

Screening algorithms for detecting dysphagia: A validation study of Thai EAT-10 combined with the 3-Ounce Water Swallow Test

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ABSTRACT

Background: Dysphagia assessment using standard tools is not commonly performed in Thailand because it relies on equipment and experts to evaluate. This study was conducted by combining the Thai EAT-10 and the 3-ounce water swallow test, an easy-to-use tool for dysphagia screening. Therefore, it is crucial to study the accuracy and appropriateness before being widely used in the Thai population.

Objectives: To evaluate the validity of the combined Thai Eating Assessment Tool 10 (Thai EAT-10) and the 3-ounce Water Swallow Test (WST) screening algorithm for detecting dysphagia compared to diagnosis by an otolaryngologist.

Materials and methods: Analytical Cross-sectional study: sample of 260 adults (aged 20 years old or older) demographic data and past medical history were assessed using a questionnaire. The accuracy of dysphagia screening tests that combine Thai EAT-10 and the 3-ounce water swallow test with pulse oximetry was compared to the clinical swallow test assessed by an otolaryngologist. The sensitivity and specificity of the swallowing screening test for detecting dysphagia were evaluated.

Results: Thai EAT-10 combined with the 3-ounce Water Swallow Test has higher validity and accuracy for dysphagia evaluation than those of the Thai EAT-10 or the 3-ounce Water Swallow Test alone. There was 100% sensitivity, 93.4% specificity, 68.1% positive predictive value (PPV), and 100% negative predictive value (NPV).

Conclusion: The Thai EAT-10 combined with the 3-ounce water swallow test and pulse oximetry has higher reliability and validity than those of the Thai EAT-10 and the 3-ounce water swallow test alone. The reliability and validity of the combined test is closed to the gold standard. Furthermore, the algorithm is appropriate for screening dysphagia in remote areas with a large population.

Introduction

Dysphagia, defined as having difficulty swallowing, is a prevalent symptom that is caused not only by medical diseases but also by aging.¹ Its consequences are complications include dehydration, malnutrition, bronchitis, upper airway infections, and life-threatening conditions such as aspiration pneumonia.^{2, 3} There are several clinical methods for screening oropharyngeal dysphagia. The gold standard for swallowing examination is Videofluorographic Swallowing Study; VFSS and

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Fiberoptic Endoscopic Examination of Swallowing (FEES). However, FEES is difficult to conduct in all patients.^{4, 5} Alternatively, swallowing screening, a minimally invasive procedure performed by speech-language therapists etc., is used to determine the likelihood of dysphagia. The systematic review by Bour *et al.* in 2009 that was conducted to determine the effectiveness and feasibility of bedside screening methods for detecting dysphagia in patients with neurological disorders. The result revealed that a water swallowing test combined with pulse oximetry was the best method for screening dysphagia in patients with high accuracy (73-98% sensitivity and 63-76% specificity).⁶ The 3-ounce water swallowing (WST) is a widely known test with high sensitivity (96.5% sensitivity and 48.7% specificity) for predicting aspiration status in a large and heterogeneous patient population who are at risk for oropharyngeal dysphagia.⁷ In addition, a self-assessment tool is essential for patients to clarify the severity of their symptoms. Belafsky *et al.* studied the accuracy and reliability of the Eating Assessment Tool (EAT-10), which consists of 10 questions for self-assessment of dysphagia. If the score is greater than or equal to 3, it means abnormal.⁸ This test can be carried out and finished in less than 2 minutes, and is easy to use.⁸ EAT-10 had high sensitivity and specificity for screening dysphagia in healthy populations (89% sensitivity and 82% specificity).⁹ Moreover, former studies suggested the usage of EAT-10 as the first tool for dysphagia screening in older adults and patients with neurological disorders.⁹ EAT-10 has been introduced in many countries and has been translated into various languages, including Thai.¹⁰⁻¹⁵ Korwanich *et al.* examined the accuracy of the EAT-10 in Thai version on patients at the Ear, Nose, and Throat clinic, Faculty of Medicine, Chiang Mai University and found that it had 96.9% sensitivity and 93.4% specificity, which showed that the use of the Thai EAT-10 was highly valid and accurate for detecting dysphagia.¹⁵

