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Covid-19

Dysphagia and mechanical ventilation in SARS-COV-2 pneumonia: It's real

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SUMMARY

Background & aims: Dysphagia can be a consequence of prolonged hospitalization in intensive care units (ICUs) due to severe SARS-CoV-2 pneumonia. This study aims at Identifying the risk factors for dysphagia in ICU patients with COVID-19 pneumonia requiring invasive mechanical ventilation, and at determining the frequency of postextubation dysphagia in this population.

Methods: Observational, descriptive, retrospective, cohort study of SARS-CoV-2 pneumonia patients admitted into the ICUs from March to May 2020. The Modified Viscosity Volume Swallowing Test (mV-VST) was used to screening for dysphagia during the first 48 h of extubation in patients requiring mechanical ventilation. Descriptive statistics, univariate and multivariate analyses were conducted. A logistic regression was applied to construct a predictive model of dysphagia.

Results: A total of 232 patients were admitted into the ICUs (age [median 60.5 years (95% CI: 58.5 to 61.9)]; male [74.1% (95% CI: 68.1 to 79.4)]; APACHE II score [median 17.7 (95% CI: 13.3 to 23.2)]; length of mechanical ventilation [median 14 days (95% CI: 11 to 16)]; prone position [79% (95% CI: 72.1 to 84.6)]; respiratory infection [34.5% (95% CI: 28.6 to 40.9)], renal failure [38.5% (95% CI: 30 to 50)])). 72% (167) of patients required intubation; 65.9% (110) survived; and in 84.5% (93) the mV-VST was performed. Postextubation dysphagia was diagnosed in 26.9% (25) of patients. APACHE II, prone position, length of ICU and hospital stay, length of mechanical ventilation, tracheostomy, respiratory infection and kidney failure developed during admission were significantly associated ($p < 0.05$) with dysphagia. Dysphagia was independently explained by the APACHE II score (OR: 1.1; 95% CI: 1.01 to 1.3; $p = 0.04$) and tracheostomy (OR: 10.2; 95% CI: 3.2 to 32.1) $p < 0.001$). The predictive model forecasted dysphagia with a good ROC curve (AUC: 0.8; 95% CI: 0.7 to 0.9).

Conclusions: Dysphagia affects almost one-third of patients with SARS-COV-2 pneumonia requiring intubation in the ICU. The risk of developing dysphagia increases with prolonged mechanical ventilation, tracheostomy, and poorer prognosis on admission (worst APACHE II score).

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1. Introduction

The WHO declared COVID-19 a pandemic on March 11, 2020 [1]. This new disease brought intensive care units (ICUs) and the health consequences of prolonged hospital admissions into focus. Dysphagia, defined as the inability to swallow liquid and/or solid elements due to a structural or functional impairment of one or more swallowing phases [2] is common after long stays in ICUs [3]. Postextubation dysphagia is defined as the difficulty or inability to effectively and safely transfer food and liquid from the mouth to the stomach, and may result in aspiration and respiratory complications [4]. Postextubation dysphagia has a widely variable incidence of 3%–62% depending upon the study consulted [5], and it is most common amongst critical care patients requiring endotracheal intubation for mechanical ventilation [6].

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Congestive heart failure, hypercholesterolemia, patient's functional status prior to admission, lengthy stays in hospital and ICUs, prolonged surgical time and the performance of perioperative transesophageal echocardiography are well-known risk factors for dysphagia in in-hospital patients [7]. Additionally, in the ICU dysphagia is favored by the muscular debilitation that affects the swallowing apparatus as part of the ICU-acquired weakness (ICUAW) that involves all muscles in the body [8,9]. To these "classic" factors, others associated with SARS-CoV-2 pneumonia are present in COVID-19 ICU patients, including treatment with corticosteroids that may produce myopathy as a side effect; hydroxychloroquine, that further increases corticosteroids myopathy; prolonged deep sedation and relaxation; orotracheal intubation that may further damage the deglutition apparatus; prone decubitus positioning, and the SARS-CoV-2 infection itself carrying neurological complications such as stroke, encephalitis or Guillain-Barré syndrome, among others [10,11]. All of these factors favor the development of ICUAW and, therefore, the occurrence of dysphagia in COVID-19 patients in the ICU [12,13].

