

The Volume-Viscosity Swallow Test for Clinical Screening of Dysphagia and Aspiration

Laia Rofes^a · Viridiana Arreola^b · Pere Clavé^{a,b}

^aCentro de Investigación Biomédica en Red de Enfermedades Hepáticas y Digestivas (CIBERehd), Instituto de Salud Carlos III, ^bUnitat d'Exploracions Funcionals Digestives, Hospital de Mataró, Barcelona, Spain

Abstract

Background: Oropharyngeal dysphagia (OD) is a major complaint among many patients with neurological diseases and in the elderly, but is often underdiagnosed. The volume-viscosity swallow test (V-VST) is a bedside method to screen patients for dysphagia.

Methods: The V-VST was designed to identify clinical signs of impaired efficacy (labial seal, oral and pharyngeal residue, and piecemeal deglutition) and impaired safety of swallow (voice changes, cough and decrease in oxygen saturation $\geq 3\%$). It starts with nectar viscosity and increasing bolus volume, then liquid and finally pudding viscosity in a progression of increasing difficulty to protect patients from aspiration. **Results:** The V-VST allows quick, safe and accurate screening for OD in hospitalized and independently living patients with multiple etiologies. The V-VST presents a sensitivity of 88.2% and a specificity of 64.7% to detect clinical signs of impaired safety of swallow (aspiration or penetration). The test takes 5–10 min to complete. **Discussion and Conclusion:** The V-VST is an excellent tool to screen patients for OD. It combines good psychometric properties, a detailed and easy protocol designed to protect safety of patients, and valid end points to evaluate safety and efficacy of swallowing and detect silent aspirations.

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Introduction

Oropharyngeal dysphagia (OD) is a major complaint among many patients with neurological diseases and in the elderly, but is not always systematically explored and detected. OD is specifically classified by the World Health Organization in the International Statistical Classification of Diseases and Related Health Problems ICD-9 and ICD-10 (787.2, R13) [1]. Although sufferers are sometimes

unaware of their oropharyngeal dysfunction, OD is a highly prevalent clinical condition as it affects more than 30% of patients with stroke, 60–80% of patients with neurodegenerative diseases, up to 13% adults aged 65 and older and more than 51% of institutionalized elderly patients [2, 3]. A Council of Europe resolution claimed that undernutrition among hospital patients is highly prevalent and leads to extended hospital stays, prolonged rehabilitation, and diminished quality of life, and identified OD as a major contributor to malnutrition [4].

Videofluoroscopy (VFS) is the gold standard to study oral and pharyngeal mechanisms of dysphagia and aspiration [5]. However, it is unfeasible to perform a VFS on every patient at risk or with suspected dysphagia. Clinical screening methods with high diagnostic accuracy must be developed to recognize and follow up patients with OD to identify patients who are at risk of aspiration or malnutrition, to identify patients who should be referred for a VFS to assess swallow function, and to help select the most appropriate bolus volume and viscosity for those patients (such as elderly patients admitted to nursing homes) who cannot easily undergo VFS [6]. The volume-viscosity swallow test (V-VST) is a bedside method to screen patients for dysphagia, to identify clinical signs of impaired efficacy and safety of swallow, and to select the appropriate bolus volume and viscosity to achieve the highest safety and efficacy of deglutition [7]. The V-VST method has been designed to favor diagnostic sensitivity as the cost of a false-negative diagnosis of a patient with aspirations is high (aspiration pneumonia) and the cost of a false-positive clinical diagnosis of impaired swallow is low (an unnecessary VFS study). In the validation study of the V-VST, we found a sensitivity and specificity for clinical signs of impaired safety of swallow (aspiration or penetration) of 88.2 and 64.7%, respectively, and a sensitivity of 100% in recognizing patients with aspiration subsequently confirmed by VFS [7].

We have validated the diagnostic accuracy of the V-VST, and we have used it to assess the prevalence of dysphagia among independently living older patients and among patients admitted to our hospital with stroke. The aim of this review is to describe the technique of the V-VST and our experience with this method in the screening of these different phenotypes of patients at risk of OD.