However, previous studies have found that dysphagia assessments were conducted using only an objective or subjective assessment.⁶⁻⁹ Combining a test to other kind of test may have the potential of bringing higher reliability and accuracy while possibly making the effectiveness of the combined tests the gold-standard. In addition, a new combination may possibly be useful to replace the gold-standard tools in remote areas.

This study aimed to evaluate the validity of the self-dysphagia assessment form, the Thai EAT-10, in combination with the 3 oz. water swallow test (WST), compared to an otolaryngologist's diagnosis and to establish appropriate and accurate assessment algorithms for daily life practice.

Materials and methods

This study was conducted in the Ear, Nose, and Throat department, Faculty of Medicine, Chiang Mai University. The sample size calculation using 85% sensitivity¹⁶ and 95% confidence indicated 196 subjects were required. To reduce data collection discrepancies, the number of samples was

raised to 270. Ten patients were excluded from the study due to incomplete demographic information. Thus, in purposive sampling, 260 patients who visited Ear Nose Throat Clinic voluntarily were recruited in this study. All participants were without any cognitive state problems.

The inclusion criteria were as follows;

1. Male or female, aged 20 years or more.
2. Never been diagnosed with dysphagia.
3. The participants had passed the Thai Mental State Examination (TMSE). The passing level scores were depended on participants' education level. For participants with elementary education background or below, the passing score must be greater than or equal to 19. For those with higher than elementary education level background, the passing score must be greater than or equal to 24.

The exclusion criteria were as follows;

1. Patients with underlying severe medical conditions such as head and neck cancer patients, end stage of life patients.
2. Patients with a nasogastric tube or tracheostomy tube.
3. Those who did not agree to give an interview or could not communicate.
4. Patients who could not perform a water swallowing test, judge by a physician.

Data of age, gender, body mass index, past medical history, education level, career, and salary per month was collected using a general questionnaire. Thai EAT-10 and the 3-ounce WST with pulse oximetry to monitor aspiration was performed separately. If one of the following assessment criteria were met, the patient would be classified as a dysphagia group:

- Score 3 or more from the Thai EAT 10 test.
- Cannot continuously swallow 90 milliliters of water within 1 minute.
- Having wet, hoarse, or voice change after swallowing all the water within 1 minute.
- Aspiration: oxygen saturation dropped 2% or more during water swallowing or choking after swallowing all the water within 1 minute.
- Coughing after swallowing all the water within 1 minute.

All samples were clinically examined by a 7 year experience otolaryngologist and a speech-language pathologist to diagnose whether or not he or she showed dysphagia conditions using the Clinical Swallow Test (CSE), which consists of general history, history of underlying medical conditions, treatment and medications received, reporting of the patient's symptoms, and oromotor function assessment. In case samples diagnosed with dysphagia by CSE, the physician would perform a fiberoptic endoscopic evaluation of swallowing (FEES) examination.

Screening algorithms process

The sequential approach was used for both tests because it is practical, logistical, and preferred in rural areas.¹⁷ The 3-ounce WST was used to confirm the result of the Thai EAT-10 (positive results and negative results confirmation). The Thai EAT-10 and 3 oz. WST were used singularly as a comparator. For this study, there are 4 algorithms of dysphagia screening processes as below (Figure 1).

Algorithm A: The 3-ounce WST was used if the Thai EAT-10 gave a negative result. This approach is applied to minimize a false negative.¹⁷ A case was considered negative if both test results are negative, meaning that if the case fails to pass either test, he/she is categorized as positive.