Critically ill patients with dysphagia have higher morbidity than those without dysphagia, requiring reintubation, surgical insertion of a feeding tube and rehabilitation more frequently after longer hospital stays [7]. The duration of ICU-related dysphagia varies depending on the cause of the dysphagia, but in general, patients recover in a short period of time alongside the resolution of the ICUAW [14,15].

There are two "gold standard" tests for the diagnosis of dysphagia: the Videofluoroscopic swallowing study (VFSS) [16] and the fiberoptic endoscopic evaluation of swallowing (FEES) [17–19]. Neither of the two explorations are recommended in patients with SARS-CoV-2 infection due to the aerosols that are generated that may favor viral spread and cross-contamination and should only be performed in patients with high risk of aspiration and malnutrition or dehydration due to dysphagia and inability to feed non-orally [3,11]. Therefore, a bedside screening test for dysphagia is advisable [3,20].

Two years before the pandemic, our center introduced the Modified Viscosity Volume Swallowing Test (mV-VST) [21], a bedside screening method that facilitates the diagnosis of dysphagia. It has been regarded as an easy hand on, reliable screening tool for dysphagia among critically ill patients in the ICU to predict the risk of aspiration during hospitalization [22]. The purpose of this study was to identify the risk factors that independently explained the development of dysphagia and risk of pulmonary aspiration in ICU patients with COVID-19 pneumonia requiring invasive mechanical ventilation. Additionally, the study sought to determine the incidence of dysphagia using the mV-VST in this population.

2. Material and methods

2.1. Study design and population

This was an observational, descriptive, retrospective, cohort study of patients admitted to ICUs of the Germans Trias i Pujol general hospital (Badalona, Catalonia) due to SARS-COV-2 pneumonia during the first wave of the pandemic (2nd March to 11th May, 2020) in Spain. Patients requiring orotracheal intubation and mechanical ventilation for seven or more days, older than 18 years of age, alert and able to cooperate were consecutively recruited into the study. No exclusion criteria were defined. Thus, the clinical health records of all SARS-COV-2 patients accomplishing the inclusion criteria and admitted to ICUs with personnel trained to perform the mV-VST at bedside were reviewed.

2.2. Modified Viscosity Volume Swallowing Test (mV-VST)

The mV-VST is based on the swallowing of nectar, pudding and liquid viscosities [21,22]. These viscosities are achieved by mixing mineral water with the dose of a thickener indicated by the manufacturer; in this study, the thickener Nutilis Clear® (Nutricia) was used [23]. Viscosities were stained with blue food coloring to visualize pulmonary aspiration. Before starting the mV-VST, the patient was asked to say his or her name to identify the tone of voice. The mV-VST begun with the nectar viscosity. Increasing volumes of 5, 10 and 15 mL were consecutively placed in the patient's mouth with a 50-mL syringe. The following safety parameters were assessed each time: presence of cough, desaturation > 3%, change in the tone of voice by asking the patient to repeat his/her name, and presence of pharyngeal residue by asking the patient whether he/she has the sensation of food remaining in the pharyngeal area. If there was no alteration in any of the safety parameters, the same assessment was progressively performed with the pudding- and liquid-viscosity volumes, respectively. Dysphagia and risk of aspiration were discarded only in those patients safely swallowing all tested viscosities. In case a single safety parameter was altered, the evaluation of that viscosity was suspended. The patient was rendered as having dysphagia and no oral intake was allowed provided the high risk of pulmonary aspiration. The mV-VST process is shown in Fig. 1.

In this study, the mV-VST was performed once within 48 h after the patient was extubated and prior to starting oral intake as per the ICU protocol. In patients with a fenestrated tracheostomy tube, the mV-VST was done using the fenestrated inner cannula and a deflated cuff.

