Accuracy of the volume-viscosity swallow test for clinical screening of oropharyngeal dysphagia and aspiration

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Abbreviations: OSR, oropharyngeal swallow response; VFS, videofluoroscopy; LV, laryngeal vestibule; V-VST, volume-viscosity swallow test; HV, healthy volunteers; GPJ, glossopalatal junction; UES, upper esophageal sphincter.

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Introduction

Oropharyngeal dysphagia is a major complaint among many patients with neurological diseases and among the elderly. The prevalence of functional oropharyngeal dysphagia is very high: it affects more than 30% of patients who have had a cerebrovascular accident, 52%–82% patients with neurodegenerative diseases, more than 35% patients with head and neck diseases, and more than 60% of elderly institutionalized patients. Oropharyngeal dysphagia may give rise to clinically relevant complications such as aspiration pneumonia, malnutrition and/or dehydration. When a decrease in deglutition safety occurs, choking and tracheobronchial aspiration results in pneumonia in 50% of cases, with an associated mortality of up to 50%. Impaired safety also limits the ability of patients to ingest all the calories and water that they need to be adequately nourished and hydrated. A 10-year review found the number of elderly patients with aspiration pneumonia increased 93.8% while other types of pneumonia in the elderly decreased. A recent resolution of the Council of Europe claimed that undernutrition among hospital stays, prolonged rehabilitation, and diminished quality of life, and identified oropharyngeal dysphagia as a major contributor to malnutrition. The current state of the art of oropharyngeal dysphagia management aims at early identification of patients at risk for aspiration, assessment of alterations in the biomechanical events of oropharyngeal swallow response (OSR), and prevention and treatment of the potential complications of dysphagia such as aspiration pneumonia and malnutrition.

Videofluoroscopy (VFS) is the gold standard method for studying the oral and pharyngeal mechanisms of dysphagia and for evaluating efficacy, and safety of swallow. VFS can identify the main signs of oropharyngeal dysfunction, which are delay in pharyngeal swallow, penetration of bolus into the laryngeal vestibule (LV), tracheobronchial aspiration and oropharyngeal residue, and can assess the short term effect of therapeutic strategies on dysphagic patients. Using this technique, we have recently shown that patients with neurogenic dysphagia presented high prevalence of impaired safety during liquid boluses and that increasing bolus viscosity to nectar and pudding viscosity exerted a strong therapeutic effect on safety of deglutition. In contrast, increasing bolus volume impaired safety during liquid boluses and that patients with neurogenic dysphagia presented high prevalence of impaired safety during liquid boluses and that increasing bolus viscosity to nectar and pudding viscosity exerted a strong therapeutic effect on safety of deglutition. In contrast, increasing bolus volume impaired safety of deglutition in these patients. High prevalence of dysphagia among vulnerable patients and the dynamic condition of this symptom according to the natural history of each disease makes it unfeasible to perform a VFS on every patient or to repeat VFS studies during disease evolution. Clinical screening methods with high diagnostic accuracy are, therefore, needed to recognize patients with oropharyngeal dysphagia, to identify patients at risk of aspiration and who should be referred for a VFS, and to help select the most appropriate bolus volume and viscosity for those patients who cannot easily undergo VFS.

This study was specifically designed to assess the diagnostic accuracy of a clinical bedside test, the volume–viscosity swallow test (V-VST), to predict signs of dysphagia and impaired safety of deglutition (penetration, aspiration) observed during VFS studies, and to identify patients whose deglutition could be improved by increasing bolus viscosity. To that end we studied patients with prevalent conditions causing dysphagia such as old age, neurological diseases and head and neck diseases.

Material and methods

Sample

The study population included two main groups of participants: Group 1 were healthy volunteers (HV) (n = 12) to assess normal swallow physiology (Table 1) and Group 2 were patients with oropharyngeal dysphagia (n = 85). We studied 85 consecutive patients with swallowing difficulties whom we received for evaluation between January and December 2006. Demographic information of the study patients is shown in Table 1. Our study included (a) 40 elderly patients of whom 23 had cerebrovascular disease; 8, chronic pneumopathy; 2, diabetes and 7, other geriatric diseases; (b) 24 patients with neurodegenerative diseases of whom 7 had amyotrophic lateral sclerosis; 4, multiple sclerosis; 2, Parkinson’s disease; 2, Alzheimer’s disease; 2, Huntington’s disease; 2, Duchenne muscular dystrophy and 5, other neurodegenerative diseases, and (c) 21 patients with head and neck diseases of whom 4 had Zenker’s diverticulum or cricopharyngeal bars, and 16 patients had undergone previous surgery, 4 oral, 2

