WST normal	Yes	15/38.5%*	18/16.2%*	32/25.2%*	7/4.3%*	*26/26.8%*	*7/13.2%*	18/30.5%*	15/16.5%*
	No	24/61.5%*	93/**83.8**%*	95/74.8%*	22/**95.7**%*	*71/73.2%*	*46/86.8%*	41/69.5%*	76/**83.5**%*
p-value			0.004*		0.026*		*0.055*		0.043*

Statistically significant results are marked with an asterisk (*), and insignificant results are written in italics. The most sensitive and most specific results are bolded. In simplified WST, only coughing and average drinking bolus size are evaluated.
SS = swallowing speed.

TABLE III.
Water Swallow Test (WST) Parameters and Their Connections to Penetration/Aspiration (pen/asp) Findings in Videofluoroscopy.

		No pen/asp *n*/%	pen or asp *n*/%
Coughing during drinking	No	132/**96.4**%*	10/76.9%*
	Yes	5/3.6%*	3/23.1%*
p-value			0.022*
Coughing after drinking	No	115/**83.9**%*	5/38.5%*
	Yes	22/16.1%*	8/61.5%*
p-value			0.001*
Coughing both	No	113/**82.5**%*	4/30.8%*
	Yes	24/17.5%*	9/69.2%*
p-value			<0.001*
Wet–hoarse voice	No	*136/99.3%*	*12/92.3%*
	Yes	*1/0.7%*	*1/7.7%*
p-value			*0.166*
Average drinking bolus size	>20 mL	*38/27.7%*	*1/8.3%*
	≤20 mL	*99/72.3%*	*11/91.7%*
p-value			*0.185*
Swallowing speed (SS)	>10 mL/s	71/51.8%*	3/23.1%*
	<10 mL/s	66/48.2%*	10/76.9%*
p-value			0.048*
WST normal (without SS)	Yes	96/70.1%*	2/15.4%*
	No	41/29.9%*	11/**84.6**%*
p-value			<0.001*
WST normal with SS	Yes	60/43.8%*	2/15.4%*
	No	77/56.2%*	11/**84.6**%*
p-value			0.047*

Statistically significant results are marked with an asterisk (*) and insignificant results are written in italics. The most sensitive and most specific results are bolded.

SS = swallowing speed.

tests enhanced the sensitivity but reduced the specificity when compared to either the WST results or EAT-10 total score results alone. Statistically significant associations with the combined test (EAT-10 cut-off 16 and WST) results with the VFS findings were also found in the oral phase (sensitivity of 78.3% and specificity 49.6%, LR+ 1.554, LR− 0.438, $p = 0.014$), pharyngeal phase (sensitivity of 69.8% and specificity of 53.6%, LR+ 1.504, LR− 0.563, $p = 0.006$), and esophageal phase (sensitivity of 62.6% and specificity of 57.6%, LR+ 1.476, LR− 0.649, $p = 0.015$).

Age was not significantly correlated with the EAT-10 total scores, but it was correlated with the VFS findings and WST results: older patients were more likely to have abnormal VFS findings ($p < 0.001$), average drinking bolus size ≤20 mL ($p < 0.001$), or swallowing speed <10 mL/s ($p = 0.001$). Qualitative measures of the WST, such as coughing and possible voice change, were not correlated with age. Gender did not significantly correlate with the EAT-10 scores or VFS results. In the WST, there were no significant differences between genders in the qualitative parameters or total WST results, but females were more likely to have a slower swallowing speed ($p < 0.001$) and a smaller average drinking bolus size ($p < 0.001$).

DISCUSSION

Coughing and an average drinking bolus size were the most important parameters in the WST predicting normal and abnormal VFS results, respectively. The absence of coughing predicted a normal VFS with an 89.7% specificity and a normal WST (without swallowing speed) with an 82.1% specificity. The most sensitive predictor of abnormal findings in VFS was an average drinking bolus size of ≤20 mL with a 79.1% sensitivity. Moreover, a 20 mL liquid bolus also revealed penetration or aspiration in the VFS more sensitively than a smaller 10 mL bolus. Our results are in line with the meta-analysis of Brodsky et al. where WST studies were analyzed based on volume and sequence of swallows: consecutive sips of 90–100 mL were 91% sensitive and 53% specific to rule out aspiration and small volume with single sips predicted aspiration with 71% sensitivity and 90% specificity.[20] Unlike the results of Wu et al., we found out that swallowing speed observation did not seem to be useful in predicting VFS findings.[14] Therefore, we introduced sWST (with only coughing and bolus size observed) as a sensitive method to predict normal and abnormal VFS findings but its clinical feasibility needs further investigation. Dysphagia is a common symptom and requires quick and simple tools to evaluate swallowing. WST (and simplified version, sWST) could be helpful when a clinician is deciding whether to make a referral to VFS or not.