Algorithm B: The 3-ounce WST was used if the Thai EAT-10 gave a positive result. This approach was applied to minimize a false positive.¹⁷ A case is considered positive if both test results are positive, meaning that if the case passes either test, he/she is categorized as negative.

Algorithm C: Only the Thai EAT-10 is performed to categorize.

Algorithm D: Only the 3-ounce WST is performed to categorize.

Statistical analysis involved descriptive and inferential analyses with a 5% significance level where in the variables were determined by percentage, mean, and standard deviation. Other statistics performed include sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the Thai EAT-10 combined with the 3-ounce WST. Receiver operating curves (ROCs) were calculated for each scale to determine the area under the curve.

Results

Total number of samples recruited in this study was 260. The mean age was 46.5 ± 16.4 years (20-92 years). Percentage of participants described by demographic characteristics is shown in Table 1. There were 32 participants (12.3%) who were diagnosed with dysphagia by CSE. All of them were confirmed with FEES as dysphagia positive.

The number of participants with positive and negative results in each test are shown in Figure 2. In addition, algorithm A provided the highest sensitivity and specificity with PPV of 68.1% and NPV of 100%, algorithm B provided 78.1% sensitivity and 100% specificity with 100% PPV and 97.0% NPV. Both Thai EAT-10 (algorithm C) and 3-ounce WST (algorithm D) alone showed lower values of sensitivity and specificity (Table 2). The ROC curve of algorithm A shows the highest area under curve (Figures 3 and Table 3).