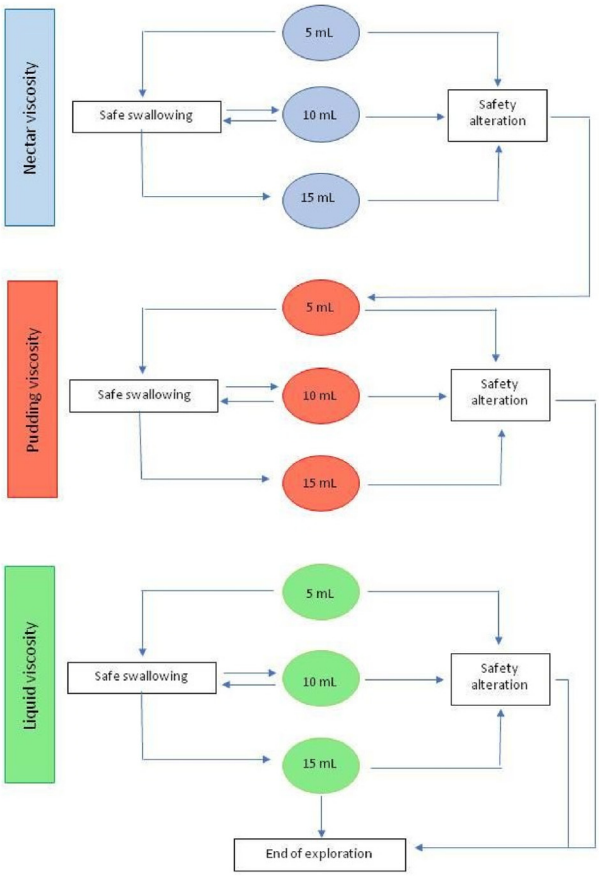

Fig. 1. mV-VST for dysphagia in the ICU.

2.3. Data collection

Demographic (gender, age), body mass index (BMI), main diagnosis and prognosis [Acute Physiology, Age and Chronic Health Evaluation (I-IV) (APACHE) Sequential Organ Failure Assessment (SOFA) scores]; number of days to COVID-19 symptoms onset before hospital and ICU admission; COVID-19 pharmacological supportive treatments prescribed; development of renal insufficiency, respiratory bacterial infection or sepsis; number of days on mechanical ventilation; number of days in hospital and in the ICU; Intubation, prone decubitus or tracheostomy required; presence of dysphagia, and death were collected in Microsoft Excel® from patients' clinical health records.

2.4. Sample size

The study power to identify risk factors for dysphagia was calculated based on the 232 critically ill patients with COVID-19 pneumonia who were admitted to our hospital during the first wave of the pandemic. Considering an estimated 13.3% incidence of dysphagia in intubated patients due to respiratory reasons [21], a 22.7% incidence of dysphagia in the study population [21], and a two-tailed statistical significance, we found that the power of our study was 96.4% (nsize stata v.14.2) to adequately identify dysphagia related factors.

2.5. Statistical analysis

Data statistical analysis was performed in Stata® version 14.2. Means and medians with their respective 95% confidence intervals (CIs) were calculated for quantitative variables and proportions, respectively. The Shapiro–Wilk test was applied to confirm the normal distribution of data. Simple logistic regressions were used for an univariate analysis of possible factors associated with the probability of developing dysphagia and to identify potential confounders. A multivariate analysis by logistic regression was used to establish determining factors and to construct a predictive model of dysphagia.

2.6. Ethical considerations

The clinical research ethics committee (CREC) of the Germans Trias i Pujol hospital approved the development of the study (Resolution number: PI-20-376). The CREC accepted the exemption of obtaining written consent from patients or caregivers due to the exceptionality of the situation during the pandemic.

