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Original article

Utility of the modified Volume-Viscosity Swallow Test for bedside screening of dysphagia in critically ill patients☆

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SUMMARY

Background and aim: Aspiration and dysphagia are frequent in critically ill patients, and evidence of the validity of bedside screening tests is lacking. This study evaluated the modified Volume-Viscosity Swallow Test (mV-VST) as a screening tool for aspiration and dysphagia in intensive care unit patients.
Methods: An observational, prospective longitudinal cohort single-center study included patients older than 18 years old, on mechanical ventilation for at least 48 h, conscious and cooperative. Patients had been admitted in intensive care between March 2016 and August 2019 at a university hospital in Spain. Data from the mV-VST and the flexible endoscopic evaluation of swallowing (FEES) test in extubated and tracheostomized patients were collected; the ROC curve was obtained for each group, and the sensitivity (Se), specificity (Sp), positive (pPV) and negative (nPV) predictive values of mV-VST were calculated and compared with the FEES results. We calculated percentages and 95% confidence intervals (CI) for qualitative variables and means or medians for quantitative variables according to the Shapiro-Wilk test. A univariate analysis identified dysphagia risk factors in each group.
Results: The study included 87 patients: 44 extubated and 43 tracheostomized with similar age, body mass index, Sequential Organ Failure Assessment, Charlson comorbidity index, type and reason for admission. Aspiration with FEES was significantly higher in extubated patients than in tracheostomized patients, 43.2% vs. 23.2%, respectively, $p = 0.04$. With the mV-VST, aspiration was detected in 54.5% of extubated patients and in 39.5% of tracheostomized patients. In the extubated group, the Se of mV-VST to detect aspiration was 89.5%, Sp was 72%, and nPV was 90%. In the tracheostomized group, Se was 100%, Sp was 78.8%, and nPV was 100%. The ROC curve showed that mV-VST similarly identifies aspiration in extubated and tracheostomized patients.
Conclusions: Dysphagia and aspiration are frequent amongst patients in intensive care after mechanical ventilation. The mV-VST is a valid screening tool to detect aspiration and dysphagia in extubated and tracheostomized patients.

Background

Across Europe, critically ill patients in intensive care units (ICU) tend to be slightly older and more severely ill over the years [1]. Alongside old age and disease severity, ICU admission is one of the most important risk factors for dysphagia [2]. Dysphagia comprises the inability to safely swallow liquid and/or solid elements with an abnormal delay in transferring food from the oropharynx to the stomach [3,4], caused by structural or functional impairment of one

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Abbreviations

APACHE	Acute Physiology and Chronic Health Evaluation
ARDS	Adult respiratory distress syndrome
BMI	Body mass index
CI	Confidence interval
CRRT	Continuous renal replacement therapy
FEES	Fiberoptic endoscopic evaluation of swallowing
ICU	Intensive care unit
ICUAW	ICU-acquired weakness
IMV	Invasive mechanical ventilation
MRC	Muscle power assessment
mV-VST	Modified Viscosity Volume Swallowing Test
nPV	negative predictive value
ns	Not significant
NUTRIC	Nutrition risk in the critically Ill
PED	Postexturbation dysphagia
pPV	positive predictive value
ROC	Receiver operating characteristic
Se	Sensitivity
SOFA	Sequential organ failure assessment
Sp	Specificity
VFSS	Videofluoroscopic swallowing study
V-VST	Volume-Viscosity Swallow Test

or more of the swallowing phases [5]. It may result in aspiration and subsequent complications, including pneumonia, chemical pneumonitis, atelectasis, bronchospasm, hypoxemia [6], and increases the probability of malnutrition, significantly compromising ICU patients' clinical status [7]. Dysphagia is an independent predictor of 28- and 90-day mortality in the ICU [8].

Around 40% of patients suffer from postextubation dysphagia (PED) after mechanical ventilation [9]. Silent, non-diagnosed aspiration concerns 36% [95% confidence interval (CI): 0.22 to 0.50] of PED patients [9]. PED is not routinely screened; therefore, it is poorly recognized as a healthcare problem in the ICU [6]. The early identification of PED is necessary for the safe use of oral route in these patients [7,9,10].

Tracheostomy is widely used in ICU patients with complex respiratory conditions to secure an unobstructed and accessible airway to maintain adequate ventilation, oxygenation, and management of respiratory secretions [11]. The increased risk for swallowing disorders, aspiration, and silent aspiration is due to the underlining disease of these patients and not to the tracheostomy itself [12,13].

Multiple bedside tests are available for the screening of dysphagia [14], including the Volume-Viscosity Swallow Test (V-VST) (2008) [15]. The V-VST is a strength test that uses boluses of different volumes and viscosities to identify clinical signs of impaired efficacy and safety of swallow (piecemeal deglutition, residue, cough, voice changes, and oxygen desaturation $\geq$3%) [16]. The V-VST screens and assess the prevalence and complications of oropharyngeal dysphagia in diverse clinical conditions, but with limited evidence in ICU patients [17–19]. The V-VST is an excellent tool with solid psychometric properties, an easy protocol, and valid endpoints to detect silent aspirations and assess the safety and efficacy of swallowing [17,20]. In the modified Volume-Viscosity Swallow Test (mV-VST), patients start with nectar, then pudding, and finally liquids if swallowing is safe [21]. The flexible endoscopic evaluation of swallowing (FEES) is one of the most commonly used methods for the objective assessment of swallowing, together with the videofluoroscopic swallow study (VFSS) [21,22]. The effective management of oropharyngeal secretion and the efficacy of the clearing mechanisms, such as coughing and throat clearing, can be assessed simply and directly with the FEES [22]. Like the mV-VST, the FEES can be carried out at the bedside. However, bedside examinations may lack sufficient sensitivity to be used for screening purposes in the ICU [14,22,23]. Most studies were conducted in post-stroke adults [17,18], limiting the generalization of results to the clinically diverse population of an ICU [8,14,16].