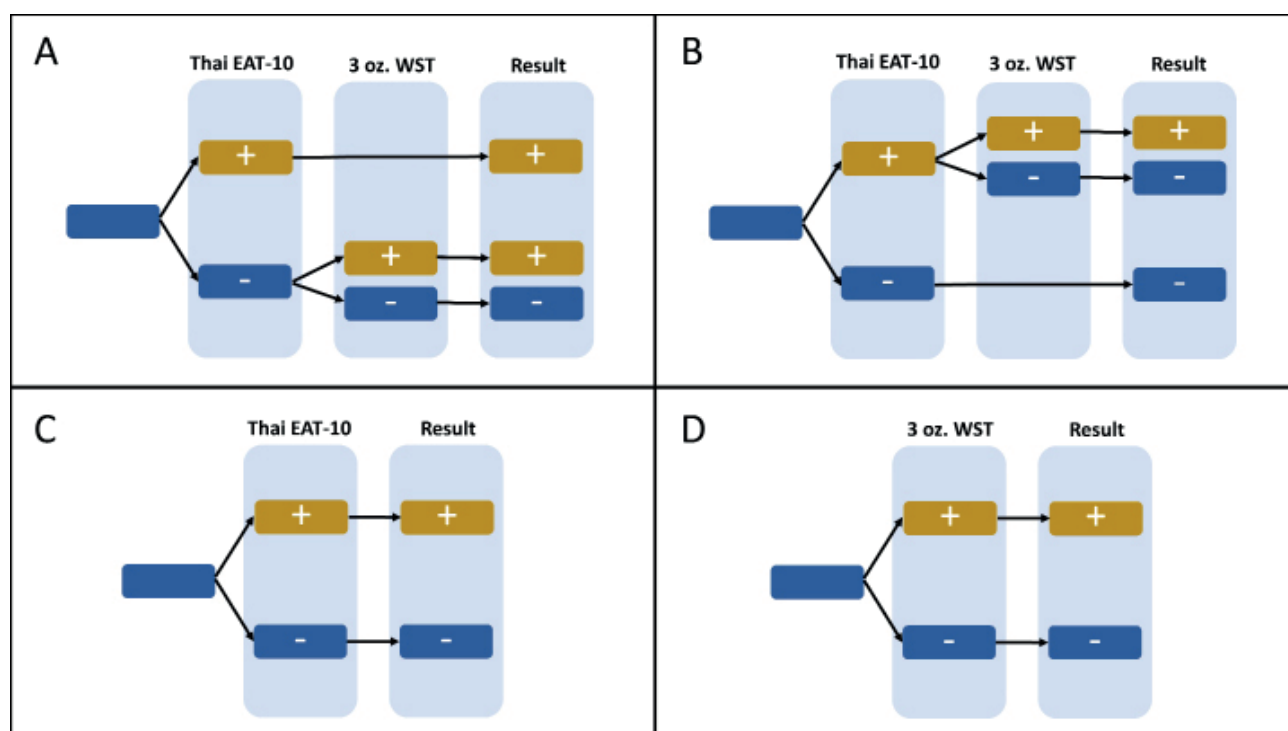


Figure 1 Screening algorithms process.

Table 1 Characteristic of participants and dysphagia patients.

Characteristic		Participants (260) N (%)	Dysphagia patients (32) N (%)
Gender	Male	108 (41.5)	26 (81.3)
	Female	152 (58.5)	6 (18.8)
Age	Mean±SD (years)	46.5±16.4	68.3±10.3
	Min-Max (years old)	20-92	42-92
	<30 years old	60 (23.1)	0
	31-59 years old	135 (51.9)	3 (9.4)
	≥60 years old	65 (25)	29 (90.2)
BMI	Mean±SD	23.8±4.4 kg/m ²	23.8±4.3 kg/m ²
	Min-Max	14.7-43.3 kg/m ²	14.7-43.3 kg/m ²
Medical condition	No	149 (57.3)	6 (18.8)
	Yes, hypertension, cancers, hyperlipidemia	111 (42.7)	26 (81.3)
Status	Single	102 (39.2)	1 (3.1)
	Married	152 (58.5)	29 (90.6)
	Widow	4 (1.5)	2 (6.3)
	N/A	2 (0.8)	0
Educational level	Under Bachelor's degree	156 (60)	26 (81.3)
	Upper Bachelor's degree	102 (39.2)	6 (18.7)
	N/A	2 (0.8)	0
Salary per month	<30,000 Baht	213 (82)	28 (88.5)
	>30,000 Baht	46 (17.7)	4 (12.5)
	N/A	1 (0.3)	0

