Chapter 13
Predictive Roles of the Repetitive Saliva Swallowing Test (RSST) in Aspiration Pneumonia and Other Respiratory Diseases: Does the RSST Have a Predictive Role in Aspiration Pneumonia and Other Respiratory Diseases?

Yuki Yoshimatsu

Abstract Patients with dysphagia do not always present with subjective symptoms. However, asymptomatic dysphagia can also cause clinical issues, especially in those with respiratory conditions. Therefore, adequate screening is an essential beginning to their care. The repetitive saliva swallowing test (RSST) is one of the safest screening methods for dysphagia; it can be easily performed by nonprofessionals in any setting. There is evidence of its predictive values in aspiration pneumonia, chronic obstructive pulmonary disease (COPD), artificial ventilation, and other conditions. Additionaly, it has recently been found to be a strong predictor of the risk of future COPD exacerbation. The cost-effectiveness, harmlessness, and simplicity make it an optimal screening method for the large population of patients with respiratory conditions, although different cutoff values may be useful in different populations. It also takes into account multiple aspects of the swallowing ability, such as respiration, musculature, cognition, and general well-being.

Keywords Aspiration · Screening · Repetitive saliva swallowing test · RSST · COPD

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1 Introduction: Dysphagia Screening

Patients with dysphagia do not always present with subjective symptoms. Therefore, adequate screening is an essential beginning to the total care of aspiration pneumonia. A screening test is performed to identify patients at risk of dysphagia and to evaluate the necessity for a more comprehensive evaluation. These screenings are performed in a wide range of patients, by a wide range of professions. Therefore, it must be a simple and safe method, while assuring a high sensitivity to the specific patient group intended to be screened.

There are many screening tests for dysphagia and aspiration (Table 13.1). Screening tests can range from self-assessed questionnaires, such as the Eating Assessment Tool (EAT-10) [1] and Sydney Swallow Questionnaire (SSQ) [2], to observer-rated questionnaires and diagnostic procedures performed by an examiner such as the repetitive saliva swallowing test (RSST) [3], water swallow test (WST) [4], modified water swallow test (mWST) [5], and food test [6]. Examination techniques such as pulse oximetry [7] and cervical auscultation [8] can be used by itself or in conjunction with other screening tests. The simple swallow provocation test (SSPT) [9] is a unique method that allows screening for the pharyngeal sensation and does not require patient cooperation. There are also tests that allow for screening in patients with a tracheal cannula, such as Evan's blue dye test [10] and modified Evan's blue dye test (MEBDT) [11].

Clinicians must select the appropriate screening method depending on the setting, patient group, capacity, and evidence. Among these tests (and numerous others), the repetitive saliva swallowing test (RSST) is one of the safest methods. Originally being developed to screen for dysphagia, it has been applied to other purposes in recent years. In this chapter, we will investigate the RSST and the physiology underlying its broad applicability in respiratory disorders.

2 The RSST and Its Utility

2.1 What Is the RSST?

The RSST was developed in Japan by Oguchi et al. to safely and simply screen patients for functional dysphagia [3]. When performing this test, the patient is instructed to swallow their own saliva as many times as possible in 30 seconds. The examiner counts the number of swallows completed successfully by palpating the patient's laryngeal movement. Commonly, the index finger and middle finger are placed on the hyoid and thyroid cartilage (Fig. 13.1). In their original report, the authors suggest that when the RSST value is less than three times per 30 seconds, further investigation for functional dysphagia should be planned.