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Age and sex of patients with oropharyngeal dysphagia and healthy volunteers included in the study (*p &lt; 0.05 vs healthy volunteers, †p &lt; 0.05 vs elderly patients)</th>
</tr>
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<tr>
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<tr>
<td>Patients with dysphagia</td>
<td>85</td>
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<tr>
<td>Elderly patients</td>
<td>40</td>
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<td>Neurodegenerative diseases</td>
<td>24</td>
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<td>Head and neck diseases</td>
<td>21</td>
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Conclusions: The V-VST is a sensitive clinical method to identify patients with dysphagia at risk for respiratory and nutritional complications, and patients whose deglutition could be improved by enhancing bolus viscosity. Patients with a positive test should undergo videofluoroscopy.

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pharyngeal, and 10 laryngeal, one-third of these patients with head and neck diseases had undergone tracheotomy. Protocol studies were approved by the Institutional Ethical Committee of the Hospital de Mataró (Mataró, Spain).

**Experimental design**

Patients and HV were screened with the V-VST for clinical signs of oropharyngeal dysphagia and aspiration; and given a VFS of swallow to assess VFS signs of safety and efficacy of deglutition,\(^\text{7,8}^\) OSR,\(^\text{8,10}^\) and the effect of bolus volume and viscosity.\(^\text{8}^\) Clinical and videofluoroscopic studies were conducted on the same day starting with the V-VST (performed by VA and MR) and followed by the VFS (performed by PC and LM), blind to the clinical results. The main aim of the study was to assess the diagnostic sensitivity and specificity of the V-VST taking the results of the VFS of swallow study as the gold standard.

**Measurement of bolus viscosity and volume**

Similar bolus volumes (5 mL, 10 mL and 20 mL) and viscosities (liquid, nectar and pudding) were used for the V-VST and VFS studies. Bolus viscosity was measured by a rotational viscosimeter (Haake VT5000, Thermo Electron GmbH, Karlsruhe, Germany) in mPa.s at 25°C. For V-VST studies, liquid viscosity was obtained by using mineral water at room temperature (21.61 ± 0.21 mPa.s), nectar viscosity by adding 4.5 g of the thickener Resource ThickenUp (Novartis Consumer Health SA, Barcelona, Spain) to 100 mL mineral water (295.02 ± 25.91 mPa.s), and pudding by adding 9 g—100 mL mineral water (3682.21 ± 223.20 mPa.s) (n = 12). For VFS studies, liquid viscosity (20.40 ± 0.23 mPa.s) was obtained by mixing 1:1 mineral water and the X-ray contrast Gastrografin (Berlimed SA, Madrid, Spain) both at room temperature, nectar viscosity (274.42 ± 13.14 mPa.s) by adding 3.5 g of thickener Resource ThickenUp (Novartis Consumer Health SA, Barcelona, Spain) to liquid solution and pudding viscosity (3931.23 ± 166.15 mPa.s) by adding 8 g of the thickener (n = 12). Solutions were prepared 10 min prior to measurement. Boluses of 5 mL, 10 mL, and 20 mL of each viscosity series were offered to patients with a syringe during V-VST and VFS studies to ensure accurate measurement of bolus volume.\(^\text{8}^\)