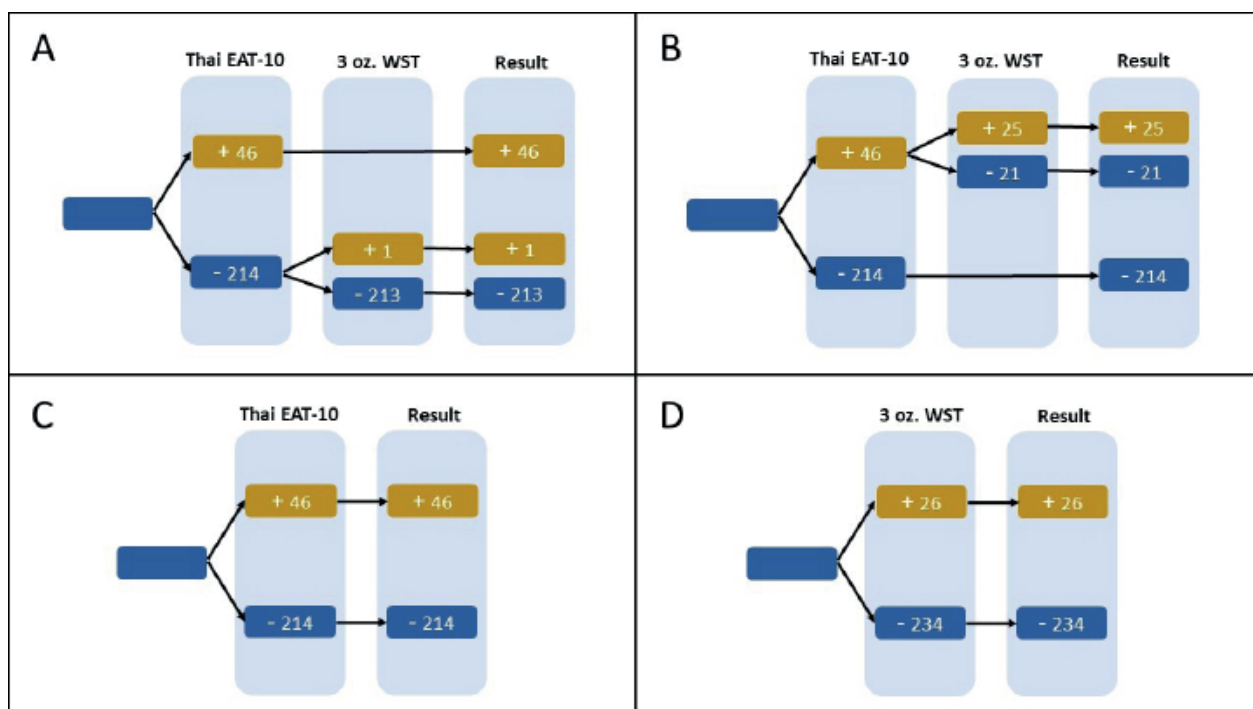
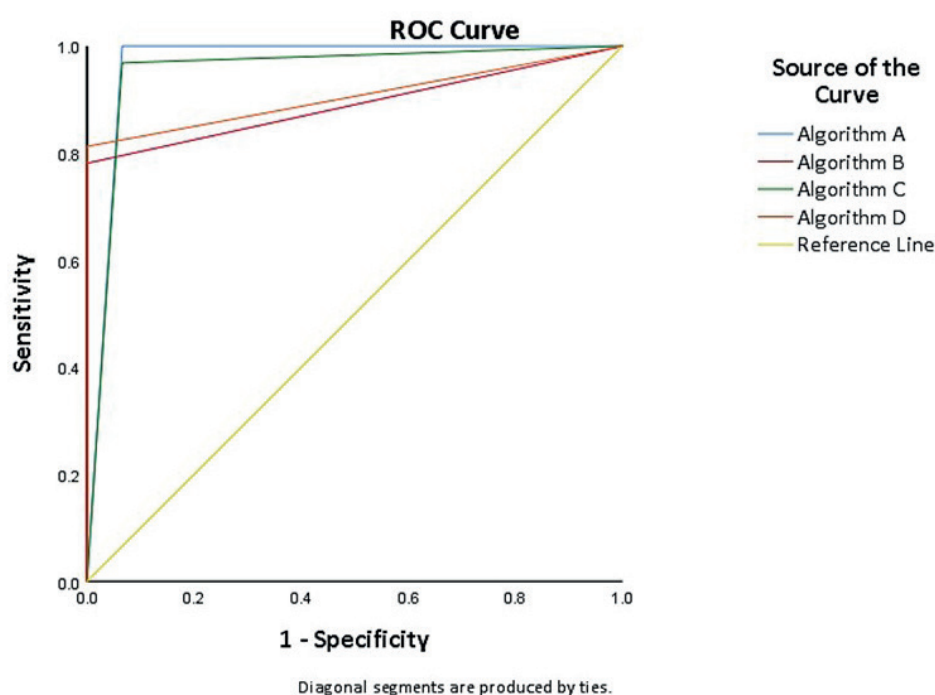
**Figure 2** Tests from different algorithms.

Table 2 Measures of validation and efficacy for dysphagia screening test.

Algorithm	Sensitivity (95% CI) (%)	Specificity (95% CI) (%)	PPV (%)	NPV (%)
A	100 (86.7-100)	93.4 (89.2-96.1)	68.1	100
B	78.1 (59.6-90.0)	100 (97.6-100)	100	97.0
C	96.8 (82.0-99.8)	93.4 (89.1-96.1)	67.4	99.5
D	81.3 (62.9-92.1)	100 (97.9-100)	100	97.4

**Figure 3** ROC curve showed sensitivity and specificity of dysphagia screening techniques.**Table 3** Area under ROC curve of dysphagia screening techniques.