This study evaluated the validity of the mV-VST at the bedside for the screening of aspiration in critically ill ICU patients, comparing extubated and tracheostomized individuals. The secondary objectives were the incidence of dysphagia using FEES and the risk factors for aspiration and dysphagia. An exploratory objective was the prevalence of dysphagia at 30 and 60 days after hospital discharge.

Methods

Study design

This was an observational, prospective longitudinal cohort single-center study designed to validate mV-VST to diagnose dysphagia in extubated and tracheostomized ICU patients. Validation was made comparing mV-VST with the FEES (the gold standard test).

Recruitment and study population

Patients admitted to the ICU at the Germans Trias i Pujol tertiary university hospital (Badalona, Barcelona, Spain) between 1st March 2016 and 31st august 2019 were consecutively recruited. The inclusion criteria were patients older than 18 years with invasive mechanical ventilation (IMV) for at least 48 h, presenting normal state of consciousness and be cooperative at the time of the FEES and the mV-VST. Patients with previous dysphagia and those who did not consent to participate in the study were excluded.

Study assessments

The mV-VST was carried out by a trained nurse and the FEES by a trained team of otorhinolaryngologists; both tests were conducted at patients' bedside within 24 h. The nurse did not have access to the FEES results and the otorhinolaryngologists did not have access to the mV-VST results. FEES and mV-VST were conducted within 24 h after extubating the patient without a pre-established order. In tracheostomized patients, FEES and mV-VST were carried out in patients disconnected from mechanical ventilation for at least 6 h with a fenestrated cannula, fenestrated sleeve, and deflated cuff.

Before starting FEES and mV-VST, extubated patients were asked to say their names to identify the tone of their voices. In tracheostomized patients, changes in the tone of their voices could not be assessed despite carrying out both tests with the tracheostomy cuff deflated.

The mV-VST is based on swallowing nectar, pudding, and liquid viscosities [21,24] prepared by mixing mineral water with a thickener indicated by the manufacturer; in this study, patients received the thickener Nutilis Clear® (Nutricia) [25]. The mV-VST began with the nectar viscosity (Fig. 1). Increasing volumes of 5, 10, and 15 ml were consecutively placed in the patient's mouth with a 50 ml syringe. In the original V-VST, the third bolus is 20 ml; however, in this study the bolus was reduced to 15 ml to help patients manage the volume considering that they had not received any liquid or