Table 13.1 Screening tests for dysphagia

No.	Name of test	Method	Criteria	Significance
1	Eating Assessment Tool (EAT-10) [1]	A 10-item questionnaire of subjective symptoms of dysphagia	≥ 3 points suggest alterations in swallow	Identify patients with dysphagia who should undergo further assessment.
2	Sydney Swallow Questionnaire (SSQ) [2]	17-item self-reported questionnaire of subjective symptoms of dysphagia using a visual analogue scale	The higher the score obtained, the higher the swallowing dysfunction (no cutoff value)	Measures symptomatic severity of dysphagia. Useful in assessing the response to a treatment
3	Repetitive saliva swallowing test (RSST) [3]	Repeat dry swallows for 30 seconds	< 3 is recommended for further assessment	Low cost and harm. Evidence in relation to aspiration, pneumonia, and COPD exacerbation
4	Water swallow test (WST) [4]	Swallow 30 mL of water	Drinking all within 5 seconds without choking is considered normal	Evaluates oral and pharyngeal phages of swallowing
5	Modified water swallow test (mWST) [5]	Swallow 3 mL of cold water	Check for choking, multiple swallows, or inability to swallow	Safer than the water swallow test
6	Food test [6]	Swallow 4 g of pudding placed on the tongue	Check for choking, changes in breathing or voice, or inability to swallow	For some patients, more acceptable than the WST
7	Pulse oximetry [7]	Measure oxygen saturation while eating/drinking	A decrease of ≧ 2–5 % is abnormal (but is not solely dependent on aspiration). Further assessment is recommended	Cutoff not validated. Increased utility when combined with WST
8	Cervical auscultation [8]	Auscultate above the cricoid cartilage in front of the sternocleidomastoid muscle during swallow	Listen for abnormal sounds of swallowing and swallowing-related respiration	Applicable in any setting but accuracy is questionable
9	Simple swallow provocation test (SSPT) [9]	Apply water (0.4 mL, 2.0 mL) through a nasal cannula placed in the oropharynx, and measure time to swallow initiation	≥ 3 seconds is abnormal	Does not require patient cognition. Can screen for oropharyngeal sensation
10	Evan's blue dye test [10]	In patients with a tracheal cannula, place food dye in the oral cavity	Abnormal if food dye is aspirated from the cannula	Can be performed at the bedside without patient cooperation. Accuracy is questionable
11	Modified Evan's blue dye test (MEBDT) [11]	In patients with a tracheal cannula, try oral intake with food dye	Abnormal if dye is aspirated from the cannula	Can test different consistencies (solids, thickened liquids, etc.). Accuracy is questionable

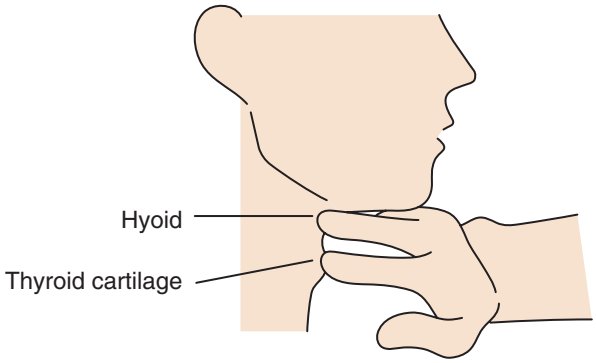

Fig. 13.1 How to perform the RSST. The patient is instructed to swallow their own saliva as many times as possible in 30 seconds. The examiner counts the number of swallows completed successfully by palpating the laryngeal movement. Commonly, when the examiner is sitting across from the patient, the middle finger of the examiner is placed on the patient's hyoid and the index finger on the thyroid cartilage. If the examiner is standing next to the seated patient, the examiner may place their index finger on the hyoid and the middle finger on the thyroid cartilage (illustration by Yurika Hirano)

2.2 The Cutoff Value of RSST

The cutoff value of the RSST was derived from the original study on 60 healthy participants [3]. Its validity has been further established through their next study of 131 patients with functional dysphagia (the cause being cerebrovascular disorder in 94 patients, brain tumor 6, brain injury 6, other neurological diseases 13, pneumonia 8, and other 4) [12]. An RSST score less than three was statistically significantly related to aspiration on videofluoroscopy, and the sensitivity and specificity were 0.98 and 0.66, respectively. The high sensitivity of RSST supports its effectiveness as a screening method for dysphagia.

2.3 Comparison of RSST to Other Screening Methods

Factors that may affect the ability to perform RSST include not only pharyngeal movement but also oral function, salivation, muscular structure and strength, holding and restarting the respiratory cycle repeatedly (the coordination of respiration and deglutition), cognition, and cooperation. It is not the best measure to screen for one specific part of the swallowing function (i.e., the simple swallow provocation test is a better method to screen for pharyngeal sensorial declination). On the contrary, it may be said that the RSST is an optimal method to screen for the whole swallowing ability. Its necessity to repeat actual swallows enables one to differentiate between those who can swallow (but possibly only in slow or uncoordinated reactions) and those who can repeatedly swallow as a means of safe oral intake.