3. Results

Between 2nd March and 11th May, 2020, 232 COVID-19 patients were admitted to the ICU, of whom 167 (72%) were intubated; 57 (34.1%) died and 110 (65.9%) survived and were extubated (Table 1). Mean age of the total sample was 60.5 years (95% CI: 58.5 to 61.9); 74.1% were men (95% CI: 68.1 to 79.4). Mean APACHE II score was 17.7 (95% CI: 13.3 to 23.2). 78.9% of patients were on hydroxychloroquine while 71.1% received corticosteroids (dose: 1.5–2 mg methylprednisolone) for an average of 7 days. Intubated patients were mechanically ventilated for an average of 14 days (95% CI: 11 to 16); 79% (95% CI: 72.1 to 84.6) were on prone decubitus and 40.1% required a tracheostomy. The most frequent complication was renal failure that happened in 38.7% (95% CI: 30 to 50) of patients while 34.5% (95% CI: 28.6 to 40.9) developed a concomitant respiratory infection. 17.7% (95% CI: 13.3 to 23.2) developed systemic sepsis with positive blood cultures. Overall mortality was 25.9% (95% CI: 20.6 to 31.9) and reached 34.1% (95% CI: 27.3 to 41.7) amongst the intubated patients.

From the 110 total extubated patients, mV-VST was performed in 93 (84.5%); 25 (26.9%) were diagnosed with postextubation dysphagia (Fig. 2). The mV-VST was not done in 15.5% of patients mainly due to referrals to new COVID-19 units with no trained personnel to perform the test.

3.1. Factors associated with the risk of dysphagia

In the univariate analysis, APACHE II mean score, prone decubitus and its duration, mean number of days on mechanical ventilation, requiring a tracheostomy, concomitant respiratory infection, development of renal failure during admission, and length of ICU and hospital stay were significantly associated with dysphagia (Table 2).

3.2. Factors independently explaining dysphagia

According to the multivariate analysis, the APACHE II mean score (OR: 1.1; 95% CI: 1.01 to 1.3; $p = 0.04$) and having a tracheostomy (OR: 10.2; 95% CI: 3.2 to 32.1; $p < 0.001$) independently explained the dysphagia (Table 3). The resulting predictive model forecasted the probability of developing dysphagia with a ROC curve near to 1 (AUC = 0.8, 95% CI: 0.7 to 0.9) (Fig. 3).

4. Discussion

This study provides data on the frequency and clinical factors associated to postextubation dysphagia in critically ill patients due to SARS-COV-2 pneumonia who were admitted to the ICU during the first pandemic outbreak. Almost one-third of SARS-COV-2 individuals requiring intubation and mechanical ventilation developed postextubation dysphagia and were at risk of pulmonary aspiration. To the best of our knowledge, this is one of the few studies to report on the frequency of dysphagia amongst SARS-COV-2 patients in the ICU. In other publications, the authors also reported frequent dysphagia and swallowing dysfunction amongst non-intubated and intubated patients with severe COVID-19 treated in the ICU [24–27]. Thus, 8 of 41 non-intubated patients (20%) presented with dysphagia symptoms during hospitalization as assessed with the V-VST [26]. 36% of 100 COVID-19 adults were not allowed oral intake based on an initial speech and language therapy assessment after extubation [28]. Episodes of silent aspirations and abnormal laryngeal findings were present in as many as 24 of 25 (96%) COVID-19 patients at the time of a FEES after extubation [24]. Likewise, 67% (39 out of 58) patients surviving COVID-19 were recommended to be nil by mouth after assessing the impact of intubation and extubation, proning, tracheostomy, critical illness, and delirium on swallowing [25]. Inhalation and lack of protective reflexes were found to last beyond hospital discharge in some COVID-19 survivors [27]. In our study, all patients fully recovered 6 months after hospital discharge according to medical records, suggesting that dysphagia most probably happened due to a muscle weakness dysfunction.