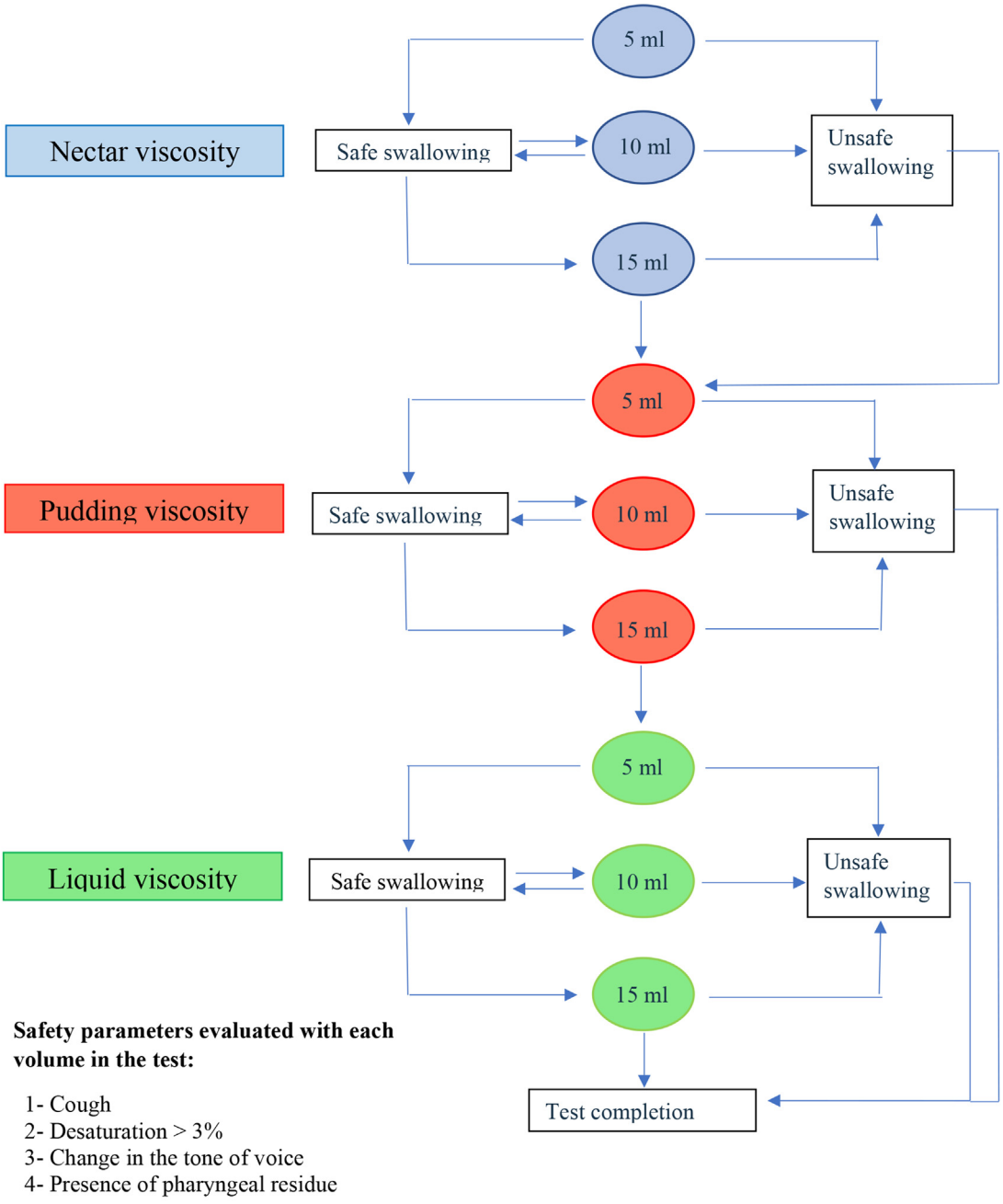


Fig. 1. Scheme used to carry out the modified Volume-Viscosity Swallow Test.

solid by oral route for several days. As recently described [26], viscosities were stained with blue food coloring to visualize pulmonary aspiration and easily differentiate cough due to pulmonary secretions from bronchial aspiration, especially in tracheostomized patients.

Four safety parameters were assessed with each viscosity: (1) presence of cough; (2) desaturation >3%; (3) change in the tone of voice by asking the patients to repeat their names; and (4) presence of pharyngeal residue by asking the patients whether they have the sensation of food remaining in the pharyngeal area. If there was no alteration in any of the safety parameters in the nectar viscosity, the pudding and liquid viscosities were progressively assessed. The liquid was the last viscosity tested because ICU patients have the greatest difficulty in swallowing liquids [6]. After six intakes by the end of the mV-VST, fatigue may worsen dysphagia due to ICU-acquired weakness (ICUAW), and the risk of aspiration with the intake of liquids become more evident [27]. In contrast to the original V-VST that considers the presence of pharyngeal residue an efficacy parameter, we evaluated as a safety parameter as ICU dysphagia patients are more likely to suffer pulmonary aspiration of a pharyngeal residue due to their reduced strength to propel it back through to the mouth [6].

Dysphagia and risk of aspiration were excluded only in patients presented safe swallowing in all tested volumes and viscosities in the mV-VST. In case of an altered safety parameter, the evaluation was discontinued, diagnosing dysphagia and risk of aspiration. No

oral intake was allowed. In the FEES, aspiration was diagnosed after its direct visualization during the test.

Data collection

We collected the demographic characteristics (age, gender), diagnosis at admission, and ICU severity scores, using the Acute Physiology And Chronic Health Evaluation (APACHE) II [28], the Sequential Organ Failure Assessment (SOFA) [29], and the Charlson Comorbidity Index (CCI) [30]. We also assessed nutritional parameters, using Body Mass Index (BMI) and the Nutrition Risk in the Critically Ill (NUTRIC) score [31], and muscle strength with the Medical Research Council (MRC) scale [32]. Clinical variables considered in this study were: shock, acute respiratory distress syndrome (ARDS), days on IMV, and the need for continuous renal replacement therapy (CRRT). We evaluated dysphagia with the results of FEES and mV-VST, status at hospital discharge, at 30 and 60 days after discharge. These data were obtained by phone call, asking the patients about clinical symptoms related to dysphagia such as cough, or by reviewing medical records. In the hospital where this study was carried out, most of the patients diagnosed with dysphagia after admission to the ICU are followed by the dysphagia unit that exists in the center. This unit is a multidisciplinary team, including otorhinolaryngologists, speech therapists and dieticians, with the possibility of carry out another exploration with FEES, but frequently, after the work of the speech therapist, oral intake is started without presenting alterations and without requiring new instrumental evaluations. All data were registered in a Microsoft Excel® file.

Study sample size

Considering a 5% alpha error, 80% power, a 30% dysphagia incidence diagnosed by FEES [26,33], a 20% minimum difference expected between FEES and mV-VST, and a 1: 1 allocation to each test, the necessary sample size was 43 extubated and 43 tracheostomized ICU patients. We obtained sample size calculation with the co1p size command of Stata® statistical software version 14.2 (Stata Corp, College Station, TX).

Statistical analysis

Means and medians with 95% confidence intervals (Cis) were calculated for quantitative variables, and percentages with 95% CIs were calculated for qualitative variables. We used the Shapiro-Wilk test to confirm the normal distribution of data, the Chi-Squared test or the Fisher's exact test for qualitative variables in the univariate analysis to compare groups and to identify risk factors for dysphagia, and the Student's t-test or the non-parametric U-Mann-Whitney test for quantitative variables, depending on their normality. We obtained the ROC curve with the *dt* command of Stata® statistical software version 14.2 (Stata Corp, College Station, TX) to validate the mV-VST and used the *roccomp* command to compare groups. We used the Wilson test to calculate the CIs for sensitivity (Se), specificity (Sp), positive predictive value (pPV) and negative predictive value (nPV). A p-value <0.05 was considered statistically significant. Statistical analysis was carried out using Stata® statistical software version 14.2 (Stata Corp, College Station, TX).