As shown in Table 13.1, various screening methods of dysphagia have been developed. Compared to the other commonly performed tests, the RSST requires only a watch to measure 30 seconds. There is no need for specific equipment, hence

causing no economic burden. There is no associated risk of aspiration with the test, and it only requires one minute, including the time to explain the procedure. The feasibility of the RSST makes it an excellent screening tool for all settings, including any outpatient clinic, primary care setting, and even home care or nursing facilities, as long as the patient is alert and able to cooperate.

Another notable characteristic of the RSST is its safety. As it only solely requires the patients themselves to perform a purely physiological function (a dry swallow), there is no known risk associated with the test. There need not be any concern about complications that may be associated with other screening methods such as nasal membrane damage, aspiration, choking, or pneumonia. This encourages all professions and even family members to perform this test. Another important factor to consider when performing a screening test is the risk of transmitting droplets (aerosols) during the test. Most swallowing assessments involve this risk, including examination of the oral mechanism, testing cough reflexes, as well as the WST, mWST, food test, SSPT, Evan's blue dye test, and MEBDT. Because the RSST holds no risk of transmitting aerosols, it is a safe test from the standpoint of infection control. During the worldwide pandemic of the novel coronavirus, the RSST was the only test that the Society of Swallowing and Dysphagia of Japan permitted in regions that the infection had spread.

3 Predictive Roles of RSST in Aspiration Pneumonia

Over the years, some studies have used the RSST for more than the initial aim, which was to screen for the necessity for dysphagia assessment. In these further studies, the RSST has sometimes been modified to establish its efficacy in screening similar conditions, while the cutoff level has also been modified from its original level.

3.1 Treatment of Aspiration Pneumonia

For example, in a prospective observational study regarding the switch from intravenous to oral antimicrobials in 38 aspiration pneumonia patients, one of the criteria was RSST $\geq$2 [13]. In an analysis of feeding function and jaw stability in bedridden elderly patients, RSST $\leq$3 was considered abnormal [14].

3.2 Oral Intake in Aspiration Pneumonia

The RSST has also been investigated as one of the measures to predict the ability of oral food intake. In a study of 77 elderly patients admitted for acute pneumonia who were fasting due to aspiration risk, RSST $\geq$1 was found to be 1 of the predictors of oral intake at discharge (AUC 0.77, sensitivity 0.81, specificity 0.67) [15]. In this study, the Glasgow Coma Scale had a higher AUC (0.79) with a sensitivity and specificity of 0.71 and 0.80. There was no predictive effect in the modified water swallow test, simple swallowing provocation test, or cough test.

4 Predictive Roles of RSST in COPD

4.1 Dysphagia in COPD

Chronic obstructive pulmonary disease (COPD) is considered to be a systemic disease, and dysphagia is increasingly recognized as one of its common complications. Dysphagia is found to be related to a higher risk of COPD exacerbation and, hence, mortality. Therefore, early identification of dysphagia is essential in this group. In order to efficiently identify dysphagia in patients with COPD, it is necessary to understand the pathophysiology of why this group of patients develops dysphagia.

Patients with COPD have many factors that can cause dysphagia [16]. These include patient background factors, such as a smoking history and older age; respiratory issues, such as altered respiratory patterns and a lack of respiration-swallowing coordination; and systemic complications of COPD, such as GERD, sarcopenia, frailty, and sleep apnea syndrome. These multifactorial causes of dysphagia make dysphagia in patients with COPD unique. Therefore, when screening for dysphagia in patients with COPD, a method that is capable of screening for multiple aspects of the swallowing function is necessary.

4.2 Dysphagia Screening in COPD

The simple swallow provocation test (SSPT) has been reported to be a predictor of COPD exacerbation [17, 18]. However, this is not as simple as it sounds, both for physicians as well as patients. It requires the preparation of specific supplies and abundant practice and also causes discomfort for the patients. One previous study stated the possibility that the RSST may be a better method than the SSPT to detect dysphagia in patients with mild COPD [19].