**Clinical assessment of dysphagia by the volume—viscosity method**

Clinical assessment of dysphagia was conducted by expert swallow therapists (VA, MR). The aim of the V-VST is to identify clinical signs of impaired efficacy of swallow,\(^\text{11}^\) such as impaired labial seal, oral or pharyngeal residue, and piecemeal deglutition (multiple swallows per bolus), and clinical signs of impaired safety during swallow such as changes in voice quality (including wet voice), cough or a decrease in oxygen saturation ≥3% measured with a finger pulse-oximeter (Nellcor OxiMax, Philips Medical Systems, Eindhoven, Netherlands) to detect silent aspirations.\(^\text{12,13}^\) The probe of the pulse-oximeter was placed on the index finger of the right hand and baseline readings were obtained 2 min prior to starting the test. Cough and/or fall in oxygen saturation ≥3% were considered major clinical signs of tracheobronchial aspiration.\(^\text{12}^\) The volume—viscosity method is an effort test in which boluses of increasing volume and difficulty are administered to check for clinical signs of impaired efficacy and safety in each swallow (Fig. 1). In addition the V-VST examines whether patient’s swallow efficacy and safety is improved by increasing viscosity. The V-VST was designed to protect patients from aspiration by starting with nectar viscosity and increasing volumes from 5 mL to 10 mL and 20 mL boluses in a progression of increasing difficulty (Fig. 1A). When patients completed the nectar series without major symptoms of aspiration (cough and/or fall in oxygen saturation ≥3%), a less safe liquid viscosity series was assessed also with boluses of increasing difficulty (5 mL to 20 mL). Finally, a safer pudding viscosity series (5 mL–20 mL) was assessed in the same way (Fig. 1A). If the patient presented signs of impaired safety at nectar viscosity, the series was interrupted, the liquid series was omitted, and a more safe pudding viscosity series was assessed (Fig. 1B). If the patient presented signs of impaired safety at liquid viscosity, the liquid series was interrupted and the pudding series was assessed (Fig. 1C). All clinical explorations including oxygen saturation measurements were filmed with a digital video camera (DVR-PC100E, Mini DV, Sony Corporation, Tokyo, Japan) and recorded for objective review.

**Diagnosis of videofluoroscopic signs**

Subjects were studied in a lateral projection and images included the oral cavity, pharynx, larynx, and cervical esophagus.\(^\text{8,10}^\) VFS recordings were obtained by using a Super X T-20 Toshiba Intensifier (Toshiba Medical Systems Europe, Zoetermeer, Netherlands) and images were recorded at 25 frames/sec (Panasonic AG DVX-100B, Matsushita Electric Industrial Co., Ltd., Osaka, Japan). Swallows were analyzed by equipment (Swallowing Observer, Image & Physiology SL, Barcelona, Spain) developed to capture and digitize the swallowing sequences to assess VFS signs according to accepted definitions.\(^\text{7,8,11}^\) and to measure the OSR.\(^\text{8,10}^\) Penetration was defined as the entrance of swallowed material into the LV, and aspiration as the passage of this material below the vocal folds.\(^\text{7,8,10}^\) During VFS studies, we used the same strategy to protect patients from aspiration and the same bolus volume and viscosity as in the clinical assessment by the V-VST (Fig. 1).

**Measurement of OSR**

Measurements of oropharyngeal reconfiguration during OSR were obtained during 5 mL nectar swallows because all patients swallowed this bolus. Timing of the opening or closing events occurring at the glossoptalatal junction (GPJ), velopharyngeal junction, LV, and upper esophageal sphincter (UES) were measured, GPJ opening being given the value of Time = 0 (Fig. 2).\(^\text{8,10}^\) Overall duration of OSR (GPJ opening – LV opening) and speed of oropharynx reconfiguration from a respiratory to digestive pathway (GPJ opening - LV closure) were determined (Fig. 2). Patients with dysphagia were
classified into those with safe deglutition and those with impaired safety (penetration or aspiration).  

Data analysis and statistical methods

Quantitative parameters were described by median (age) or mean ± S.E.M (physiological values), and comparisons were assessed by the non-parametric Kurskal–Wallis and Mann–Whitney tests. Qualitative parameters were described by frequencies. Safety and efficacy of deglutition were assessed by prevalence of clinical or VFS signs. The effect of bolus volume and viscosity increments on safety and efficacy parameters was assessed by the non-parametric Cochran Q test, which compares multiple related proportions. When this test gave significant results, combinations of two paired proportions were compared by the McNemar test. The same methodology was used for clinical and VFS signs.  The results for each group of patients with safe or unsafe swallow and those of healthy subjects were compared against each group using Student’s t-test for variables with normal distribution and the Mann–Whitney U test for variables without normal distribution. Sensitivity, specificity, and positive and negative predictive values of the clinical signs were calculated to assess the diagnostic accuracy of all clinical signs or symptoms in predicting both videofluoroscopic aspiration and penetration (considered the gold standard).  