Results

General characteristics of the study population

A total of 803 patients were admitted to the ICU between 1st March 2016 and 31st August 2019 and screened for study entry. Eighty-seven patients met the inclusion criteria and 714 were excluded for different reasons (see Fig. 2): 44 patients were assessed after extubating, and 43 had a tracheostomy.

Demographic characteristics of the extubated and tracheostomized populations were similar (Table 1). Both groups were most commonly admitted urgently because of a medical condition. Patients were overweight (mean BMI above 25 and below 30) and had a low malnutrition risk (median NUTRIC Score below 5). According to the SOFA score (median: 8), mortality risk on admission was between 15% and 20%, and comorbidity was similar between groups. Tracheostomized patients were more commonly admitted due to a non-neurological pathology ($p < 0.001$), had a higher APACHE II ($p = 0.02$) and a higher NUTRIC Score ($p = 0.004$) on admission than extubated patients.

During the admission, tracheostomized patients presented shock ($p = 0.025$), required CRRT (ns), developed ARDS ($p = 0.003$) more frequently, and needed IMV for a longer time ($p < 0.001$) while in the ICU than extubated patients. The stay in the ICU and in the hospital ward was also longer for tracheostomized than for extubated patients, $p < 0.001$ (Table 1).

At discharge from the hospital, a similar proportion of extubated and tracheostomized patients were referred to another hospital, although a slightly higher percentage of extubated patients went home. The number of deaths was higher among tracheostomized patients compared to extubated patients (Table 1).

Prevalence of dysphagia among extubated and tracheostomized patients

A total of 43.2% of extubated patients had dysphagia, 100% of whom had been admitted urgently, and 73.7% due to a neurological condition (Table 2). In addition, 100% had a nasogastric tube, while 68% of extubated patients without dysphagia had one ($p = 0.006$).

Comparatively, 23.2% of tracheostomized patients had dysphagia; 10% had a neurological condition on admission, and a smaller proportion had been admitted urgently compared with those without dysphagia (Table 3).

At 30 and 60 days post-discharge from the hospital, 14% and 7% of extubated patients persisted with dysphagia, respectively, while 2.5% of tracheostomized patients referred dysphagia at 30 days and none at 60 days (Table 1).

Incidence of aspiration

Aspiration detected by the FEES was significantly higher (43.2%) in extubated patients than in tracheostomized patients (23.2%), $p = 0.04$. When assessed with the mV-VST, aspiration was detected in 54.5% and 39.5% of extubated and tracheostomized patients, respectively.

Validation of the mV-VST

In extubated patients, the Se of the mV-VST to detect aspiration was 89.5% (95% CI: 68.6 to 97.1), the Sp was 72% (95% CI: 52.4 to 85.7), and the nPV was 90% (95% CI: 69.9 to 97.2) (Table 4).

In tracheostomized patients, the Se of the mV-VST to detect aspiration was 100% (95% CI: 72.2 to 100), with a Sp of 78.8% (95% CI: 62.2 to 89.3), and a nPV of 100% (95% CI: 87.1 to 100) (Table 5).

The ROC curve value obtained with mV-VST for tracheostomized patients was higher (0.9; 95% CI: 0.8–0.92) than the ROC curve value obtained for extubated patients (0.8; 95% CI: 0.7–0.9), without reaching statistical significance (Fig. 3). mV-VST shows a similar ability to identify aspiration in both groups.

