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LARYNGOLOGY

Dysphagia characteristics at FEES examination in post-extubation patients with COVID-19

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SUMMARY

Objective. The aims of this study was to analyse fibreoptic endoscopic evaluation of swallowing (FEES) findings in tube-fed patients with coronavirus disease 2019 (COVID-19).

Methods. Seventeen patients who had been intubated during intensive care unit (ICU) stay were enrolled. Pooling of secretions, dysphagia phenotype, penetration/aspiration and residue after swallow were assessed through FEES. The Functional Oral Intake Scale (FOIS) scores were also collected. Patients with significant swallowing impairment were evaluated again after 2 weeks.

Results. All patients were tube-fed at enrollment. According to the FEES results, 7 started total oral feeding with at least one consistency. The more common dysphagia phenotypes were propulsive deficit and delayed pharyngeal phase. Pooling of secretions, penetration/aspiration, and residue after swallow were frequently documented. A significant improvement in FOIS scores was found during the second FEES examination.

Conclusions. Swallowing impairment in patients with severe COVID-19 after discharge from the ICU is characterised by propulsive deficit and delayed pharyngeal phase. Most of these patients required feeding restrictions even if feeding abilities seem to improve over time.

KEY WORDS: deglutition disorders, COVID-19, intubation, dysphagia, fiberendoscopic evaluation of swallowing

Introduction

Several authors have described oropharyngeal dysphagia (OD) associated with COVID-19 with the aim to analyse its prevalence, severity and evolution [1-3]. Accordingly, several national and international societies developed position statements and commentaries to support clinicians involved in the management of patients with COVID-19 and OD [4,5]. However, the described populations were non-homogeneous and included patients who were admitted in the intensive care unit (ICU) (some requiring non-invasive ventilation, some orotracheal intubation), with or without tracheotomy, as well as those who were managed in rehabilitation and internal medicine departments [1-3,6].

OD is common in patients with COVID-19 [1] and its pathogenesis can be related to several factors. Frajkova et al. [2] identified 6 potential mechanisms of OD development: 1) oropharyngeal and laryngeal trauma; 2) neuromuscular weakness; 3) reduced laryngeal sensitivity; 4) altered sensorium; 5) gastro-oesophageal reflux; and 6) impaired respiratory-swallowing coordination. In addition, in ICU patients orotracheal intubation, mechanical ventilation and tracheostomy (all common scenarios in patients with COVID-19) are all independent risk factors for OD [1,7]. Previous studies on the prevalence of post-extubation dysphagia in the ICU largely vary according to the methodology used[8],

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while in a systematic review of the literature McIntyre et al. [9] reported that post-extubation dysphagia was present in 41% in critical ill adult patients.
OD limits the safely ingestion of adequate amounts of food and liquids thus placing the patient at increased risk for poor nutrition, dehydration, and morbidity in general [10]. In addition, it represents a key predictor of aspiration pneumonia [2] and an independent risk factor for malnutrition during hospitalisation [1] with consequent increased length of hospital stay and adverse outcomes and mortality. This is particularly true in patients with COVID-19, since they are, due to the severity of lung disease, particularly prone to suffer from respiratory complications after tracheal aspiration [2]. For these reasons, early identification of dysphagia is mandatory since it can reduce the incidence of these complications thus improving the clinical outcome. The diagnostic workup in this context usually comprises aspiration screening and, in case of screening abnormalities, a full dysphagia assessment, including, where appropriate, instrumental testing with fiberoptic endoscopic evaluation of swallowing (FEES) or videofluoroscopic swallow study (VFSS) [11].
FEES is considered an aerosol generating procedure and it is not recommended in patients with COVID-19 [5]. However, FEES has several advantages compared to VFSS. First, it is feasible in different clinical settings (such as ICU) and there is no need for radiation exposure. Additionally, it enables assessment of swallowing anatomy including the integrity of the cranial nerves, pharyngeal and laryngeal sensory-motor function, saliva and bolus management, and the effectiveness of compensatory strategies (postural manoeuvres, bolus modification) [12]. For these reasons, FEES procedures specifically developed to avoid COVID-19 infection of the examiner and of the patients being examined. Nonetheless, only limited data are available on the swallowing characteristics of patients with COVID-19 analysed through FEES [13]. In particular, no data exist on the phenotype of post-extubation dysphagia and its evolution, even if this information may be useful for clinical management of this population.
The aims of the study were to analyse FEES findings in tube-fed COVID-19 patients who were previously intubated and discharged from the ICU. We aimed to analyse secretions pooling, swallowing safety and efficacy, dysphagia phenotype, functional oral intake, and short-term evolution of the swallowing impairment.

