Dysphagia and Mechanical Ventilation in Sars-Cov-2 Pneumonia: It's Real

M^a Luisa Bordeje Laguna (✉ luisabordeje@gmail.com)

Hospital Universitari Germans Trias i Pujol <https://orcid.org/0000-0003-4129-7309>

Pilar Marcos-Neira

University Hospital Germans Trias i Pujol: Hospital Universitari Germans Trias i Pujol

Itziar Martínez de Lagrán Zurbano

Hospital de Mataró: Hospital de Mataró

Esther Mor Marco

Hospital Germans Trias i Pujol: Hospital Universitari Germans Trias i Pujol

Carlos Pollan Guisasola

Hospital Germans Trias i Pujol: Hospital Universitari Germans Trias i Pujol

Constanza Dolores Viñas Soria

Hospital Germans Trias i Pujol: Hospital Universitari Germans Trias i Pujol

Pilar Ricart Martí

Hospital Germans Trias i Pujol: Hospital Universitari Germans Trias i Pujol

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Abstract

BACKGROUND. Severe SARS-CoV-2 pneumonia has brought intensive care units (ICUs) and the consequences of prolonged hospitalisation, such as dysphagia, into focus.

METHODS. Study population: Patients with severe pneumonia due to SARS-CoV-2 who required admission to critical units from March to June 2020. Dysphagia diagnostic method: Modified Viscosity Volume Swallowing Test (mV-VST). Objectives. To identify risk factors for dysphagia in patients with severe SARS-CoV-2 pneumonia requiring invasive mechanical ventilation and determine their incidence. Statistical analysis: Descriptive analysis of means or medians according to the normality of quantitative variables and proportions for the descriptive variables (95% CI). Univariate analysis of dysphagia using simple logistic regression. Multivariate analysis and construction of a predictive model for dysphagia using logistic regression.

RESULTS. Descriptive analysis. Sample size: 232 patients; 72% (167) required intubation. Of these, 65.9% (110) survived and 84.5% (93) underwent the mV-VST, which diagnosed 26.9% (25) with dysphagia. Age: 60.5 years (95% CI: 58.5 to 61.9). Men: 74.1% (95% CI: 68.1 to 79.4). APACHE II score: 17.7 (95% CI: 13.3 to 23.2). Mechanical ventilation: 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). Overall mortality: 25.9% (95% CI: 20.6 to 31.9). Mortality in intubated patients: 34.1% (95% CI: 27.3 to 41.7). No patient diagnosed with dysphagia died. Univariate analysis. APACHE II, prone position, days of mechanical ventilation and need for tracheostomy, respiratory infection, kidney failure developed during admission and length of ICU and hospital stay were significantly associated ($p < 0.05$) with dysphagia. Multivariate analysis. Dysphagia is independently explained by 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 resulting predictive model predicts dysphagia with a good ROC curve (AUC: 0.8; 95% CI: 0.7 to 0.9)

CONCLUSIONS. Dysphagia affects almost one-third of patients, and the risk of developing dysphagia increases with prolonged mechanical ventilation, tracheostomy and greater severity on admission (APACHE II score).

Introduction

The WHO declared COVID-19 a pandemic on March 11, 2019. This new disease has brought intensive care units (ICUs) and the consequences of prolonged admission into focus. Such consequences include 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 ¹.

In recent years, there has been a considerable increase in the number of publications that discuss dysphagia associated with ICU admission. Although the number of publications is very important, their quality is questionable for several reasons: 1) the heterogeneity of the pathology presented by hospitalised patients (postsurgical patients, patients with neurological, septic pathology, etc.); 2) the

changes made in recent years with respect to early mobilisation that entail a functional improvement; 3) the different diagnostic methods used; and 4) ignorance of the presence of previous dysphagia, among other issues²⁻⁶. Knowing the real incidence of dysphagia associated with ICU admission presents a challenge; according to a systematic review, it can vary from 3–62%⁷.