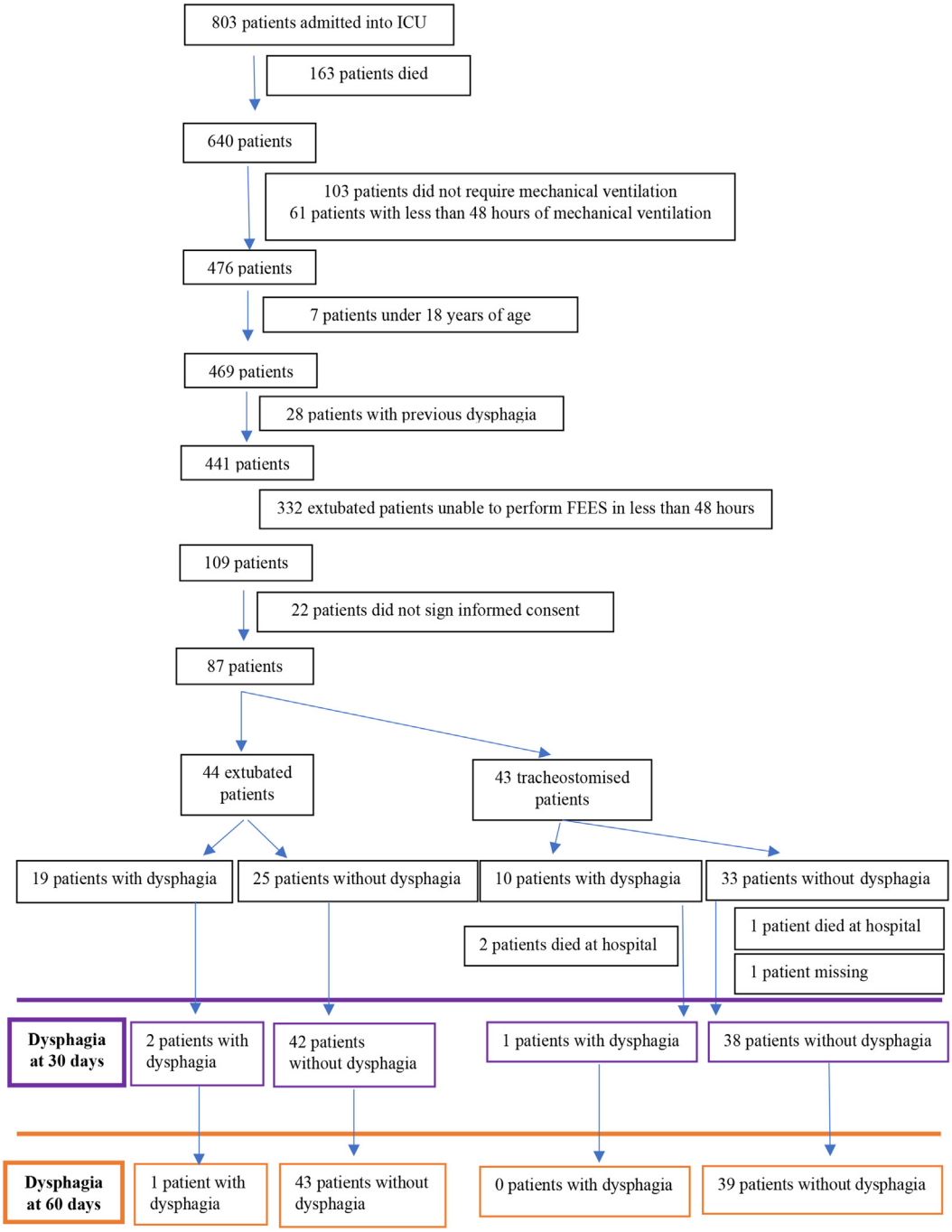


Fig. 2. Patients flow chart of the study.

Discussion

This study validates the mV-VST as a bedside tool for the screening of aspiration in ICU patients. The mV-VST seems valid for both extubated and tracheostomized patients. Given that extubated and tracheostomized patients presented a differing clinical situation and prognosis in this study, the validation of the mV-VST has been reported separately. Indeed, tracheostomized patients have poorer clinical condition, poorer prognosis, and require longer IMV than extubated patients.

Few studies address dysphagia and aspiration in extubated and tracheostomized patients in the ICU. Some medical-surgical risk factors associated with dysphagia in the ICU described in the literature are patient's functional status, increased hospital and ICU stay, the presence of heart failure, hypercholesterolemia, the need for multiple intubations, the performance of perioperative transoesophageal echocardiograms, a prolonged surgical time, and admission for sepsis [33]. In the meta-analysis by McIntyre et al., including 25 articles with 150 potential risk factors for dysphagia, they identified only two risk factors: gender and duration of intubation [9]. However, neither of them was a predictor of ICU-acquired dysphagia [9]. The authors justified the findings by patients' and diagnostic methods' heterogeneity [9].

Table 1
Demographic and clinical characteristics of the study population at admission, ICU, and hospital discharge.

	Extubated (n = 44)	Tracheostomized (n = 43)	p value
On admission			
Age in years, median (95% CI)	60.5 (48.8–67)	64 (55.3–71.4)	ns
Sex male, % (95% CI)	63.6 (48.9–76.2)	55.8 (41.1–69.6)	ns
BMI in kg/m^2, mean (95% CI)	26.8 (23.8–29.3)	28.6 (26–31.1)	ns
SOFA score, median (95% CI)	8 (7–9)	8 (7–10)	ns
APACHE II score, median (95% CI)	15 (12–18)	22 (17–25)	0.02
Charlson comorbidity index, median (95% CI)	3 (2–4)	3 (2–4)	ns
NUTRIC score, median (95% CI)	3 (3–5)	5 (4–6)	0.004
Type of admission			ns
Urgent, % (95% CI)	95.5 (83–99)	93 (80–98)	
Scheduled, % (95% CI)	4.5 (1.1–17)	7 (2.2–20)	
Reason for admission			ns
Medical, % (95% CI)	84.1 (69.8–92.4)	76.7 (61.5–87.2)	
Surgical, % (95% CI)	15.9 (7.6–30.2)	23.3 (12.8–38.5)	
Disease on admission			<0.001
Neurological, % (95% CI)	61.4 (46–74.8)	20.9 (11.1–36)	
No neurological, % (95% CI)	38.6 (25.3–54)	79.1 (64–88.9)	
During ICU stay			
Shock, % (95% CI)	65.9 (50.5–78.6)	86 (71.8–93.7)	0.025
CRRT, % (95% CI)	18.2 (9.2–32.8)	34.9 (22–50.5)	ns
ARDS, % (95% CI)	20.5 (10.8–35.3)	51.2 (36.2–66)	0.003
Days on IMV, (median) (95% CI)	11 (10–15)	35 (33–40)	<0.001
MRC scale, median (95% CI)	4 (3–5)	5 (3–6)	ns
Dysphagia (FEES), % (95% CI)	43.2 (29.2–58.4)	23.2 (12.8–38.5)	0.04
Dysphagia (mV-VST), % (95% CI)	54.5 (39.5–68.8)	39.5 (25.9–55)	ns
Nasogastric tube, % (95% CI)	81.8 (67.2–90.8)	95.3 (82.7–99)	0.048
Length of stay in ICU (days), median (95% CI)	19.5 (18–23)	47 (39–49.5)	<0.001
Length of stay in hospital (days), median (95% CI)	30.5 (24–39)	64 (54.1–75.3)	<0.001
At hospital discharge			
Destination at discharge from hospital			ns
Home, % (95% CI)	47.7 (33.2–62.6)	34.9 (22–50.5)	
Other hospital, % (95% CI)	52.3 (37.4–66.8)	58.1 (42.7–72.1)	
Death, % (95% CI)	0	7 (2.2–20)	
Dysphagia at 30 days, % (95% CI)	14 (6.3–28.2)	2.5 (0.3–16.5)	ns
Dysphagia at 60 days, % (95% CI)	7 (0.2–2)	0	ns

APACHE II: Acute physiology and chronic health evaluation; ARDS: Adult respiratory distress syndrome. BMI: Body mass index; CI: Confidence interval; CRRT: Continuous renal replacement therapy. FEES: Fiberoptic endoscopic evaluation of swallowing; ICU: Intensive care unit. IMV: Invasive mechanical ventilation. MRC: Muscle power assessment; mV-VST: Modified viscosity volume swallowing test. NUTRIC: Nutrition risk in the critically Ill; ns: Not significant; SOFA: Sequential organ failure assessment.