Materials and methods

Participants

Seventeen patients with polymerase chain reaction (PCR) verified COVID-19 entering the pneumology department after discharge from the ICU where they had been intubated were included in the study. Patients were discharged from the ICU when clinical stability was reached. Criteria for clinical stability included: a) successful extubation; b) successful weaning from invasive mechanical ventilation in patients without tracheostomy; c) ability to maintain spontaneous breathing > 24 consecutive hours with or without non-invasive respiratory support with a $Fi0_2 < 50\%$; d) no signs of haemodynamic instability or septic shock, and no need for vasopressor support.
The inclusion criteria were: history of invasive mechanical ventilation through prolonged oro-tracheal intubation (≥ 48 hours) during ICU stay, tube feeding, age > 18 years, functional oral status, able to cooperate, and able to manage respiration in intervals without ventilatory support during weaning. Exclusion criteria were: previous history of dysphagia, unconsciousness, intolerance to the components of the tested foods, additional neurologic diseases, and history of head and neck cancer.
The Functional Oral Intake Scale (FOIS) [14], a seven-point ordinal scale indicating limitations in oral feeding which ranges from one (nothing by mouth) to seven (total oral diet with no restriction), was used to collect information regarding oral intake. The FOIS was administered immediately before the FEES examination.

FEES examination

FEES is considered an aerosol generating procedure and to guarantee safety for both patients and examiners and to minimise the risk of direct or fomite transmission of the virus, a standardised procedure was used for all evaluations. The FEES examiner was first trained in how to use personal protective equipment: Filtering FacePiece (FFP)2/3 mask, gloves, protective eyewear, water-proof disposable gowns and disposable hairnet were used during the examination. A disposable endoscope (Ambu® aScope™ 4 RhinoLaryngo Slim, Ambu, Denmark) was used with a working length of 300 mm and an insertion cord diameter of 3.0 mm, and allowed a full FEES with minimum discomfort for the patient and no limitations for the examiner. The endoscope was connected to a high-quality, portable, full-HD resolution (1920 x 1080) 12.8-inch touchscreen monitor (Ambu® aView™ 2 Advance, Ambu Denmark), providing large, sharp images. The monitor was covered with a plastic bag to prevent its contamination. All videos were stored in an anonymous form in AVI format.
Each patient was seated on their bed, leaning back (between 75-90° approximately) and keeping the head in a neutral position to obtain the best posture for the examination. No local anaesthetic drugs (e.g., lidocaine spray) were used in order to not alter pharyngo-laryngeal sensitivity [15].

Fourteen patients were tracheotomised and in these cases the FEES examinations were performed with the patients off the ventilator. The tracheal cuff was maintained deflated during the swallowing examination. The endoscope was introduced into the widest nasal cavity and kept at a level just inferior to the uvula to maximise the field of view, including the larynx, glossoepiglottic valleculae and piriform sinuses [12]. Three different textures of food were provided during FEES examination to evaluate swallowing:

- liquid: room temperature water dyed with skim milk (< 50 mPa·s at 50 s^{-1} and 300s^{-1}; International Dysphagia Diet Standardisation Iniatiative – IDDSI Level 0) [15] was used for thin liquid trials;
- semisolid: room temperature Crème Line vanilla pudding (Nutrisens Medical SAS, Francheville, France) (2583.3 ± 10.41 mPa·s at 50 s^{-1} and 697.87 ± 7.84 mPa·s at 300 s^{-1}; IDDSI Level 4) was used for semisolid trials;
- solid: a quarter and half of an 8-gram dry biscuit (4 g per trial; IDDSI Level 7) were used for solid trials.