Coughing and an abnormal WST (failing any parameter in WST) were also the most useful parameters for detecting penetration/aspiration in VFS. The least useful parameters predicting VFS findings or penetration/aspiration in VFS were a wet–hoarse voice and the swallowing speed. Accordingly, both qualitative and quantitative parameters for a WST are needed, especially observation of coughing and an average bolus size. Possible changes in the voice can be challenging to observe for an unexperienced rater and seem to be somewhat irrelevant in the WST interpretation so we suggest that it could be left out. Moreover, the swallowing speed measurement seems not to be useful and can direct attention away from other observations such as swallow counting.

The swallowing task affects the bolus size. In a recent study with an Indian population, there were significantly different bolus sizes between normal swallows and rapid swallows. Normative values varied significantly according to age.[21] Even if the swallowing speed itself was not measured, the advice to “drink as quick as possible” was useful because a larger average bolus size was related to quicker drinking and made it easier to rate the WST results. It is also important to keep in mind that gender and age affect the bolus volume and swallowing speed, which was shown in our study as well as in a study with the neurologic patient population.[22]

EAT-10 has been proven to be a valid instrument to evaluate dysphagia and it is also suitable for follow-up.[4,5,18,23–27] It has also been commonly used in dysphagia screening and has been introduced to predict penetration/aspiration.[28–30] Cheney et al. showed that an EAT-10 cut-off 16 reached a sensitivity of 71% and a specificity of 53% in predicting aspiration (PAS >5).[9] Our previous study also indicated that an EAT-10 cut-off 16 for liquids predicted a FEES-controlled penetration/aspiration with a 70.4% sensitivity and a 42.0% specificity.[5] In this present VFS-controlled study, the sensitivity of the EAT-10 cut-off at 16 for predicting penetration/aspiration was 84.6% and the specificity 67.4%. In addition, other studies have indicated that EAT-10 scores can predict penetration/aspiration.[8,18,26,31–33] However, there are also contradictory results.[34] One reason for these results is that EAT-10 scores vary considerably according to the etiology of the dysphagia, as shown in the present study (Table I). Therefore, optimal cut-off values are not easy to determine. Moreover, EAT-10 is patient's subjective opinion of symptom gravity, and it was originally developed for documenting dysphagia severity and for follow-up.[4] Its usefulness for screening remains unelucidated.

We also studied whether the combination of the WST results with the EAT-10 results would be useful in screening for referral to VFS. Combining the EAT-10 cut-off 16 with the WST resulted in an increase in sensitivity but a decrease in specificity. Subsequently, if the aim is to prevent unnecessary VFSs, a WST alone is more specific, and even the sWST was more valuable in enhancing sensitivity for predicting abnormal VFS findings than combining the results of the WST and the EAT 10 cut-off 16. However, combining the test results seemed to be useful for enhancing sensitivity when predicting penetration or aspiration. It is also notable that WST (swallow performance screener) and EAT-10 (PROM) measure different things, WST detecting more about swallowing efficacy and safety and EAT-10 about symptom severity and impact of dysphagia.

There were some limitations in this study. The cohort was heterogeneous with numerous different etiologies, which might affect the EAT-10 results. On the other hand, this study covered almost all VFSs performed in our large tertiary care unit and it served as a cross-section of the VFS population over 1 year. Only Finnish-speaking people were included so there is a possibility of a cultural bias. The study comprised not only of oropharyngeal dysphagia patients but also of those with esophageal and gastric problems, which may have affected the results. The analyses of the VFSs were made by a single radiologist (JV) and the WST interpretations by a single ENT doctor (JK), and results were not controlled nor intra-rater reliability considered.

CONCLUSION

Coughing and an average drinking bolus size were the most important parameters in a WST when predicting findings in a VFS, whereas the swallowing speed did not seem to be useful. A bolus of 20 mL revealed more sensitive penetration or aspiration in a VFS than a 10 mL bolus. The WST was superior to EAT-10 when screening for referrals to VFS.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Tero Vahlberg for assistance with planning statistical analyses, Prof. Jérôme Lechien for providing GLUPS-score, and helpful nurses in Department of Radiology at Turku University Hospital.

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