We used the mV-VST to assess dysphagia and risk of pulmonary aspiration at the patients' bedside. The mV-VST reliability and simply use [22] were highly valuable when it was required to deliver care in personal protective equipment in an unusually challenging and demanding ICU environment. Therefore, having in place a screening method for dysphagia in the ICU that can be performed by specialized critical care nurses at the bedside as many times as necessary throughout the patient ICU stay becomes mandatory [21,27]. In our experience, the use of a fast and simple method such as the mV-VST may contribute to safely screening for

Table 1
Demographic and clinical characteristics of the studied population (n = 232).

Variable	Value	95% CI
Age (years)	60.5	58.5–61.9
Sex (male: %)	172/232 (74.1)	68.1–79.4
BMI (kg/m^2)	29	28–30
DM2 (%)	17.7	13.3–23.2
APACHE II score (median)	18	18–20
Median number of days from the onset of symptoms to hospitalization	9	8–10
Median number of days from the onset of symptoms to ICU admission	10	12–15
Length of ICU stay (median, days)	11	10–12.3
Length of Hospital stay (median, days)	27	26–30
Patients on hydroxychloroquine (%)	183/232 (78.9)	73.1–83.7
Patients on chloroquine (%)	44/232 (19)	14.4–24.6
Patients on corticosteroids, boluses, or regimen (%)	165/232 (71.1)	64.9–76.6
Patients on remdesivir (%)	8/232 (3.4)	1.7–6.8
Patients on tocilizumab (%)	97/232 (41.8)	35.6–48.3
Median number of days on corticosteroids treatment	7	7–8
Patients with sepsis with positive blood culture (%)	44/232 (17.7)	13.3–23.2
Patients with respiratory infection (%)	80/232 (34.5)	28.6–40.9
Patients with renal failure (%)	90/232 (38.7)	30–50
Patients requiring intubation (%)	167/232 (72)	65.8–77.4
Patients requiring prone decubitus (%)	132/167 (79)	72.1–84.6
Patients requiring tracheostomy (%)	67/167 (40.1)	32.9–47.8
Patients requiring mechanical ventilation (median, days)	14	11–16
Patients requiring ECMO (%)	12/167 (7.2)	4.1–12.3
Dysphagia in overall sample (%)	27/232 (11.6)	8–16.5
Dysphagia in intubated patients (%)	25/167 (22.7)	15.8–31.6
Dysphagia in intubated patients who were tested (%)	25/93 (26.9)	18.8–37
Death in overall sample (%)	60/232 (25.9)	20.6–31.9
Death in intubated patients (%)	57/167 (34.1)	27.3–41.7
Death in intubated patients with dysphagia (%)	0/25 (0)	0

APACHE: acute physiology, age and chronic health evaluation; CI: confidence interval; DM2: type 2 diabetes mellitus; ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit; OR: odds ratio.

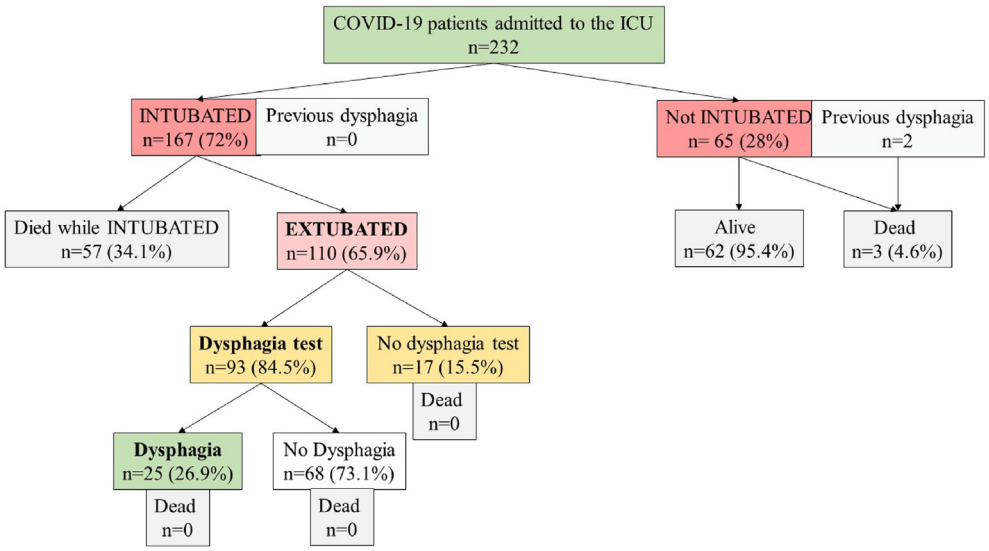

Fig. 2. Study disposition of patients.