4.3 RSST in COPD

Recently we reported the usefulness of RSST in detecting patients at high risk of COPD exacerbation. In our previous retrospective study, the results of the RSST were significantly lower in patients with exacerbations in the previous year [20]. In the prospective study following this, patients with a low RSST were at significantly higher risk of exacerbation in the next year (Fig. 13.2) [21]. The RSST was a stronger predictor of COPD exacerbation than the presence of exacerbation in the past year (which is currently considered as the strongest predictor). Additionally, the optimal cutoff value of the RSST in this population was found to be 5. Patients with COPD who scored 5 or more in RSST were at significantly lower risk of having an

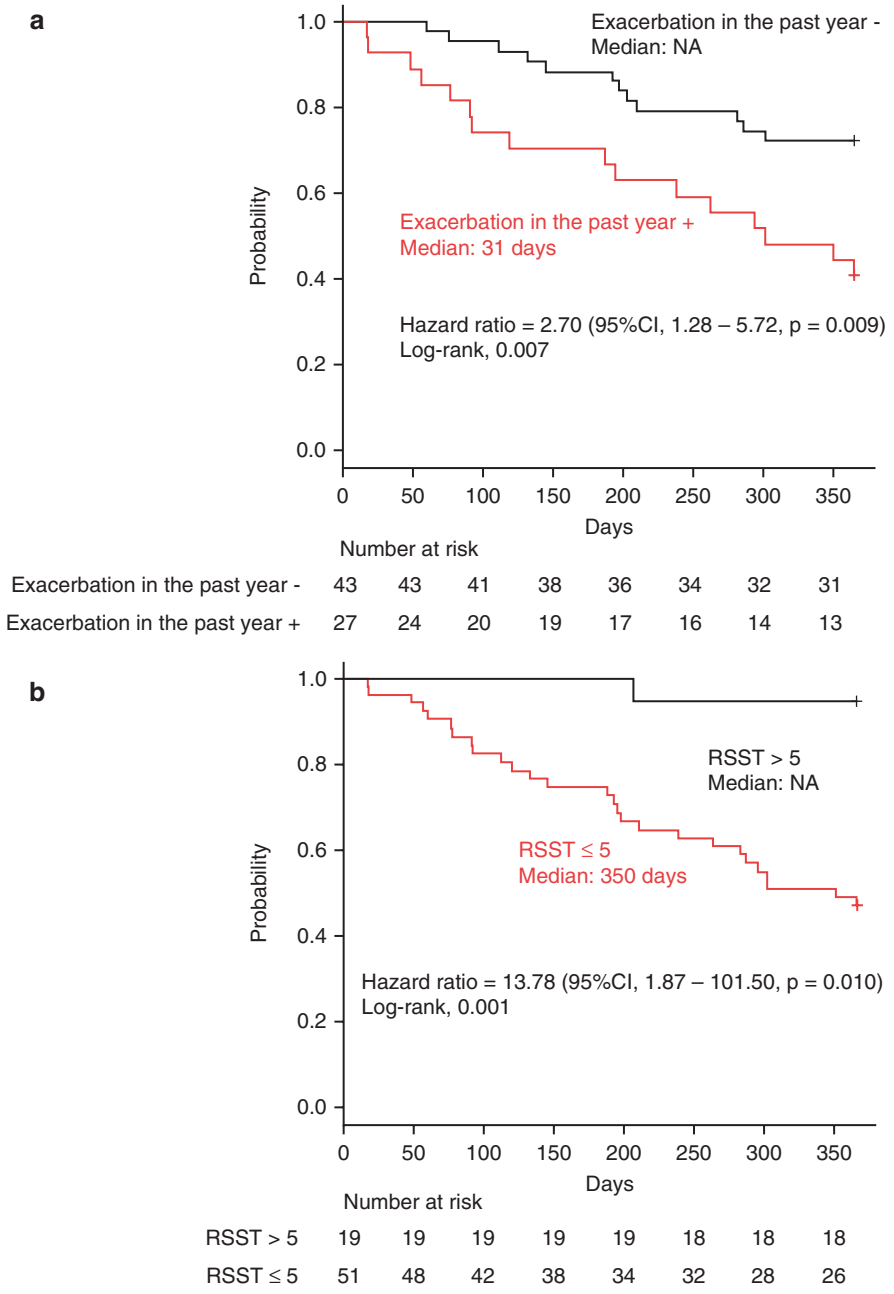

Fig. 13.2 Kaplan-Meier curves of the time to first exacerbation (any severity) (**a**) stratified by the presence of exacerbation in the past year and (**b**) stratified by the RSST cutoff value of 5. The time to first exacerbation was significantly longer in patients with no history of exacerbation in the past year than in those with exacerbation (**a**) and in those with an RSST value >5 (**b**). The RSST was a stronger predictor of exacerbation than a history of exacerbation [21]

exacerbation in the following year. Moreover, no patients who scored 5 or more had a moderate or severe exacerbation in the following year. The RSST may therefore be useful in screening for those at risk of exacerbation, especially moderate to severe exacerbation.