FEES examinations were rated independently by three operators using the video files. All were phoniatricians involved daily in dysphagia management; all attended a course (2 days) on FEES ratings. Examiners were blind to each other and to participants' data, since videos were stored in an anonymous form. Two independent phoniatricians rated the videos using validated ordinal scales for swallowing safety and efficiency; inter-rater reliability between the 2 raters was analysed. In case of a difference > 1 level at each FEES rating scale between the 2 raters, a 3rd phoniatrician assessed the videos and decided on both ratings [14].

Different parameters were analysed using the FEES examination:

- pooling of secretions before the first swallow was analysed using the Murray Secrection Scale [16], a four-point scale with higher scores indicating more severe pooling;
- dysphagia phenotypes were defined according to the videoendoscopic scenarios proposed by Desuter [17]. In particular, the presence of the following six phenotypes was assessed: protective deficit, posterior oral incontinence, delayed pharyngeal phase, oropharyngeal dyspraxia, propulsion deficit, and resistive issue. Protective deficits include impairment of the following mechanisms: laryngeal elevation, glottis closure, and tongue propulsion. Posterior oral incontinence is defined as inability of the patient to contain the bolus in the oral cavity when asked to. Delayed pharyngeal phase is defined as a delay of at least one of the following mechanisms when the patient is asked to swallow: arytenoid approximation and glottis closure, laryngeal elevation, and tongue base propulsion. Oropharyngeal dyspraxia is the absence of pharyngeal swallowing and consequently retention of the bolus in the mouth or the appearance of cyclical movements of aborted movements of tongue base retraction. Propulsion deficit occurs when residue in the valleculae and/or the piriform sinuses are found with weak tongue base retraction and/or, pharyngeal peristalsis and/or laryngeal elevation. Finally, resistive issue is found when residues occur in the retrocricoid region;
- safety impairment (penetration/aspiration): the severity of penetration/aspiration was rated using the Penetration Aspiration Scale (PAS) [18]. The PAS is an 8-point scale ranging from 1 (materials do not enter the airway) to 8 (materials enter the airway, pass below the vocal folds and no effort is made to eject). Penetration was defined as the bolus entering the laryngeal vestibule over the rim of the larynx (PAS score from 2 to 5). Aspiration was defined as the bolus passing below the true vocal folds (PAS score 6 or above). Swallow safety was also evaluated similar to Tabor et al. study [19]. In particular, based on the PAS score, each swallow was classified as unsafe if the material entered the laryngeal vestibule (PAS ≥ 3). Information regarding the timing of unsafe swallows ("before", "during" or "after" the swallow) were also collected. The worst PAS score for each consistency and for each subject was considered for statistical analyses;
- efficiency impairment (pharyngeal residue): the amount of pharyngeal residue after the swallow was rated using the Yale Pharyngeal Residue Severity Rating Scale (YPRSRS) in the vallecula and piriform sinus [20]. Efficiency of swallow was also evaluated. In particular, a YPRSRS scores ≥ 3 (mild residue) was considered suggestive of an inefficient swallow. The worst YPRSRS score for each consistency and for each subject was considered for statistical analyses;
- similar to the study of Osbeck Sandblom et al. [13], laryngeal evaluation was performed in order to highlight the presence of movement impairment, active adduction of the vocal cords during expiration, vocal fold lesions, oedema and/or erythema of the vocal folds and supraglottal structures.

Patients with significant swallowing impairment were evaluated again at 2 weeks to check for possible improvement of swallowing function.

Statistical analysis

Statistical tests were performed using the SPSS 28.0 statistical software (SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov test was used to test the normality of the distribution of FEES parameters among the patients. Since this test demonstrated that the distribution was not normal, non-parametric tests were used. Inter-rater reliability of FEES scoring between the two phoniatricians was analysed. Weighted kappa with quadratic weighting was calculated; k values

were interpreted as follows: ≤ 0.20 poor agreement, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 good, and 0.81-1.00 very good [21]. Wilcoxon test was used to compare the differences in FOIS scores obtained during the first and second FEES evaluation. Fisher's exact test was used to compare the distribution of dysphagia characteristics (safety, efficiency, phenotypes, laryngeal evaluation) between the two FEES evaluations because the variables were considered categorical. Statistical significance was considered at $p < 0.05$.