dysphagia in critically ill COVID-19 patients. However, the risk for aspiration pneumonia due to silent aspirations in patients who passed the mV- VST may be underestimated in practice [22]. Furthermore, the V-VST may be moderately reliable for detecting dysphagia among medical and geriatric patients [29] an additional limitation to be taken into account when performing the assessment. In this study, oral intake was forbidden in patients with a single safety parameter altered in the mV-VST to minimize the risk of pulmonary aspiration in patients with already highly compromised lungs.

In our study, tracheostomy, length of stay in the ICU and in hospital, duration of the mechanical ventilation, need for prone decubitus, respiratory infection and in-hospital renal failure were all associated with dysphagia. However, based on the stronger associations between variables, dysphagia was more likely amongst COVID-19 patients with prolonged mechanical ventilation and tracheostomy. This is probably due to the acute respiratory distress syndrome, the sustained muscle relaxation during intubation and treatment with corticosteroids required in severe COVID-19 patients as recommended by different scientific societies during the

Table 2
Univariate analysis: variables associated with dysphagia in COVID-19 patients in the ICU.

Variable	OR	95% CI	p
Age (years)	1.03	0.99 to 1.09	0.17
Sex (male)	2.08	0.55 to 7.89	0.28
IBM (kg/m^2)	1.02	0.94 to 1.11	0.67
DM2	2.73	0.93 to 8	0.07
APACHE II score	1.12	1.02 to 1.24	**0.02**
Median number of days from the onset of symptoms to hospitalization	1	0.9 to 1.11	0.99
Median number of days from the onset of symptoms to ICU admission	1.04	0.96 to 1.12	0.32
Length of ICU stay	1.04	1.01 to 1.07	**0.003**
Length of Hospital stay	1.05	1.02 to 1.078	**0.001**
Hydroxychloroquine	0.78	0.26 to 2.33	0.65
Chloroquine	1.21	0.36 to 3.87	0.75
Corticosteroids, bolus or regimen	1.97	0.59 to 6.52	0.27
Remdesivir	2.87	0.38 to 21.6	0.31
Tocilizumab	0.83	0.33 to 2.11	0.7
Median number of days of corticosteroid treatment	1.2	0.95 to 1.5	0.13
Positive blood culture	2.44	0.85 to 7.03	0.1
Respiratory infection	5.45	1.92 to 15.43	**0.001**
Renal failure during ICU stay	6.37	2.34 to 17.39	**<0.001**
Mechanical ventilation	1.06	1.03 to 1.09	**<0.001**
Prone position	10	1.27 to 79	**0.029**
Length of time in prone position (days)	1.39	1.12 to 1.71	**0.003**
Tracheostomy	10.3	3.38 to 31.4	**<0.001**
ECMO (%)	0.9	0.09 to 9.1	0.93
Length of time on ECMO therapy (days)	0.86	0.53 to 1.38	0.53

APACHE: acute physiology, age and chronic health evaluation; CI: confidence interval; DM: diabetes mellitus; ECMO: extracorporeal membrane oxygenation; ICU: intensive care unit; OR: odds ratio.
Bold values signifies $p < 0.05$.

first wave of the SARS-COV-2 pandemic [15]. These findings are in line with other results that showed that COVID-19 patients with a tracheostomy needed more time to start oral intake compared to patients with endotracheal tube only after extubation [25]. Similarly, days on feeding tube and length of mechanical ventilation and ICU/hospital stay were higher in patients in the ICU [30]. In our research, tracheostomy, more severe COVID-19 disease and poor prognosis based on the APACHE II score were predictors of dysphagia. Age, proning and pre-existing respiratory disease were predictors of postextubation oral intake status in other studies on COVID-19 patients admitted to the ICU [28]. Although the presence of dysphagia in this study did not imply an increase in patient mortality, as it was found in other researches [30], dysphagia was associated with an increment of ICU and hospital stay duration [3,30].