Dysphagia screening technique	Estimate	SE	p value	95% Confidence interval	
				Lower bound	Upper bound
Algorithm A	0.967	0.010	<0.001	0.947	0.987
Algorithm B	0.891	0.044	<0.001	0.805	0.977
Algorithm C	0.951	0.020	<0.001	0.912	0.991
Algorithm D	0.906	0.041	<0.001	0.826	0.987

Discussion

In Thailand, history taking, physical examination, and clinical assessment have been performed to diagnosed patients who possibly suffering from dysphagia caused by cerebrovascular disease and head and neck cancer. Widely known dysphagia diagnostic tests in Thailand are swallowing water at a volume of 3-5 milliliters^{9, 10} and 90-milliliter water swallow test, such as PMR Siriraj Swallow Screening and dysphagia assessment in patients with cerebrovascular disease at Srinagarind Hospital.¹⁸ Water swallowing test is accepted widely because of its high

sensitivity. While the small volume (1-5 mL) of water swallowing test has been used in patients who were suspected to have dysphagia, neurologic disease, or respiratory disease, with a 71% sensitivity and 90% specificity,⁶ it could have false-negative at a high rate if used with patients who has a mild symptom of dysphagia.⁶ On the other hand, using water volume of 90-100 milliliters is considered as a high sensitivity test and suitable for screening dysphagia in a population without severe congenital disease or dysphagia-associated disease risk group. Such a protocol is needed to provide a diagnosis

and prognosis before planning treatment and rehabilitation.⁶ However, the high volume of the WST has a risk of causing aspiration in severe dysphagia patients. Therefore, pulse oximetry in combination with water swallowing test and viscous powders used in combination with the WST such as the V-VST swallowing test, especially for patients at risk of aspiration, such as stroke patients⁹, has been recommended to monitor silent aspiration.⁶ However, many countries use self-assessment tools such as the EAT-10, including the Thai version, to screen dysphagia because it is easy to use, takes minimal chair time, and has high sensitivity and specificity.^{8, 9, 14}

According to the results of this study, dysphagia assessment in participants using both Thai EAT-10 and the 3-ounce WST found that algorithm A provided highest area under ROC curve compared to the other algorithms. The reasons may be from the high sensitivity and specificity of Thai EAT-10, which help to increase the test's accuracy. Furthermore, using both tests means that objective and subjective evaluations have been applied. Therefore, most of the signs and symptoms of dysphagia can be detected. Compared to previous studies^{7,9}, this study provided higher sensitivity and specificity, which may be due to using a standard reference tool, sample sizes, and different characteristics, resulting in various results.

It is noteworthy to mention that to use the gold-standard tool (FEES), meaning physicians have to insert parts of equipment into the body which can be dangerous or disturbing, and might not be appropriate or ethical to apply the gold standard tool in every sample. In this study we use the gold standard tools only when the case required confirmation of other clinical results. As a result, the data on the number of people with dysphagia may be less than using the gold standard in every participant. Further research may consider this dilemma during the study design.

In addition, the Thai EAT-10 or the 3-ounce water swallow test alone also provides high sensitivity and specificity. The choice of tools to assess dysphagia should take patient safety into account. The use of Thai EAT-10 alone may also be appropriate due to its being easy to use and safe in the community.

Conclusion

The Thai EAT-10 combined with the 3-ounce water swallow test and pulse oximetry has higher reliability and validity than the Thai EAT-10 and the 3-ounce water swallow test alone. The reliability and validity of the combined test is close to the gold standard. Furthermore, the algorithm is appropriate for screening dysphagia in remote areas with a large population.

Conflict of interest

The authors declare no conflicts of interest.

Ethical approval

This study was approved by the institutional review board and ethically approved the study of the Faculty of Dentistry (No.3/2563) and the Faculty of Medicine,

Chiang Mai University(No.054/2563).

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