Results

Characteristics of the recruited population are reported in Table I. All patients were tube-fed at the first evaluation (FOIS score = 1 in all the cases). The median ICU stay was 31 days, tracheal cannula was removed at 13.5 days (median) after ICU discharge and FEES examination was performed at 43 days after hospital admission. FEES was performed using all three consistencies in only 2 patients. In the remaining 15 patients, semisolid was always tested, liquid was tested in 10 patients and solid was never tested. One or more consistencies were not tested if there was a significant risk of choking. All subjects included in the study completed the FEES protocol using at least one consistency (semisolid in all the cases).

Table I. Characteristics of the population at the time of the first FEES examination. Medians are reported as well as interquartile ranges (in parentheses).

	Total (n = 17)
Gender	17 males
Age	68 years (64-71)
FOIS	1 (1-1)
Duration of intubation	9 days (8-10)
Duration of mechanical ventilation	30 days (21-40)
Tracheostomy	14 (82.4%)
ICU stay	31 days (22-39)
Feeding tube removal after ICU discharge	17.5 days (9.25-26)
Tracheal cannula removal after ICU discharge	13.5 days (6.75-22.25)
FEES examination from ICU discharge	43 days (32-53)

FOIS: Functional Oral Intake Scale; ICU: intensive care unit.

According to the FEES results, 10 patients maintained tube dependent feeding because deglutition was considered unsafe. The remaining 7 patients started a total oral diet: 2 with a single consistency (FOIS = 4), 4 with multiple consistencies but requiring special preparations or compensations (FOIS = 5), and one with no restrictions (FOIS = 7). The time required to complete FEES never exceeded 15 minutes. FEES inter-rater agreement ranged from good to very good. In particular, inter-rater agreement with each of the different consistencies for the PAS ($k > 0.91$) and for the YPRSRS in the vallecula and piriform sinus ($k > 0.86$ and $k > 0.88$, respectively) was very good.

FEES examination was performed again in patients with a FOIS score ≤ 4. Twelve patients were evaluated twice, 3 patients three times, 2 patients four times, and one patient five times.

Feeding

The results of FOIS scores were collected for all the patients before and after the first and the second FEES examination (Fig. 1). Information regarding oral intake were gathered during the second FEES examination in patients who were evaluated twice, and after 2 weeks from the first FEES in those (n = 5) who had a FOIS score > 4 and did not undergo a second FEES. A significant improvement in the FOIS score was demonstrated at Wilcoxon test ($p = 0.038$).

Swallowing

Saliva residue

At the first FEES examination the median Murray scale score was 2 (interquartile range 2-3). In only 3 patients

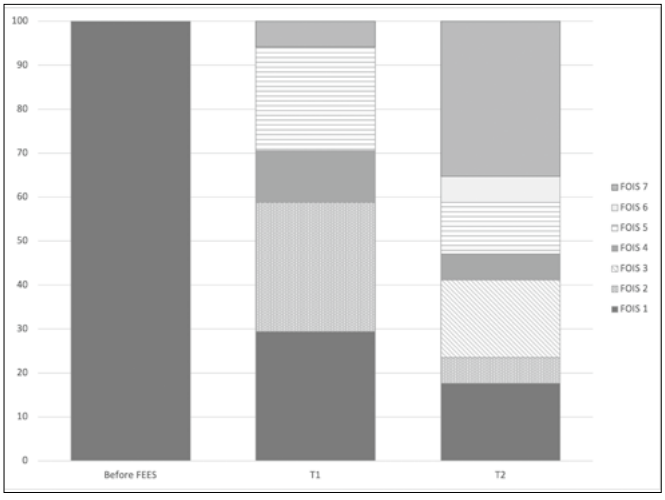

Figure 1. Functional Oral Intake Scale (FOIS) scores obtained before and after the first (T1) and second (T2) FEES examination. Information regarding FOIS were collected also in patients who were not evaluated again using FEES.

were there no visible secretions anywhere in the hypopharynx. On the other hand, secretions pooling in the larynx were seen in 8 of 17 patients (47.1%). At the second FEES examination, the median Murray scale score decreased (median score 1, interquartile range 1-3) as well as the percentage of patients with secretions pooling in the larynx (5 out of 12 patients, 41.7%). This difference was found not significant at Fisher's test (p = 0.157) (Fig. 2).