The pathophysiology of dysphagia in critically ill patients has been widely described⁸. The six most important mechanisms are direct trauma to the orotracheal tubes and/or tracheostomy, ICU-acquired weakness⁹, decreased laryngeal sensitivity, altered consciousness, the presence of gastroesophageal reflux and asynchrony between respiration and swallowing^{10,11}. Among the described risk factors for dysphagia, several are clearly identified, such as congestive heart failure, functional status prior to admission, increased hospital and ICU stay, hypercholesterolemia, prolonged surgical time and the performance of perioperative transoesophageal echocardiography⁸. One factor associated with the development of dysphagia in the ICU is ICU-acquired weakness (ICUAW). The swallowing apparatus is muscular and, therefore, is affected in the same way as other muscles^{10,12}.

To these “classic” factors, others associated with SARS-CoV-2 pneumonia have been added. Treatment for SARS-CoV-2¹³ includes corticosteroids, which produce myopathy as a side effect; hydroxychloroquine, which increases corticosteroid myopathy; deep sedation and relaxation for a prolonged period; additionally, orotracheal intubation causes physical damage, patients may need to be positioned in prone decubitus, and SARS-CoV-2 infection itself can cause neurological damage (stroke, encephalitis and Guillain-Barré, among other concerns). All of these factors favour the development of ICUAW and, therefore, the occurrence of dysphagia^{14,15}.

Critically ill patients with dysphagia have higher morbidity than those without dysphagia. Thus, they more frequently require reintubation with a greater probability of death, they frequently require surgical access to food, they have longer hospital stays and, frequently, they need to be discharged to rehabilitation centres⁸.

The duration of ICU-related dysphagia varies depending on the cause, but in general, patients recover in a short period of time since dysphagia in these cases is closely related to ICUAW^{16,17}.

Currently, for the diagnosis of dysphagia in critical patients, either of two “gold standard” tests should be used: Videofluoroscopic swallowing study (VFSS)¹⁸ or fiberoptic endoscopic evaluation of swallowing (FEES)^{19,20}. In a VFSS, water with barium contrast is administered at different volumes and textures, and the moment of swallowing is visualised using continuous scanning. In comparison, for FEES, an endoscope is introduced through the nostrils to the glottic area, and swallowing is observed directly as the patient consumed water with different volumes and textures²¹. Both explorations are relatively contraindicated in cases of SARS-CoV-2 infection since they generate aerosols, which favour contagion; thus, the published articles do not recommend their use, and such studies should be strictly limited to patients with a high risk of aspiration/malnutrition²².

Therefore, a bedside screening test is recommended. For this, complete personal protective equipment (PPE) must be worn with an FFP3 mask, and it is recommended to keep 2 metres away from the patient at the time of swallowing and to stay to the patient's side to avoid the trajectory of the aerosols²². Two years before the pandemic, our centre validated the Modified Viscosity Volume Swallowing Test (mV-VST)²³, a bedside screening method that facilitates the diagnosis of dysphagia and was performed during the first wave of the pandemic prior to the start of the oral diet (Fig. 1).

The purpose of this study was to determine the incidence of dysphagia with the mV-VST and to identify the factors associated with its occurrence in patients with severe pneumonia due to COVID-19.

Material And Methods

Study population: Patients with severe COVID-19 pneumonia who required admission to the ICU of the Germans Trias i Pujol Hospital in Badalona from March to June 2020.