4.4 Why Is the RSST a Good Predictor in COPD?

Reportedly, the altered respiratory pattern due to COPD contributes to the increase in the incidence of inspiration occurring immediately before or after swallowing, as opposed to the more common pattern in which expiration occurs before and after swallowing in healthy individuals. The incoordination between respiration and swallowing is said to put patients with COPD at risk of aspiration [22], along with other systemic factors discussed before. We suspect that this is why screening tests such as the EAT-10, SSPT, and WST, which concentrate on a specific aspect of swallowing, are not particularly useful in this population. The RSST, which requires sufficient respiration-swallowing coordination, adequate musculature, cognition, and general well-being, is an effective method of screening for the swallowing function as a whole. RSST may also be more convenient in subclinical (asymptomatic) dysphagia, which is common in patients with mild COPD.

4.5 Swallowing During Artificial Ventilation

In a study of healthy volunteers, the occurrence rate of inspiration after swallow was found to be higher during bi-level positive airway pressure (BiPAP) than in normal breathing and continuous positive airway pressure (CPAP). When inspiration (instead of expiration) happens after swallowing, it is considered to be a risk factor of aspiration. In this study, RSST was a predictive variable of the risk of an inspiration to occur after swallow [23]. As artificial ventilation is often used for respiratory support during COPD exacerbations, this is an interesting area for further research.

5 Variables Affecting the RSST

When performing the RSST in the clinic, examiners are frequently confronted with patients insisting that they were not able to perform the RSST well because of xerostomia. We can assure them not to worry, as this has been already investigated.

5.1 Saliva Secretion

Whether saliva secretion or mouth dryness affects the results of the RSST is still controversial. In a study of 120 non-patients and 40 patients with dysphagia, neither the actual amount of saliva secretion nor the subjective dryness of the mouth affected the RSST results significantly [24]. It has been reported that there is little relation between xerostomia, or the feeling of dryness in the mouth, and actual hyposalivation [25]. However, it is true that some studies show the relation between dry mouth and a lower RSST value [26].

5.2 Effect of Moisturizing the Mouth Before the RSST

Whether the use of artificial saliva enables more swallows than without it has been investigated by Oguchi et al. in their original report [1]. According to this study, moisturizing the mouth with artificial saliva showed no significant change in the results of the RSST. On the other hand, lemon water has been reported to increase saliva secretion. It reduced the elongation of swallowing intervals (thus increasing the RSST score) with the effect depending on the concentration of lemon water [27]. However, as feasibility is one of the strengths of RSST over other screening tests, the usage of lemon water may not be applied easily. Therefore, it is currently recommended that the RSST be done without the use of water, but minimal amounts of water (such as 1 mL) may be used to moisturize the mouth if necessary. If patients attempt to accumulate saliva in their oral cavity prior to the RSST in order to score higher in the test, they should be instructed not to do so.

5.3 Patient Background

In the previously stated study, the number of doctor-prescribed medications did not affect the RSST results [24]. This study did, however, find that the swallowing frequency in RSST was less in older subjects than younger, and in female subjects than their male counterparts. Implementing a different cutoff depending on age and gender groups may be a topic to be considered for investigation.

5.4 Cognitive Function

Cognitive function and verbal communication ability are vital in performing the RSST successfully. In a study of elderly patients, RSST could only be completed by 59%, the inability mostly being due to dementia [28]. Prior to the test, clinicians

should make sure the patient understands that their maximal effort is required during the test.

5.5 Examiner

The sensitivity and specificity of RSST for aspiration differ among studies [12, 26]. The study population has a considerable influence on this difference. Although it is a relatively simple test, the understanding and experience of the examiner may also affect the results [26]. Therefore, when performing this test with others, it is essential to practice and share how to count the number of swallows correctly. Some patients have more subtle thyroid cartilage or hyoid movement than others. Also, patients often attempt to swallow but do not complete the swallow (i.e., the swallow is interrupted). To correctly count the number of swallows during the RSST, it is helpful first to ask the patient to swallow once to become familiar with that particular patient's swallow pattern on palpation.

6 Conclusion

The RSST is a convenient, safe, and reliable method to screen the swallowing function in multiple aspects. It has a predictive role in aspiration pneumonia and COPD exacerbation. Its high feasibility and sensitivity make it an optimal screening tool.

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