Dysphagia phenotypes

The presence of at least one dysphagia phenotype was demonstrated in 15 of 17 patients (94.1%). A propulsion deficit was the most common one (n = 11/17, 64.7%), followed by protective deficit (n = 5/17, 29.4%) (Fig. 3). Nine patients (52.9%) showed only one isolated phenotype, while the remaining 6 patients (35.3%) showed two combined phenotypes. During the second FEES examination performed in 12 patients the presence of at least one dysphagia phenotype was demonstrated in 9 patients. The most common dysphagia phenotype was a propulsion deficit (5/12, 41.7%), followed by protective deficit (n = 4/12, 33.3%). No significant differences in the dysphagia phenotype during the first and second FEES examination was demonstrated at Fisher's test (p = 0.755).

Swallowing safety

The differences in the distribution of the 3 PAS categories (normal, penetration, aspiration) for the 3 consistencies are reported in Table II. During the first FEES examination penetration was more frequent with liquid (7 of 12 patients, 58.3%), followed by semisolid (5 of 17 patients, 29.4%). Aspiration occurred more frequently with liquid (3 patients, 25%) than with semisolid (2 patients, 11.8%). Regarding swallowing safety, with the liquid consistency 10 of 12 patients (83.3%) had unsafe swallows (3 patients had aspiration and 7 had penetration). Compromised airway protection occurred across all timing zones (before *vs* during *vs* after), however unsafe swallow with liquid consistency was more frequent "during" the swallow (7 out of 10 patients). With the semisolid consistency, 7 patients (41.2%)

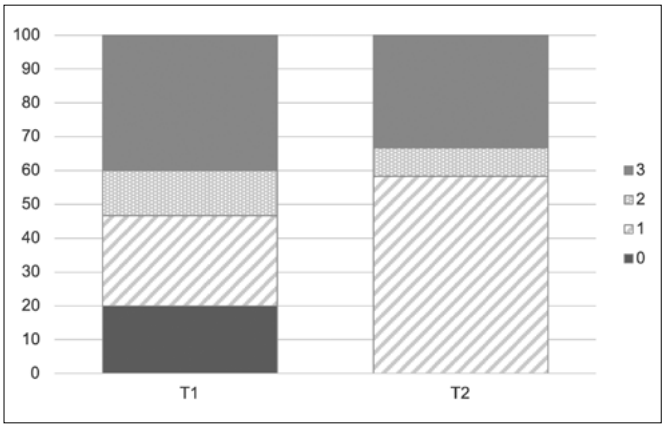

Figure 2. Secretions pooling analysed using the Murray scale at the first (T1) and second (T2) evaluation.

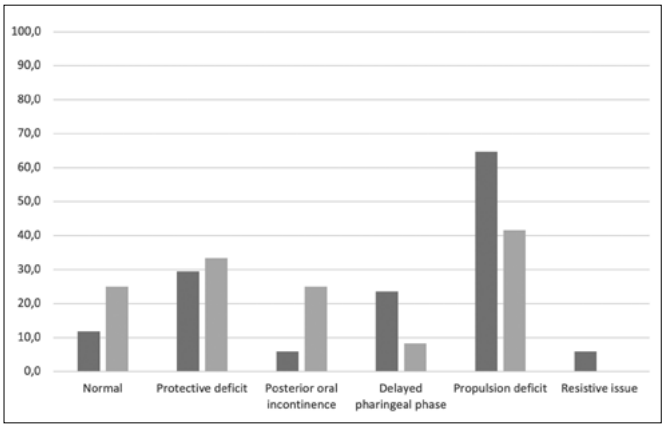

Figure 3. Dysphagia phenotypes at the first (T1 - dark grey) and second (T2 - light grey) FEES examination.

Table II. Penetration Aspiration Scale (PAS) scores obtained in the cohort of patients. The results are reported as absolute (relative) frequencies. The PAS scores were categorised in Normal, Penetration (PAS score from 2 to 5) and Aspiration (PAS score 6 or above). The number of patients tested with the different consistencies during the first (T1) and second (T2) FEES examination are reported in parentheses.