Methods

Management of Oropharyngeal Dysphagia in a General Hospital

The algorithm of management of OD at the Hospital de Mataró (Barcelona, Spain) begins with the identification by a doctor or a nurse of a patient in the risk population for OD, the screening of the nutritional state of the patient by a dietitian, the screening for OD and aspiration by a speech-swallow therapist or trained general practitioner and nurse using the V-VST, and finally, if the result of this process is positive, a videofluoroscopic study of swallow to diagnose the patient, to assess the safety and efficacy of deglutition and to select the treatment for the patient.

Performance of the V-VST

The patient should be sitting, with his back resting against the seatback and feet on the ground. Some pillows can be used to keep the patient in the right position. Hyperextension of the neck should be avoided. The explorer should be placed in front of the patient, sitting slightly below the patient. The explorer will offer the bolus to the patient carefully with a syringe. The exploration (including oxygen saturation measurements) can be recorded with a digital video camera for objective review.

Signs of Impaired Efficacy of Swallow

Efficacy of swallow is evaluated by the identification of the following clinical signs: the efficacy of labial seal, the presence of oral or pharyngeal residue and the presence of piecemeal deglutition (multiple swallows per bolus). The efficacy of labial seal is evaluated by observing if part of the bolus, once placed inside the mouth, escapes through the lips; the presence of oral residue is detected by asking the patient to open his/her mouth after deglutition and observing if part of the bolus remains in the mouth; the presence of pharyngeal residue is detected by asking the patient if he feels some kind of residue or nuisance in the pharynx or the need to swallow another time.

Signs of Impaired Safety of Swallow

Safety of swallow is assessed by evaluating the presence of voice changes, cough or a decrease in oxygen saturation $\geq 3\%$ measured with a finger pulse-oximeter (Nellcor OxiMax, Philips Medical Systems, The Netherlands) placed on the index finger of the right hand. The fall in oxygen saturation is determined by the difference between baseline (baseline readings are obtained 2 min prior to starting the test) and minimum readings during the 2 min period after each swallow. A fall in oxygen saturation $\geq 3\%$ is considered a sign of aspiration into the airway. Before the start of the test, the patient is invited to clearly pronounce his name (or some automatic answer) to obtain the normal pattern of voice. After each deglutition, the patient is invited again to pronounce his name to evaluate if any change is produced. Wet voice, low intensity, lack of voice or the need to clear the throat indicate impaired safety of swallow. The decrease in oxygen saturation and cough can occur before deglutition (indicating the inefficacy of the glossopalatal seal), during deglutition (indicating a delay in the laryngeal vestibule closure) or after deglutition (indicating the presence of residue and a postdeglutitive aspiration).

V-VST Algorithms

Short Algorithm

The volume-viscosity method was designed as an effort test in which boluses of increasing volume and difficulty are administered (fig. 1). The V-VST examines whether patients' swallow efficacy and safety is changed by increasing viscosity. The V-VST was designed to protect patients from aspiration by starting with nectar viscosity and increasing volumes from 5- to 10- and 20-ml boluses in a progression of increasing difficulty. If patients complete the nectar series without major symptoms of aspiration (cough and/or fall in oxygen saturation $\geq 3\%$), a less safe liquid viscosity series is assessed also with boluses of increasing difficulty (5, 10, 20 ml). Finally, a safer pudding viscosity series (5, 10, 20 ml) is assessed in the same way. If the patient presents signs of impaired safety at nectar viscosity, the series is interrupted, the liquid series is omitted and a safer pudding