Modified Viscosity Volume Swallowing Test (mV-VST)²³

The mV-VST is based on the swallowing of nectar, pudding and liquid textures. These textures are achieved by mixing mineral water with the dose of thickener indicated by the manufacturer. To visually detect aspiration, all textures are stained with food coloring. The swallowing test is shown in Fig. 1. Before starting the examination, the patient is asked to say his or her name to identify the tone of voice. The exploration begins with the nectar viscosity. Increasing volumes (5, 10 and 15 mL) are consecutively placed in the patient's mouth with a 50-mL syringe. For each bolus administered, the following safety parameters are assessed: Presence of cough, desaturation > 3%, change in tone of voice (evaluated by asking the patient to repeat his/her name) and the presence of pharyngeal residue (the patient is asked whether he/she has the sensation of food remaining in the pharyngeal area). If there is no alteration in any parameter, the same assessment is performed with the pudding-viscosity boluses, and if there are no alterations, the evaluation progresses to the liquid viscosity. In the case of alteration in a single safety parameter, the evaluation of that viscosity is suspended, and the next safest viscosity is administered. In cases of safety alterations when swallowing the pudding viscosity, the liquid texture will not be evaluated.

In the case of critically ill patients breathing with a tracheostomy tube, the following considerations should be taken into account: The ideal situation for assessing dysphagia is for the patient to breathe with a fenestrated tracheostomy tube, deflated cuff and fenestrated inner cannula to allow proper assessment of the tone of voice and the presence of aspiration. If the critically ill patient is breathing with a nonfenestrated cannula, the mV-VST examination will be performed with a deflated cuff; in this case, the patient must breathe without a respirator, and changes in the tone of voice cannot be assessed. This exploration is carried out by members of the ICU nursing staff who have been adequately trained.

This swallowing test has been validated in critical patients through a single-centre study that compared its results with FEES as the gold standard. The results showed a sensitivity of 93%, a specificity of 75%, a negative predictive value of 96% and a positive predictive value of 63%. After these results, protocol required the administration of the swallowing test prior to the start of oral intake, which facilitated the performance of this study during the COVID-19 pandemic.

Objectives

The main objective was to identify the risk factors that independently explain the development of dysphagia in ICU patients affected by severe COVID-19 pneumonia requiring invasive mechanical ventilation. The secondary objective was to determine the incidence of dysphagia in these patients.

Inclusion criteria:

- The need for intubation and mechanical ventilation for seven or more days.
- Patients of legal age who were conscious and able to cooperate.
- Regarding consent to participate in the study, the Research Ethics Committee of the hospital accepted the exemption of informed consent due to the exceptional nature of the pandemic situation.

Exclusion criteria: None

When is the test performed?

- When the patient has been extubated, the test will be performed within 48 hours.
- When the patient is using a fenestrated tracheostomy tube, the test will be performed with the fenestrated inner cannula and a deflated cuff.
- When the patient is using a nonfenestrated tracheostomy tube, the test will be performed with a deflated cuff.

Sample size and data collection

Instead of calculating the appropriate n to find the risk factors associated with dysphagia, we calculated the power that the study would have by analysing the 232 critically ill patients affected by COVID-19 pneumonia who were admitted to our hospital during the first wave of the pandemic.

Power of the study implied by this n: Considering two-tailed significance, an incidence of dysphagia in critically ill patients in our ICU who were intubated for purely respiratory causes of 13.3% and a dysphagia incidence in the study sample of 22.7%, we found a power of 96.4% (nsize stata v.14), which was adequate to identify the factors that explained the presence of dysphagia.

Demographic variables related to severity at admission (APACHE II and SOFA scores) and type of pathology at admission were collected. Evolutionary variables were collected, including renal, infectious

and respiratory complications; days of mechanical ventilation; need for tracheostomy; appearance of dysphagia; ICU and hospital stay; and mortality.

Statistical analysis

Data collection was performed in Excel® and then exported to the statistical programme Stata® version 14.2 for analysis. The following statistical tests were applied:

1. Descriptive analysis of means or medians according to normality for quantitative variables and proportions for the descriptive variables, both with their respective 95% CIs. Normality was determined using the Shapiro-Wilk test.
2. Univariate analysis for dysphagia and possible confounding factors using simple logistic regression.
3. Multivariate analysis and construction of a predictive model for dysphagia using logistic regression.

Results

Descriptive analysis

During the study period, 232 patients were admitted, of whom 167 (72%) were intubated and 110 (65.9%) survived. A total of 93 (84.5%) underwent the mV-VST test, and 25 (26.9%) were diagnosed with dysphagia. See flow chart (Fig. 2).