		Consistency					
		Liquid		Semisolid		Solid	
		T1 (12 pts)	T2 (10 pts)	T1 (17 pts)	T2 (12 pts)	T1 (2 pts)	T2 (5 pts)
PAS	Normal	2 (16.7%)	3 (30%)	10 (58.8%)	7 (58.3%)	2 (100%)	5 (100%)
	Penetration	7 (58.3%)	7 (70%)	5 (29.4%)	3 (25%)	/	/
	Aspiration	3 (25%)	/	2 (11.8%)	2 (16.7%)	/	/

had unsafe swallows and compromised airway protection occurred more frequently "after" the swallow (5 of 7 patients). During the second FEES examination, penetration was more frequent with liquid (7 of 10 patients, 70%), followed by semisolid (3 of 12 patients, 25%). Aspiration was demonstrated only for semisolid (2 of 12 patients, 16.7%). Regarding swallowing safety, with the liquid consistency 7 of 10 patients (70%) had unsafe swallow. Compromised airway protection occurred more frequently "during" the swallow (5 of 7 patients). With the semisolid consistency 5 patients (41.7%) had unsafe swallow and compromised airway protection occurred more frequently "after" the swallow (3 of 5 patients). No differences in the distribution of unsafe swallow were demonstrated at Fisher's test between the first and second FEES examination ($p = 0.406$ for liquid; $p = 0.637$ for semisolid).

Swallowing efficiency

The YPRSRS scores obtained are reported in Table III. At the first FEES examination the median YPRSRS vallecula score was 2 for all consistencies, while the YPRSRS piriform sinus score ranged from 1.5 for the solid to 3 for the semisolid. Regarding swallowing efficiency, with the liquid consistency 4 and 5 of 12 patients (33.3% and 41.7%) had at least mild residue after swallow in the valleculae and piriform sinuses, respectively. With the semisolid consistency, 7 and 8 of 17 patients (41.2% and 47.1%, respectively) had at least mild residue after swallow in the valleculae and piriform sinuses. Finally, solid consistency was tested in only 2 patients. None had mild residue after swallow in the valleculae and piriform sinuses. At the second FEES examination, the median YPRSRS vallecula and piriform sinus score was 3 for liquid and semisolid, while lower values were found for the solid. Swallow was not considered efficient with the liquid consistency in 6 of 10 patients (60%) who had at least mild residue after swallow in the valleculae and piriform sinuses. With the semisolid consistency, 6 of 12 patients (50%) had at least mild residue after swallow in the valleculae and piriform sinuses. Finally, with the solid consistency only 2 of 5 patients (40%) had at least mild residue after swallow in the valleculae. The differences in the distribution of efficient and non-efficient swallow between the first and second FEES examinations were not significant at Fisher's test.

Laryngeal evaluation

Abnormal laryngeal findings are reported in Table IV. The majority of patients had normal vocal cords movement. Only one patient had a vocal fold lesion (stable also during the second FEES examination). Oedema of the epiglottis was demonstrated in only 2 patients during the first evaluation and in none during the second. This difference was found not significant at Fisher's test ($p = 0.335$). A slight ventricular fold oedema and a slight-to-moderate arytenoid oedema were found in 7 and 12 of 17 patients during the first FEES examination, respectively, and in 2 and 7 patients during the second. These differences were not significant at Fisher's test ($p = 0.197$ and $p = 0.507$, respectively).

Discussion

In the present study the characteristics of OD in tube-fed critically-ill patients with COVID-19 treated with mechanical ventilation were analysed using FEES. The OD phenotypes have been analysed for the first time in this population and OD safety and efficacy data of the only existing FEES study [13] have been replicated. As several mechanisms contribute to development of OD in this population, the study design did not allow to clarify the role of COVID-19 in addition to prolonged intubation. Nonetheless, the data provided support in understanding the characteristics and severity of OD and consequently in developing management plans.

Feeding

All patients had enteral nutrition through a nasogastric tube at the time of the first FEES examination. According

Table III. Yale Pharyngeal Residue Severity Rating Scale (YPRSRS) scores obtained in the cohort of patients. The results are reported as median and interquartile range (in parentheses). The number of patients tested with the different consistencies during the first (T1) and second (T2) FEES examination are reported in parentheses.