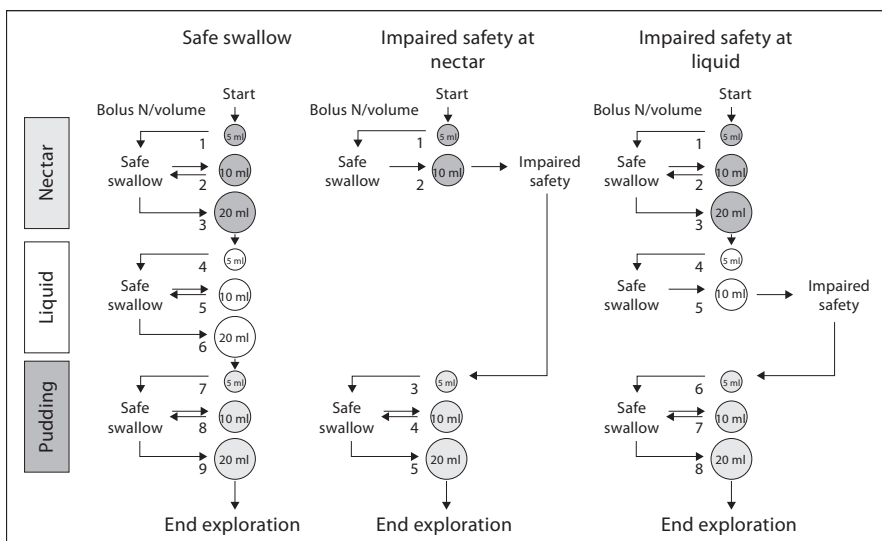


Fig. 1. V-VST short algorithm. Left diagram: patients with safe swallow completed the pathway. Middle diagram: representative pathway for patients with impaired safety at 10 ml nectar. Right diagram: representative pathway for patients with impaired safety at 10 ml liquid.

viscosity series is assessed, and if the pudding viscosity is safe and no residue is observed, pudding viscosity is recommended. If the patient presented signs of impaired safety at liquid viscosity, the liquid series is interrupted and the pudding series is assessed. In this case, the most effective volume of nectar viscosity is recommended.

Long Algorithm

Two additional viscosities can be added at the end of the short algorithm of the V-VST to evaluate the minimum amount of thickener needed to allow a safe and effective swallow. If the patient presents signs of impaired safety at nectar viscosity and the extreme spoon-thick viscosity is safe, a conservative spoon-thick series is assessed. If the patient presents signs of impaired safety at this viscosity, the exploration is interrupted and the extreme spoon-thick viscosity recommended, but if the patient completes the conservative spoon-thick series without major symptoms of aspiration, the honey viscosity is finally evaluated (fig. 2). The aim of the inclusion of these new two viscosity series is to optimize the viscosity needed and to enhance the compliance with the thickener treatment.

Viscosities

The short algorithm of V-VST was validated using a starch-based thickener (Resource ThickenUp, Nestlé Nutrition, Switzerland). The terms used, the amount of thickener necessary to add to 100 ml of water, viscosities obtained, and equivalences with the National Dysphagia Diet Task Force viscosities are shown in table 1. Moreover, the new generation of thickeners based on xanthan gum (Resource ThickenUp Clear, Nestlé Nutrition, Switzerland), can also be used to perform the V-VST; the necessary amount of thickener