In our study, a greater proportion of extubated individuals developed dysphagia compared to tracheostomized patients. A possible reason could be that extubated patients were more commonly admitted because of a neurological condition. Dysphagia is more frequent in both ischaemic and haemorrhagic strokes than in other ICU conditions [31,32]. Stroke is the most common cause of neurogenic oropharyngeal dysphagia, while distinct cortical and subcortical intracerebral haemorrhages are related to swallowing dysfunction and dysphagia in the ICU [31,32]. Additionally, in our study, more extubated patients with dysphagia had a nasogastric tube that may have further impaired swallowing [34].

Tracheostomy may be considered a risk factor for dysphagia as it produces an obstacle to the glottic closure reflex, reduces subglottic pressure, decreases laryngeal elevation, and decreases hypopharyngeal and laryngeal sensitivity [35]. However, evidence shows that ICU patients who aspirate pre-tracheostomy also aspirate post-tracheostomy, and those who do not aspirate pre-tracheostomy do not aspirate post-tracheotomy either [12]. Studies have not demonstrated a causal relationship between tracheostomy tube placement, dysphagia, and the aspiration status of the individual [36]. Neither age, number of days between pre- and post-tracheotomy, FEES evaluations, nor the number of days post-tracheotomy explains the differences in the aspiration status of the patient [12].

Overall, patients diagnosed with dysphagia during ICU admission have a worse prognosis than those without it [6]. Although the results did not reach statistical significance, our study showed higher mortality in patients with dysphagia and more frequent discharge to other hospitals rather than home. In previous research, a long duration of mechanical ventilation was independently associated with postextubation dysphagia, which is related to poor outcomes [37]. Dysphagia has remained an independent predictor for 28-day and 90-day mortality (excess 90-day mortality: 9.2%) after adjusting for disease severity and length of mechanical ventilation [38], corroborating our findings.

Although the incidence of dysphagia was high in our study, recovery was fast, and only 7% of extubated patients persisted with dysphagia 60 days after discharge from the hospital; all tracheostomized patients have recovered. Other authors have reported that dysphagia can be transient in critical illness polyneuropathy [39]. However, as many as 60.4% (n = 58/96) of ICU patients may keep reporting dysphagia symptoms until hospital discharge [40], and 30% of orally intubated survivors to an ARDS may have persistent dysphagia symptoms beyond hospital discharge [38].

A higher proportion of extubated patients presented aspiration detected with the FEES than tracheostomized patients, while aspiration was diagnosed more frequent in tracheostomized patients than in extubated patients with the mV-VST. As a screening tool, the mV-VST may detect more patients with aspiration than those who actually have it (false positives). In this study, the mV-VST identified 89.5% of extubated patients who aspirate, while a negative result would imply a 90% probability that the extubated patient does not aspirate. Similarly, the mV-VST would detect 100% of tracheostomized patients with aspiration and without aspiration. Therefore, the mV-VST is useful for ruling out aspiration due to

Table 2
Demographic and clinical characteristics of the extubated population at admission, during ICU stay, and at hospital discharge.

	Dysphagia (n = 19)	No dysphagia (n = 25)	p value
On admission			
Age in years, median (95% CI)	67 (49–70.8)	56.8 (49–65.5)	ns
Sex male, % (95% CI)	68.4 (44–85.5)	60 (39.2–77.7)	ns
BMI in kg/m^2, mean (95% CI)	24.7 (20.6–30)	27 (25.3–30.5)	ns
SOFA score, median (95% CI)	7 (7–8)	8 (7–10)	ns
APACHE II score, median (95% CI)	15 (12–18)	15 (11–21)	ns
Charlson comorbidity index, median (95% CI)	3 (1–4)	3 (1–4)	ns
NUTRIC score, median (95% CI)	4 (3–4)	3 (2–5)	ns
Type of admission			ns
Urgent, % (95% CI)	100	92 (71.6–98.1)	
Scheduled, % (95% CI)	0	8 (1.9–28.4)	
Reason for admission			ns
Medical, % (95% CI)	84.2 (59.2–95.2)	84 (63–94.2)	
Surgical, % (95% CI)	15.8 (4.8–40.8)	16 (5.8–36.9)	
Disease on admission			ns
Neurological, % (95% CI)	73.7 (48.8–89.2)	52 (32.2–71.2)	
No neurological, % (95% CI)	26.3 (10.8–51.2)	48 (28.8–67.8)	
During ICU stay			
Shock, % (95% CI)	58 (34.4–78.3)	72 (50.7–86.5)	ns
CRRT, % (95% CI)	15.8 (4.8–40.8)	20 (8.2–41.2)	ns
ARDS, % (95% CI)	15.8 (4.8–40.8)	24 (10.7–45.3)	ns
Days on IMV, (median) (95% CI)	13 (10.7–16.3)	10 (6.1–15)	ns
MRC scale, median (95% CI)	5 (3–6)	3 (3–5)	ns
Nasogastric tube, % (95% CI)	100	68 (46.8–83.7)	0.006
Length of stay in ICU (days), median (95% CI)	22 (18.4–25.3)	18 (14–23)	ns
Length of stay in hospital (days), median (95% CI)	30 (23.4–54.1)	31 (22.2–40.8)	ns
At hospital discharge			
Destination at discharge from hospital			ns
Home, % (95% CI)	42.1 (21.7–65.6)	52 (32.2–71.2)	
Other hospital, % (95% CI)	57.9 (34.4–78.2)	48 (28.8–67.8)	
Death, % (95% CI)	0	0	