The mean age was 60.5 years (95% CI: 58.5 to 61.9), and 74.1% were men (95% CI: 68.1 to 79.4). The average APACHE II score was 17.7 (95% CI: 13.3 to 23.2). Patients who were intubated were mechanically ventilated for an average of 14 days (95% CI: 11 to 16); 79% (95% CI: 72.1 to 84.6) required prone decubitus, and 34.5% (95% CI: 28.6 to 40.9) presented respiratory infection. The most frequent complication was renal failure in 38.7% (95% CI: 30 to 50). The overall mortality was 25.9% (95% CI: 20.6 to 31.9), and that of intubated patients increased to 34.1% (95% CI: 27.3 to 41.7). No patient diagnosed with dysphagia died. See the descriptive analysis in Table 1.

Table 1
Descriptive analysis of the sample

Variable	Mean/Median/Proportion	95% CI
Age (years)	60.5	58.5 to 61.9
Sex (male) (%)	172/232 (74.1)	68.1 to 79.4
BMI (kg/m2)	29	28 to 30
DM II (%)	17.7	13.3 to 23.2
APACHE II score	18	18 to 20
Onset of symptoms to prior to hospitalisation (days)	9	8 to 10
Onset of symptoms prior to ICU admission (days)	10	12 to 15
ICU stay (days)	11	10 to 12.3
Hospital stay (days)	27	26 to 30
Hydroxychloroquine (%)	183/232 (78.9)	73.1 to 83.7
Chloroquine (%)	44/232 (19)	14.4 to 24.6
Corticosteroids, boluses or regimen (%)	165/232 (71.1)	64.9 to 76.6
Remdesivir (%)	8/232 (3.4)	1.7 to 6.8

Variable	Mean/Median/Proportion	95% CI
Tocilizumab (%)	97/232 (41.8)	35.6 to 48.3
Onset of symptoms prior to hydroxychloroquine or chloroquine administration (days)	7	7 to 8
Onset of symptoms prior to corticosteroid administration (days)	15	13 to 18
Duration of corticosteroid use (days)	7	7 to 8
Sepsis with positive blood culture (%)	44/232 (17.7)	13.3 to 23.2
Respiratory infection (%)	80/232 (34.5)	28.6 to 40.9
Renal failure (%)	90/232 (38.7)	30 to 50
Intubation (%)	167/232 (72)	65.8 to 77.4
Prone decubitus (%)	132/167 (79)	72.1 to 84.6
Tracheostomy (%)	67/167 (40.1)	32.9 to 47.8
Mechanical ventilation (days)	14	11 to 16
ECMO (%)	12/167 (7.2)	4.1 to 12.3
Dysphagia in overall sample (%)	27/232 (11.6)	8 to 16.5
Dysphagia in intubated patients (%)	25/167 (22.7%)	15.8 to 31.6

Variable	Mean/Median/Proportion	95% CI
Dysphagia in intubated patients who were tested (%)	25/93 (26.9)	18.8 to 37
Death in overall sample (%)	60/232 (25.9)	20.6 to 31.9
Death in intubated patients (%)	57/167 (34.1)	27.3 to 41.7
Dysphagia in patients who died while intubated	No patient	

Univariate analysis

In the univariate analysis, the variables that were significantly associated with dysphagia were APACHE II score, prone decubitus and its duration, days of mechanical ventilation and need for tracheostomy, respiratory infection, the development of renal failure during admission and duration of ICU and hospital stay (Table 2).