Results

Demographics

Median age of all three groups of patients with dysphagia was higher than that of HV (Table 1). Our group of patients with oropharyngeal dysphagia included middle-aged patients with neurodegenerative diseases and elderly patients with cerebrovascular disease, geriatric diseases, or head and neck diseases (p < 0.05).

Clinical signs of oropharyngeal dysphagia by the volume–viscosity test

HV
All volunteers presented a safe and efficacious swallow.

Patients with oropharyngeal dysphagia
Mean duration of clinical assessment of dysphagia by the V-VST was 5.54 ± 2.18 min. Piecemeal deglutition was observed in up to 15.3% patients during liquid series, 25.9% patients during nectar series and 30.6% patients at pudding viscosity (p < 0.05, Fig. 3). Oral residue was observed in only 3.5% patients during liquid series and was significantly enhanced to up to 10.6% patients during nectar series and 12.9% patients at pudding viscosity (p < 0.05 vs liquid series). Symptoms of pharyngeal residue...
were recorded in up to 15.3% patients during liquid series, and significantly enhanced to up to 45.9% patients during nectar series and 56.6% patients at pudding viscosity (p < 0.05) (Fig. 3). Prevalence of patients with safe swallow is also represented in Fig. 3. Clinical signs of impaired safety of swallow (Table 3) were observed in 50%–75.3% patients during liquid series, 23.4%–39.2% patients during nectar series and 14.5%–27.6% patients at pudding viscosity (p < 0.05), and were significantly increased by bolus volume in each viscosity series (p < 0.05).

**Videofluoroscopic signs of oropharyngeal dysphagia**

**HV**

All volunteers presented a safe and efficacious swallow.

**Patients with oropharyngeal dysphagia**

Piecemeal deglutition was observed in 10.6%–17.6% of patients during 5 mL swallows, 21.2%–27.1% patients during 10 mL swallows, and 24.7%–36.5% patients during 20 mL swallows (p < 0.05) and was unaffected by bolus volume.

![Figure 2](image)

Figure 2: VFS recordings of 5 mL nectar swallow in: (A) healthy subject; (B) patient with dysphagia, safe swallow, and impaired efficacy (note the residue in vallecula and pyriform sinus), and (C) patient showing an aspiration into the airway as the bolus traverses the vocal cords and enters the trachea. Diagrams at the bottom of each tracing show means of temporal events at glosso-palatal junction -1-, velopharyngeal junction -2-, laryngeal vestibule -3-, and upper esophageal sphincter -4- in the following groups of subjects: (a) HV; (b) patients with dysphagia and safe swallow, and (c) patients with dysphagia and impaired safety; white dot in diagram C represents timing of laryngeal penetration and the red point, time of aspiration.

![Figure 3](image)

Figure 3: Prevalence of clinical signs of safety and efficacy of pharyngeal phase of swallowing for each bolus volume and viscosity during the V-VST. All patients with oropharyngeal dysphagia are pooled and HV are not shown. Safety of swallow was expressed as the percentage of patients that could swallow without clinical signs of cough, changes in voice, or a fall in oxygen saturation ≥3%. *p < 0.05 effect of increasing bolus volume; #p < 0.05 vs liquid viscosity.
viscosity. Prevalence of patients with oral residue was low (Fig. 4). In contrast, pharyngeal residue was a common VFS sign in patients with dysphagia. Impaired vallecular clearance was observed in 30.6% of patients during liquid series, 38.8% during nectar series and increased to 48.2% at pudding viscosity (p < 0.005). Similarly, residue in the pyriform sinus was observed in 29.4% of patients during liquid series, 34.1% during nectar series and increased to up to 44.7% at pudding viscosity (p < 0.005). Thereafter, pudding viscosity significantly increased pharyngeal residue (Fig. 4). Penetration into the LV during the pharyngeal phase was the most prevalent cause of unsafe deglutition and was observed in 37.6%–45.9% of patients when swallowing liquid boluses and 24.7%–35.3% during nectar series. Increasing bolus volume to pudding significantly reduced the prevalence of patients with laryngeal penetration to less than 14.1% (p < 0.05). More than 80.6% patients presented safe swallow at pudding viscosity, a proportion that was reduced to 52.1% during nectar series (p < 0.05) and further reduced to 32.9% at liquid viscosity (Fig. 4) (p < 0.05). Increasing bolus volume significantly impaired safety of swallow at liquid and nectar viscosity (Fig. 4).