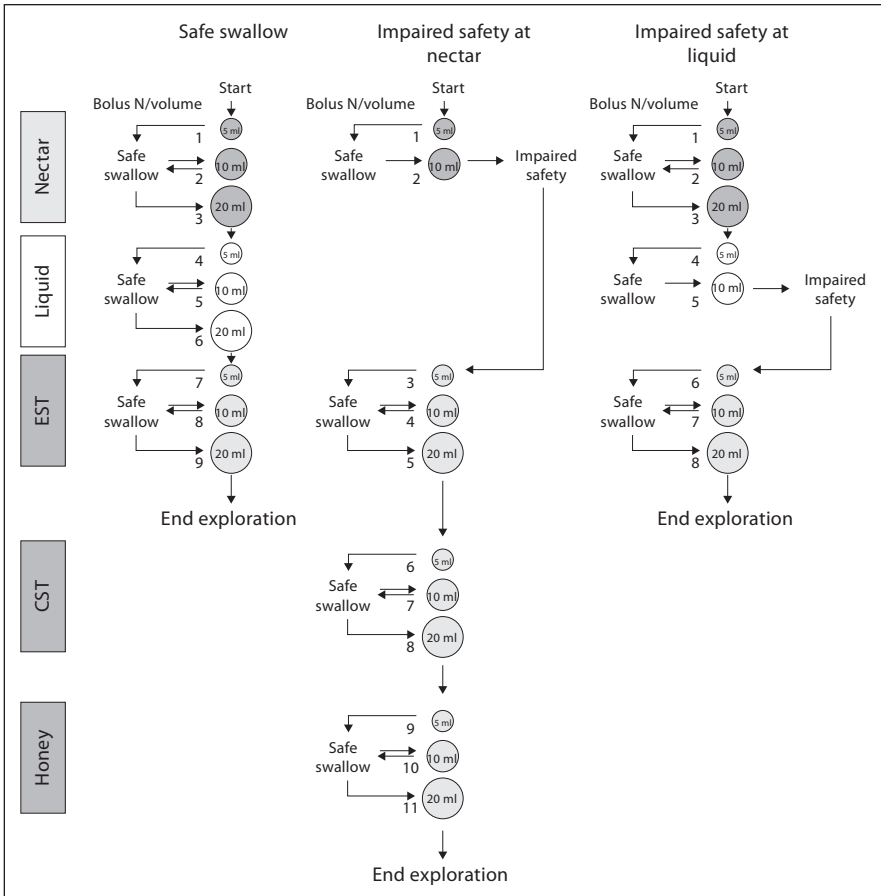


Fig. 2. V-VST long algorithm. Left diagram: patients with safe swallow completed the pathway. Middle diagram: representative pathway for patients with impaired safety at 10 ml nectar and safe swallow at EST viscosity. Right diagram: representative pathway for patients with impaired safety at 10 ml liquid. EST = Extreme spoon-thick; CST = conservative spoon-thick.

to develop the long V-VST algorithm, the viscosities obtained and equivalences with the National Dysphagia Diet Task Force viscosities are also shown in table 1.

Results

In the initial publication of the V-VST [7], 85 patients with OD were evaluated. The etiology of dysphagia of the patients studied was representative of the patients referred for a swallow study and included patients with neurological diseases, patients with neuromuscular degenerative diseases and patients with

Table 1. Equivalences with the National Dysphagia Diet Task Force viscosities, terms, quantity of thickeners and viscosities used in the short and long algorithms of the V-VST

National Dysphagia Diet Task Force		V-VST				
		Resource ThickenUp		Resource ThickenUp Clear		
	Viscosity mPa s		quantity	viscosity	quantity	viscosity
			g/100 ml water	mPa s	g/100 ml water	mPa s
Thin	1–50	Liquid	0	21	0	21
Nectar-like	51–350	Nectar	4.5	295	1.2	238
Honey-like	351–1,750	Honey	ND	ND	2.4	766
		Conservative spoon-thick	ND	ND	3.6	1,098
Spoon-thick	>1,750	Extreme spoon-thick	ND	ND	6	1,840
		Pudding	9	3,682	ND	ND

ND = Not determined.

head and neck diseases, including head and neck cancer, Zencker diverticulum and cricopharyngeal bars. Mean duration of clinical assessment of dysphagia by the V-VST was 5.54 ± 2.18 min. By means of the V-VST, the efficacy of swallow was evaluated, and we detected that at liquid viscosity, 4.7% of patients studied presented impaired lip closure, 15.3% piecemeal deglutition, 3.5% oral residue, and 15.3% pharyngeal residue. We also observed that with increased bolus volume and viscosity, the prevalence of piecemeal deglutition and oral and pharyngeal residue was increased. Safety of swallow was also assessed, and we detected that 50% of patients presented clinical signs of impaired safety of swallow (cough, changes in voice or a fall in oxygen saturation $\geq 3\%$) during 5-ml liquid bolus. In this study, up to 48% of patients with aspirations at VFS did not present cough (silent aspirators) and were clinically recognized by the V-VST by a fall in oxygen saturation $\geq 3\%$ and/or changes in voice after swallow. By means of the V-VST, we found that safety of swallow was significantly reduced by bolus volume and improved by increasing bolus viscosity. We also found in this study that the probability of a therapeutic effect (positive predictive value) from increasing viscosity to reduce penetrations and aspirations in patients identified by the V-VST was 98.9%.

The V-VST was also used to assess the prevalence of OD in independently living older persons (>70 years) [8]. Authors found that 27.2% of the 254 persons recruited presented signs of OD, 20.5% presented signs of impaired efficacy of swallow, and 15.4%, signs of impaired safety of swallow. The sensitivity and specificity of the test were used to estimate the prevalence of dysphagia in this population. The systematic application of the V-VST was also used to manage patients admitted with acute stroke to the neurology unit of the Hospital de Mataró [9]. We evaluated 98 consecutively admitted patients with the V-VST and found 60 (61.2%) presented signs of OD, 18.6% of the dysphagic patients presented signs of impaired safety of swallow, 20.3% signs of impaired efficacy, and 61.1% of them, both. Results of the V-VST were used to introduce compensatory dietary strategies based on the adaptation of viscosity and consistency of fluids and solids, to identify patients and risk of malnutrition (as dysphagia is a recognized cause of malnutrition in these patients), and to refer patients to speech language pathologists or to dietitians when appropriate to modify patients' diets, to make new assessments of swallow function if necessary, and to educate patients and caregivers about the dysphagia diet [9].