Table 2
Univariate analysis of dysphagia

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/m2)	1.02	0.94 to 1.11	0.67
DM II	2.73	0.93 to 8	0.07
APACHE II score	1.12	1.02 to 1.24	0.02
Onset of symptoms prior to hospitalisation (days)	1	0.9 to 1.11	0.99
Onset of symptoms to prior to ICU admission (days)	1.04	0.96 to 1.12	0.32
ICU stay (days)	1.04	1.01 to 1.07	0.003
Hospital stay (days)	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
Duration of corticosteroids (days)	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 admission	6.37	2.34 to 17.39	<0.001
Mechanical ventilation (days)	1.06	1.03 to 1.09	<0.001
Prone decubitus	10	1.27 to 79	0.029
Prone (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
Days of ECMO (%)	0.86	0.53 to 1.38	0.53

Multivariate analysis

Before performing the multivariate analysis, we conducted a simple logistic regression to determine which dysphagia-related variables that were significant in the univariate analysis met the confounding

criteria. Thus, respiratory infection, prone decubitus and its duration, days of mechanical ventilation and the occurrence of renal failure during admission were discarded for this analysis.

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

Table 3
Multivariate analysis

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

Discussion

This study is important because it is one of the first to publish data on the incidence of dysphagia and factors related to its occurrence in critically ill patients with severe COVID-19 pneumonia.

Although patients affected by severe COVID-19 pneumonia could have a higher possibility of developing dysphagia, the overall incidence in our series of 167 intubated patients was 26.9%; this was similar to the reports for other series, which ranged from 3–62% ^{7,22,24–27}, but higher than that reported by our group for critically ill patients admitted for respiratory pathology (13.3%) ²³. This is probably because patients affected by COVID-19 pneumonia require prolonged ventilation and muscle relaxation due to ARDS and treatment with corticosteroids according to the recommendations of different scientific societies during the first wave of the pandemic ¹³.

Regarding the multivariate analysis, it was important to assess which confounding factors were associated with the tracheostomy variable. Thus, there is a clear association between the presence of a tracheostomy and the days of mechanical ventilation, the need for prone decubitus, respiratory infection and renal failure. Therefore, these variables could not be included in the multivariate analysis. In addition, the association between dysphagia and tracheostomy (OR: 10.3 95% CI: 3.38 to 31.4) was stronger than that between dysphagia and mechanical ventilation (OR: 1.06 95% CI: 1.03 to 1.09). Clinically, we interpreted that patients with prolonged mechanical ventilation and the need for tracheostomy are more likely to develop dysphagia.

The risk factors associated with the occurrence of dysphagia in this series (tracheostomy and APACHE II severity score) are consistent with those published in the literature ^{2,4,11}. It is logical that a patient with a tracheostomy, which is associated with intubation and prolonged ventilation, may present with dysphagia, in the same way that a patient with a high severity score on admission to intensive care may develop myopathy and dysphagia.

Although the presence of dysphagia in this study did not condition an increase in patient mortality, it was associated with an increase in the duration of ICU and hospital stay. For this reason, it is very important to have in place a screening protocol for dysphagia in ICUs that can be performed by nurses specialising in bedside critical care. The mV-VST is a fast and cost-effective test that will improve the safety of critical patients and reduce costs.

Limitations

The main limitation of this study is its retrospective nature with the possible biases that this entails.

In addition, due to the hospital collapse that was experienced during the first wave of the COVID-19 pandemic, we do not have any useful data for assessing dysphagia, such as the degree of weakness that the patient presented at the time of assessment, if he/she presented any.

In any case, despite the care pressure experienced, the test was performed in 84.5% of patients who required more than one week of mechanical ventilation. Only 15.5% of these patients were not studied; thus, the risk of selection bias was relatively small.

Conclusion

Dysphagia affects almost one-third of patients with COVID-19 pneumonia who require intubation, and the risk of developing dysphagia increases with prolonged mechanical ventilation with the need for a tracheostomy and with greater severity at admission (APACHE II score).

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

Declarations

Acknowledgements.

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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 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

Competing interests.

The authors declare no conflict of interest

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Figures

Figure 1

Dysphagia test (mV-VST)

Figure 2

Flow chart of the study

Figure 3

Model for predicting dysphagia with APACHE II score and tracheostomy