Oropharyngeal swallow response

OSR in HV
Total duration of swallow response (GPJ opening-LV opening) for 5 mL boluses was short (<760 ± 2 ms). Reconfiguration of the oropharynx from a respiratory to a digestive pathway was very fast: (a) time taken to close airway entrance at the LV was ≤157 ± 1 msec and time to open the UES was ≤200 ± 1 msec (Fig. 2A).

OSR in patients with oropharyngeal dysphagia
Total duration of the OSR in patients with dysphagia and safe swallow was 1064 ± 4 ms, significantly longer than in HV (p < 0.05). The reconfiguration phase was also longer in patients compared with HV as time to LV closure in patients with safe swallowing was 302 ± 2 ms (p < 0.05 vs HV), and time to UES opening was 360 ± 2 ms (p < 0.05 vs HV, Fig. 2B). Patients with impaired safety (penetration or aspiration) presented a total OSR duration of 1162 ± 7 ms and even a more severe delay in LV closure (541 ± 6 ms, p < 0.05 vs patients with safe swallow and HV) and UES opening (410 ± 4 ms, p < 0.05 vs patients with safe swallow and HV, Fig. 2C). These results show that patients with oropharyngeal dysphagia presented slow oropharyngeal reconfiguration which correlates with impaired safety of swallowing (Fig. 2).

Diagnostic accuracy of the V-VST

Table 2 summarizes the measurements of diagnostic accuracy (sensitivity, specificity, and predictive values) of clinical signs of impaired safety and efficacy of swallowing. Main results show that diagnostic sensitivity and specificity of the V-VST for clinical signs of impaired safety of swallow (aspiration or penetration) were 88.2% and 64.7% respectively. A very important result was that the sensitivity of the V-VST was 100% in recognizing patients with aspiration confirmed by VFS. Following a negative V-VST, the probability of no aspiration (negative predictive value) was also 100%, and the probability of no penetration was 57.9%. On the other hand, specificity (probability of a negative result when the disease is absent) of the V-VST was low in the diagnosis of aspiration as a specific disorder, but achieved 64.7% (which means a false positive rate of 35.3%) if penetration was also considered a sign of impaired safety of swallow (Table 3). Overall, 25 patients presented aspiration during VFS studies and the V-VST identified clinical signs of impaired safety of swallow in all these patients. Table 3 shows no differences on basal oxygen saturation among patients with/without impaired safety at VFS. Up to 48% of patients with aspiration at VFS (14.1% of all patients with dysphagia) did not present cough (silent aspirators) and were clinically recognized by a fall in oxygen saturation ≥3% and/or changes in voice after swallow. One-third of patients with silent aspirations

Figure 4 Prevalence of VFS signs of safety and efficacy of pharyngeal phase of swallowing for each bolus volume and viscosity during VFS studies. All patients with oropharyngeal dysphagia are pooled and HV are not shown. Safety of swallow was expressed as the percentage of patients that could swallow without signs of contrast entering the LV or traversing the vocal folds for each bolus volume and viscosity. *p < 0.05 effect of increasing bolus volume; #p < 0.05 vs liquid viscosity, |p < 0.05 vs nectar viscosity.
showed oxygen desaturation during swallow. Finally, sensitivity of the V-VST in selecting patients whose safety of swallow could be improved by increasing bolus viscosity was 84.6%, specificity was 73.4% and the probability of a therapeutic effect of viscosity (positive predictive value) reducing penetrations and aspirations in a patient identified by the V-VST was 89.9%.

Discussion

Our study found high prevalence of videofluoroscopic signs of impaired safety and efficacy of swallow indicating high risk of severe respiratory and nutritional complications in a group of hospitalized patients with oropharyngeal dysphagia. We also found that most of these patients at risk of complications could be quickly, safely and accurately recognized by using a clinical bedside method we have developed as the V-VST that systematically evaluates the main clinical signs and symptoms of safety and efficacy of swallowing and monitors pulse oximetry to improve the detection of patients with silent aspirations. Our study also shows that patients identified by a positive V-VST as presenting impaired safety of swallowing should be referred for a VFS study to assess the severity, the physiopathology and potential treatment of the swallowing disorder.