APACHE II: Acute physiology and chronic health evaluation; ARDS: Adult respiratory distress syndrome. BMI: Body mass index; CI: Confidence interval; CRRT: Continuous renal replacement therapy. ICU: Intensive care unit. IMV: Invasive mechanical ventilation. MRC: Muscle power assessment. NUTRIC: Nutrition risk in the critically Ill; ns: Not significant; SOFA: Sequential organ failure assessment.

Table 3
Demographic and clinical characteristics of the tracheostomized population at admission, during ICU stay, and at hospital discharge.

	Dysphagia (n = 10)	No dysphagia (n = 33)	p value
On admission			
Age in years, median (95% CI)	66.5 (55.4–76)	63.9 (52.9–71.7)	ns
Sex male, % (95% CI)	40 (14.4–72.5)	60.6 (42.6–76.1)	ns
BMI in kg/m^2, mean (95% CI)	29.8 (25.5–33.6)	28.2 (24.5–31.3)	ns
SOFA score, median (95% CI)	8 (5–11)	8 (6–10)	ns
APACHE II score, median (95% CI)	15 (8–29)	23 (1.7–27)	ns
Charlson comorbidity index, median (95% CI)	4 (1–6)	3 (2–4)	ns
NUTRIC score, median (95% CI)	5 (4–6)	5 (4–6)	ns
Type of admission			ns
Urgent, % (95% CI)	90 (48.9–98.8)	93.9 (77.7–98.6)	
Scheduled, % (95% CI)	10 (1.2–51.1)	6.1 (1.4–22.3)	
Reason for admission			0.036
Medical, % (95% CI)	50 (20.7–79.3)	84.8 (67.4–93.8)	
Surgical, % (95% CI)	50 (20.7–79.3)	15.2 (6.2–32.6)	
Disease on admission			ns
Neurological, % (95% CI)	10 (1–51.1)	24.2 (12.2–42.4)	
No neurological, % (95% CI)	90 (48.9–98.8)	75.8 (57.6–87.8)	
During ICU stay			
Shock, % (95% CI)	80 (42.7–95.6)	87.9 (70.8–95.6)	ns
CRRT, % (95% CI)	50 (20.7–79.3)	30.3 (16.7–48.6)	ns
ARDS, % (95% CI)	50 (20.7–79.3)	51.5 (34.2–68.5)	ns
Days on IMV, (median) (95% CI)	37.5 (31.3–54.1)	35 (30–39.7)	ns
MRC scale, median (95% CI)	3 (1–5)	6 (3–7)	ns
Nasogastric tube, % (95% CI)	90 (48.9–98.8)	96.7 (80–99.6)	ns
Length of stay in ICU (days), median (95% CI)	45 (36.3–52.4)	48 (39–50.7)	ns
Length of stay in hospital (days), median (95% CI)	72 (49.6–98.1)	60 (53–72.7)	ns
At hospital discharge			
Destination at discharge from hospital			0.049
Home, % (95% CI)	10 (1.2–51.1)	42.4 (26.4–60.3)	
Other hospital, % (95% CI)	70 (35–91)	54.6 (54.5–71.1)	
Death, % (95% CI)	20 (4.4–57.3)	3 (0.4–20)	

APACHE II: Acute physiology and chronic health evaluation; ARDS: Adult respiratory distress syndrome. BMI: Body mass index; CI: Confidence interval; CRRT: Continuous renal replacement therapy. ICU: intensive care unit. IMV: Invasive mechanical ventilation. MRC: Muscle power assessment. NUTRIC: Nutrition risk in the critically Ill; ns: Not significant; SOFA: Sequential organ failure assessment.

Table 4
mV-VST validation in extubated ICU patients.

	FEES		
MECVVm	Dysphagia	No dysphagia	
Dysphagia	17	7	24
No dysphagia	2	18	20
	19	25	44

Se = 89.5% (95% CI: 68.6–97.1)
Sp = 72% (95% CI: 52.4–85.7)
pPV = 70.8% (95% CI: 50.8–85.1)
nPV = 90% (95% CI: 69.9–97.2)

FEES: Fiberoptic endoscopic evaluation of swallowing; mV-VST: Modified viscosity volume swallowing test; nPV: Negative predictive value; pPV: Positive predictive value; Se: Sensitivity; Sp: Specificity.

Table 5
mV-VST validation in tracheostomized ICU patients.

	FEES		
MECVVm	Dysphagia	No dysphagia	
Dysphagia	10	7	17
No dysphagia	0	26	26
	10	33	43

Se = 100% (95% CI: 72.2–100)
Sp = 78.8% (95% CI: 62.2–89.3)
pPV = 58.8% (95% CI: 36–78.4)
nPV = 100% (95% CI: 87.1–100)

FEES: Fiberoptic endoscopic evaluation of swallowing; mV-VST: Modified Viscosity Volume Swallowing Test; nPV: Negative predictive value; pPV: Positive predictive value; Se: Sensitivity; Sp: Specificity.