Table 3
Multivariate analysis: variables independently explaining dysphagia in COVID-19 patients in the ICU.

Variable	OR	95% CI	p
Tracheostomy	10.2	3.2 to 32.1	**<0.001**
APACHE II score	1.12	1.01 to 1.3	**0.04**

APACHE: acute physiology, age and chronic health evaluation; CI: confidence interval; OR: odds ratio.
Bold values signifies $p < 0.05$.

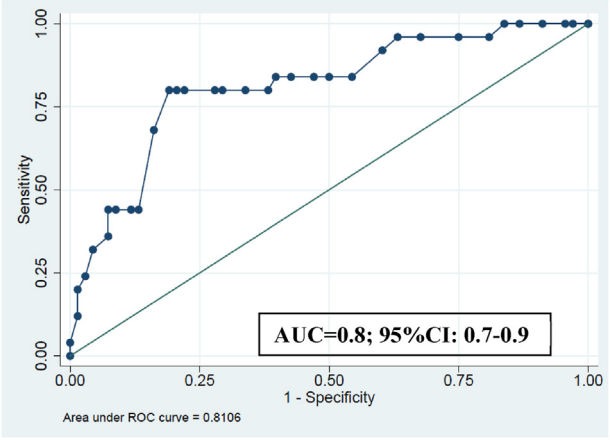

Fig. 3. APACHE II score and tracheostomy in the predictive model of dysphagia in COVID-19 patients in the ICU.

5. Limitations

Findings needs to be interpreted in the context of limitations. The retrospective and unicentric design of study may have introduced selection and record biases. Due to the high hospital care pressure that was experienced during the first wave of the COVID-19 pandemic, factors that may have explained dysphagia such as muscle weakness at assessment, or the nutritional status of patients were not documented neither the number of patients with dysphagia that were treated with adapted oral diet and thickeners or the number of patients that needed tube feeding. Despite limitations, the assessment of postextubation dysphagia was performed in 84.5% of ICU patients with SARS-COV-2 pneumonia. Only 15.5% of these patients were not studied. Overall, the results presented here may help other hospitals and ICUs to consider the dysphagia problem and adequate the management of COVID-19 patients at risk.

6. Conclusions

Dysphagia affects almost one-third of patients with SARS-COV-2 pneumonia requiring intubation in the ICU. The risk of developing dysphagia increases with prolonged mechanical ventilation, tracheostomy, disease severity and poor prognosis at admission

(APACHE II score). Screening of dysphagia at bedside may be highly valuable in these patients at risk of pulmonary aspiration.

Authors' contributions

LB, EM, CP, CV enrolled patients. PM and PR performed the statistical analysis and LB, IM, PM and PR analyzed and interpreted the patient data. IM, LB and PM were major contributors in writing the manuscript. 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

Due to the exceptional pandemic situation, the Ethics Committee from Germans Trias i Pujol Universitary Hospital approved the exemption from obtaining informed consent.

Consent for publication

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

Funding

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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Abbreviations

mV-VST	Modified Viscosity Volume Swallowing Test
VFSS	Videofluoroscopic swallowing study
FEES	Fibreoptic endoscopic evaluation of swallowing
APACHE	Acute Physiology and Chronic Health Evaluation
SOFA	Sepsis-Related Organ Failure Assessment
COVID-19	Coronavirus 2019
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
ICU	Intensive care unit
ICUAW	ICU-acquired weakness
PPE	Personal protective equipment
CI	Confidence interval
OR	Odds ratio
ROC	Receiver operating characteristic
AUC	Area under the curve

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