Dysphagia is a highly prevalent condition among vulnerable patients admitted to a general hospital with neurological or neurodegenerative diseases, head and neck diseases, and among the elderly.\(^\text{1,6}\) Data from all these patients were pooled in our analysis because they share many characteristics of the clinical complaints, pathophysiology, and risk of nutritional and respiratory complications caused by oropharyngeal dysphagia, as we found in our previous studies.\(^\text{2,3,6,8}\) In the present study we found the swallow response was severely impaired in patients with dysphagia. Overall duration of swallow response in patients was significantly longer than in HV mainly due to delay in the timing of the early phase of oropharyngeal reconfiguration from a respiratory to a digestive pathway. Our results on the prevalence of VFS signs and impaired swallow response agree with previous studies in neurological and elderly patients by our group\(^\text{8}\) and other authors.\(^\text{10,29}\) After a stroke, dysphagia may persist in some patients for many months increasing the risks of chest infection, malnutrition, dehydration and mortality.\(^\text{15–17}\) One-third of all stroke patients develop aspiration pneumonia which is the first cause of death in stroke patients after hospital discharge.\(^\text{1,16}\) Dysphagia in patients with neurodegenerative diseases causes suboptimal caloric and fluid intake and high risk for pneumonia.\(^\text{18,19}\) In a previous VFS study on patients with neurogenic dysphagia we found high prevalence (21%) of aspiration, and malnutrition (24.1% according to SGA B or C, or weight loss >10%), with a strong correlation between severity of dysphagia and malnutrition.\(^\text{6}\) We also recently found that prevalence of malnutrition (MNA < 17 in 33%), aspiration pneumonia, disability, morbidity and mortality was significantly higher in older patients with dysphagia.\(^\text{20}\)

Screening for oropharyngeal dysphagia should be low risk, quick, and low cost and aim at identifying the highest risk patients for further assessment. The consequence of a false-negative diagnosis of patient with oropharyngeal aspiration can lead to aspiration pneumonia and the death of the patient. There is evidence that implementation of dysphagia programmes, including screening,\(^\text{21}\) results in substantial reductions in pneumonia rates\(^\text{22}\) and improvement in nutritional status.\(^\text{23}\) Other authors suggest, however, that clinicians cannot detect dysphagia, aspiration and abnormal swallow physiology by clinical exploration.\(^\text{11,24}\) Current methods for clinical screening of dysphagia are the water swallow test,\(^\text{25}\) the 3 oz water test developed in the Burke Rehabilitation Center,\(^\text{9}\) the timed swallow test,\(^\text{26}\) and the standardized bedside swallow assessment.\(^\text{21,27}\) These existing screening tests involve continuous swallowing of quite large amounts of liquid and may place the patient at high risk for aspiration.\(^\text{11}\) and almost all methods have been validated only on patients with dysphagia caused by stroke.\(^\text{9,12,13,15,16,21,22,27,28}\) Limiting the application of these tests on patients with dysphagia caused by other diseases. Patients were asked to drink 50 mL,\(^\text{25}\) 3 oz,\(^\text{9}\) 150 mL,\(^\text{26}\) or 60 mL\(^\text{21,27}\) water from a glass without interruption, and coughing during or after completion or the presence of a post-swallow wet-hoarse voice quality, or swallow speed of less than 10 mL/sec were scored as abnormal. In the present study, up to 80.6%

| Table 2 | Sensitivity, specificity and predictive values (PV) of the volume—viscosity swallow test (V-VST) in patients with dysphagia |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Sensitivity (%) | Specificity (%) | Positive PV (%) | Negative PV (%) |
| Impaired safety | 88.2            | 64.7            | 90.9            | 57.9            |
| Aspiration      | 100             | 28.8            | 28.8            | 100             |
| Penetration     | 83.7            | 64.7            | 87.2            | 57.9            |
| Oral residue    | 69.2            | 80.6            | 39.1            | 93.5            |
| Pharyngeal residue | 86.4          | 34.6            | 75.0            | 52.9            |
| Piecemeal deglutition | 88.4        | 87.5            | 96.8            | 63.6            |

| Table 3 | Results of the volume—viscosity swallow test (V-VST) according to videofluoroscopy (VFS) findings |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| VFS             | Basal O. Sat.\(^a\) (%) | Cough (%) | Voice change (%) | Desaturation by ≥3% (%) |
| Safe swallow    | 98.13 ± 2.55     | 14            | 36.4            | 0               |
| (n = 22)        |                 |               |                 |                 |
| Penetration     | 97.86 ± 2.49     | 15.8          | 60.5\(^*\)      | 13.1\(^*\)      |
| (n = 38)        |                 |               |                 |                 |
| Aspiration      | 97.15 ± 2.67     | 52\(^*\)       | 56\(^*\)        | 36\(^*\)        |
| (n = 25)        |                 |               |                 |                 |