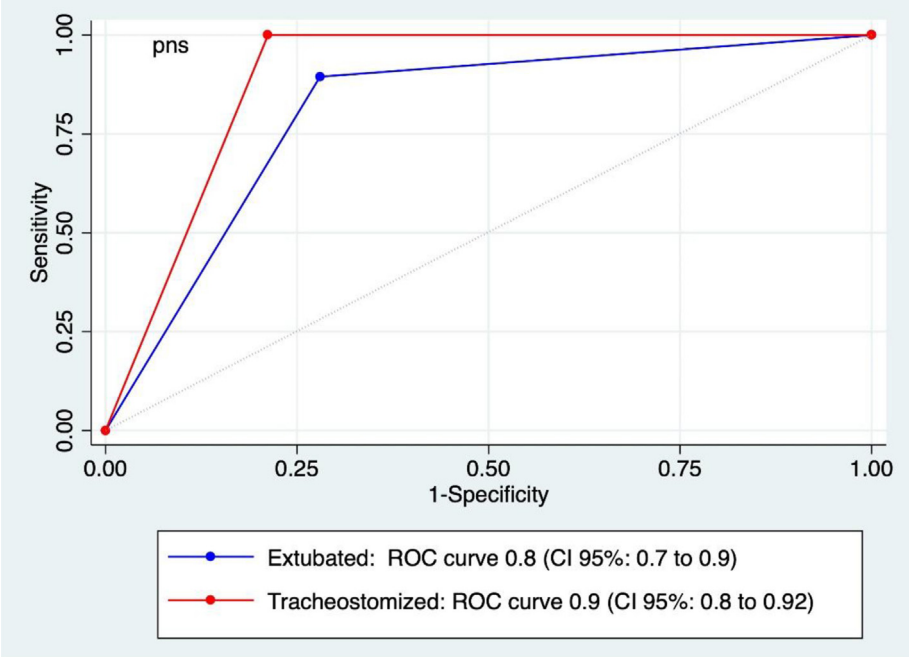
dysphagia [41]. The mV-VST may identify dysphagia better in tracheostomized patients. However, the ROC curve results in our study showed a similar capacity of both assessment tools to detect dysphagia in the two populations of ICU patients.

Similar results have been reported for the original V-VST in hospitalized patients in rehabilitation, for whom its sensitivity, specificity, and accuracy in detecting aspiration due to swallowing disorders were 83.3%, 72.6%, and 74.8%, respectively [42]. Likewise, other authors that assessed the accuracy of the original bedside V-VST for the screening of impaired safety and efficacy of deglutition found a similar high 100% sensitivity but a lower 28.8% specificity [15].

Finally, the greatest values of the mV-VST are its simplicity and low cost [21], which means that it can be repeated as many times as necessary, especially if the patient clinical circumstances change during the ICU stay. Additionally, intensive care staff can carry out the test themselves without requiring other specialists, avoiding delays in diagnosis and rehabilitation [24]. The mV-VST is a non-invasive, well-tolerated, and repeatable method to be carried out whenever it is needed at the patient's bedside [26]. The prompt identification of dysphagia in the ICU may imply a significant change in the prognosis of critically ill patients if adequate nutritional intervention and speech therapy are initiated [6,39].

This study has limitations, and findings need to be interpreted accordingly. Its observational, descriptive, and single-center design might lead to a center-specific bias, influencing data acquisition, including the phone call follow-up. The study had a heterogeneous sample of ICU patients limiting the extrapolation of results to specific populations. The influence of variables within specific groups of patients is not known. In this sense, the fact that neurological patients were more frequent in the extubated group, and that patients in the tracheostomized group were more severely ill are probably the most important biases modifying the incidence of dysphagia in these groups. Despite these limitations, this study shows preliminary findings in a medical area that deserves research. Further investigations are needed to compare and challenge these results, as well as identify risk factors for dysphagia.

Overall, our research shows that the mV-VST carried out at the bedside in critically ill patients in the ICU is valid. It may also be



CI: confidence interval

Fig. 3. Dysphagia ROC curves for extubated and tracheostomized patients.

useful for selecting the appropriate diet and minimizing the risk of complications due to aspiration in both extubated and tracheostomized patients.

Conclusions

Dysphagia and aspiration are frequent among ICU patients after mechanical ventilation. The mV-VST is a valuable tool for screening dysphagia in extubated critically ill patients and in tracheostomized patients who have required mechanical ventilation. The incidence of dysphagia detected in extubated critically ill patients was high, with a nasogastric tube being the only risk factor detected for dysphagia. Tracheostomized patients were less affected by dysphagia, and no risk factor was identified in this population.

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Authors' contributions

LBL, PMN and IMdLZ: Conceptualization, Methodology, Data interpretation. LBL, PMN and IMdLZ data collection (enrolled patients into the study). PMN data curation and analysis (performed the statistical analysis). LBL, PMN, CVS, CPG and IMdLZ writing the manuscript, draft preparation. All authors read and approved the final version of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical approval and consent to participate

The clinical research ethics committee of the Germans Trias i Pujol hospital (Badalona, Spain) approved the development of the study (resolution number: PI:16-053). All study participants signed the informed consent form.

Consent for publication

We have consent from all authors to publish the results of this study.

Declaration of Competing Interest

The authors declare no conflict of interest.

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