Discussion

The V-VST is a bedside screening method by which boluses of different volumes and viscosities are administered quickly, safely and accurately to screen for dysphagia in hospitalized and independently living patients with multiple etiologies. Moreover, the V-VST systematically evaluates clinical signs of safety and efficacy of swallow and detects patients with silent aspirations. The V-VST identifies patients who need further exploration by VFS and helps to select the ideal bolus volume and viscosity for liquids when a VFS study cannot be performed. The V-VST can be administered by any member of the multidisciplinary dysphagia team, facilitating the screening of dysphagia at all medical facilities and at any time of day, and can be repeated according the natural progression of the disease.

Previous to the publication of the V-VST method, Bours et al. [10] carried out a systematic review of the effectiveness and feasibility of bedside screening methods in detecting dysphagia in patients with neurological disorders. A form with nine items evaluating the validity, generalizability and reliability of studies was used to assess the methodological quality of the published studies, and 11 of them were considered to have sufficient quality. Using the same assessment, the V-VST study can also be classified as a study with 'good methodological quality' because just one item was not satisfied, item 2, as patients studied in the validation study of the VVST were referred for evaluation because they presented swallowing difficulties (table 2). Bours et al. [10], in their systematic review, recommend a water test combined with oximetry using coughing, choking and

Table 2. Items for the methodological assessment of the quality of studies assessing the quality of bedside screening tests for evaluation of swallowing

1. Were the reference test and the index test interpreted independently (blind)?	Yes
2. Was the index test applied independent of relevant information on clinical data of the patient regarding the target condition?	No
3. Was the reference test applied to all patients who received the index test?	Yes
4. Was the period between the reference test and the index test short enough to be reasonably sure that the target condition did not change between the two tests? (within 24 h in acute stroke, and within 7 days in other neurological diseases)	Yes
5. Was the selection of the study population valid?	Yes
6. Are data presented in enough detail to calculate appropriate test characteristics?	Yes
7. Was the study population appropriate to evaluate the proposed use of the index test?	Yes
8. Was the index test described in detail so it could be reproduced?	Yes
9. Were adequate definitions used for normal/abnormal reference test results and normal/abnormal index test results?	Yes

Adapted from Bours et al. [10]. Results of the evaluation of the V-VST.

voice alteration as the end points as the best method to screen patients for dysphagia. The water tests belong to the most extended and frequently used tests for dysphagia screening. They presented a sensitivity of 51–85% and a specificity of 66–75% to detect aspirations, and a sensitivity of 27–79% and specificity of 63–88% to detect impaired safety of swallow (penetrations or aspirations) [11–13]. These parameters are similar to the V-VST, but the water tests involve the continuous swallow of large amounts of water which may place the patient at risk of aspiration. Moreover, aspirations that occur without any clinical manifestation (silent aspirations) cannot be detected by water tests alone. This parameter is resolved with the combination of the water test with the monitoring of oxygen desaturation [14, 15]. However, the water tests do not assess any parameter related to the efficacy of swallow or evaluate the ability of patients to swallow different viscosities.

Like the V-VST, several tests have been developed using different viscosities and solids to evaluate aspiration and/or penetration. Sensitivity of these trials ranges from 41 to 100% and specificity from 57 to 82% [16–18]. Although these tests evaluate patients' ability to swallow material of different consistencies, if they are not combined with oxygen desaturation, silent aspirations can be lost.

Finally, Smith et al. [19] recommended a water test combined with oxygen saturation followed by bedside swallowing assessment with a variety of quantities and consistencies. This protocol showed a sensitivity of 80% and specificity of 68%, but the authors did not provide a detailed protocol for the swallow test and only acute poststroke patients were studied.

Conclusion

The V-VST combines good psychometric properties, feasibility, a detailed and easy to perform protocol, an algorithm designed to protect patients' safety, enough end points to evaluate the safety and efficacy of swallowing, and a system to detect silent aspirations. The V-VST detects patients who need a diagnostic study (VFS or FEES) or dietary modifications when the VFS study is not possible. We believe that the V-VST is an excellent clinical tool to screen patients for dysphagia. Patients with a positive test should undergo VFS for a full assessment of swallow function.

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