Results are expressed as % of patients presenting each clinical sign.
\(^*p < 0.05\) vs patients with safe swallow, and \(\#p < 0.05\) vs patients with penetration.
\(^a\) Indicates basal oxygen saturation.
patients could safely swallow pudding boluses; 52.1%, nectar boluses, and only 32.9% patients presented safe swallow of liquids, further confirming the high risk of liquids and the therapeutic effect of bolus viscosity. For this reason we developed the V-VST as a simple and quick (mean duration <6 min) swallow effort test by starting with a safe (nectar) viscosity and low volume (5 mL) bolus and increasing bolus volume in a progression of increasing difficulty. Liquids were only assessed if the patient presented a safe swallow at nectar thereby protecting patients from aspiration. In addition, up to 48% patients with aspirations observed in this and our previous VFS studies did not present cough following aspiration so we added pulse oximetry to the V-VST to help to identify these patients. We found both oximetry and changes in voice quality after swallow as markers of impaired safety clearly increased the diagnostic sensitivity of V-VST and the probability of identifying patients with silent aspirations or bolus penetration into the LV.

In many European hospitals there is a big discrepancy between the high prevalence, morbidity, mortality and costs caused by complications of oropharyngeal dysphagia and the low level of resources dedicated to dysphagic patients. In contrast, there is strong evidence that clinical bedside methods can detect dysphagia, although with differing diagnostic accuracy. The Burke’s 3-oz water swallow test identified 80% of patients aspirating during subsequent VFS examination (sensitivity 76%, specificity 59%). The standardized bedside swallow assessment showed a variable sensitivity (47%–68%) and specificity (67%–86%) for aspiration detection when used by speech-swallow therapists and doctors. We presented here a safe, quick and accurate clinical method (V-VST) with 88.2% sensitivity for impaired safety, 100% sensitivity for aspiration and up to 88.4% sensitivity for impaired efficacy of swallow. It is well known that diagnostic procedures with high rates of correct identification of aspirators usually have high rates of false positive results too; that is, they over-identify patients with less severe alterations of safety (penetrations) as aspirators. 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), our V-VST method has been designed to favour diagnostic sensitivity. The high negative predictive value of our clinical test also suggests that a patient with a negative V-VST does not need any further assessment for aspiration; in contrast we recommend further assessment by VFS studies in patients with V-VSTs showing any clinical sign of impaired safety to assess its severity and pathophysiology (Fig. 5). Finally, the V-VST can also help select the most appropriate bolus volume/viscosity for patients with difficult access to VFS studies because the probability of a proved therapeutic effect of viscosity in a patient identified by the V-VST is very high.

Diagnosis and management of oropharyngeal dysphagia need a multidisciplinary approach. Fig. 5 shows the algorithm of diagnosis and treatment of oropharyngeal dysphagia at our hospital. The V-VST is widely applied by nurses, dietitians and speech-swallow therapists. Future studies using V-VST on patients with malnutrition and pneumonia will clarify the relevance of dysphagia in these diseases and the clinical utility of the diagnostic method we have designed to avoid further complications and help

![Figure 5](https://example.com/fig5.png)
to select treatment. Patients with dysphagia need specific dietary adjustments. A recent resolution of the Council of Europe on food and nutritional care in hospitals recommended the development of dietary management as well as national guidelines for texture modification, texturized menus and patient and family education on dysphagia. We recommend routine assessment for oropharyngeal dysphagia by the V-VST for all patients at risk admitted to general hospitals as the first step in this process.

Conflict of interest statement

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Statement of authors

VA and MR carried out the clinical studies with the V-VST and measured the swallow response. PC and LM performed the VFS studies. EP and MSP performed the statistical analysis. PC developed the V-VST and the study, and drafted the manuscript. All authors read and approved the final manuscript.

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