		Consistency					
		Liquid		Semisolid		Solid	
		T1 (12 pts)	T2 (10 pts)	T1 (17 pts)	T2 (12 pts)	T1 (2 pts)	T2 (5 pts)
YPRSRS	Vallecula	2 (2-3)	3 (2-3)	2 (2-3)	3 (2-3)	2 (2-2)	2.5 (1.75-3.25)
YPRSRS	Piriform sinus	2 (2-3)	3 (2-3)	3 (2-4)	3 (2-3)	1.5 (1.25-1.75)	1.5 (1-2)

Table IV. Laryngeal findings during the first (T1, performed in 17 patients) and second (T2, performed in 12 patients) FEES examination. The results are reported as absolute (and relative) frequencies.

		T1	T2
Vocal folds movement	Normal	14 (82.3%)	10 (83.3%)
	Left impaired/right normal	1 (5.9%)	0 (0%)
	Impaired bilaterally	1 (5.9%)	1 (8.3%)
	Left immobile/right normal	1 (5.9%)	1 (8.3%)
Active adduction during expiration		0 (0%)	0 (0%)
Vocal folds lesions	None	16 (94.1%)	11 (91.7%)
Contact granuloma		1 (5.9%)	1 (8.3%)
Vocal folds oedema		0 (0%)	0 (0%)
Vocal folds erythema		0 (0%)	0 (0%)
Edema of the epiglottis	None	15 (88.2%)	12 (100%)
	Slight	1 (5.9%)	0 (0%)
	Moderate	1 (5.9%)	0 (0%)
Ventricular folds oedema	None	10 (58.8%)	10 (83.3%)
	Slight	7 (41.2%)	2 (16.7%)
Arytenoids oedema	None	5 (29.4%)	5 (41.7%)
	Slight	8 (47.1%)	7 (58.3%)
	Moderate	4 (23.5%)	0 (0%)

to the results of FEES, 7 of 17 patients started total oral feeding with at least 1 consistency. These results appear similar to those previously reported. Osbeck Sandblom et al.[13] found that approximately 30% of critically-ill patients with COVID-19 treated with mechanical ventilation had a normal feeding or a total oral diet with restrictions (FOIS score ≥ 5). Clayton et al. [22] reported that 37% of a group of patients with COVID-19 admitted to ICU were able to commence an oral diet after the initial assessment. These data suggest that in the early post-ICU stay, these patients may frequently require feeding restrictions, even if the ability to start with an oral diet appears to increase over time.

Swallowing

Saliva residue

Pooling of secretion was found in the majority of the patients (14 of 17) while the presence of secretions in the laryngeal vestibule was found in 41.7% of cases. Similar results were reported by Osbeck Sandblom et al. [13] who found pooling secretion and consistent secretion in the laryngeal vestibule in 92% and 46% of cases, respectively. It is possible that neuromuscular weakness and reduced sensitivity due to prolonged stay in the ICU might have played a role [13]. Prolonged analgosedation, use of neuromuscular blocking agents, non-use of muscular and neural structures, and sensory deprivation which may occur during long-term intubation have been demonstrated to negatively impact swallowing abilities [2,13].

Dysphagia phenotypes

Altogether, 94.1% of patients demonstrated swallowing impairment and in 41.2% two dysphagia phenotypes were detected. The more common were the propulsive deficit, followed by delayed pharyngeal phase. The high prevalence of swallowing impairment found in the present study is in accordance with previous reports [13,22], even if it is difficult to discuss the phenotypes leading to dysphagia since no previous study analyzed this topic in patients with COVID-19. It is possible that neuromuscular weakness and reduced sensitivity, which have been identified as causative factors of dysphagia in critically patients with COVID-19 [2], might have played a role in determining the high prevalence of propulsive deficit and delayed pharyngeal phase. In particular, neuromuscular weakness could be a consequence of prolonged inactivity of the structures involved in the swallowing act, analgosedation and use of neuromuscular blocking agents. Neuromuscular weakness may lead to dyscoordination of muscles and nerves which may reduce the force applied in the oral and pharyngeal cavities thus affecting the bolus transport. In addition, sensitive deprivation may determine an impairment of the chemoreceptors and mechanoreceptors of upper respiratory tract, including those involved in the triggering of swallowing [2], thus determining a delayed pharyngeal phase.

Swallowing safety

Penetration and aspiration were frequently documented, especially with liquids. Most patients had unsafe swallow

at both the first and second FEES examinations (83.3% and 70%, respectively). These data are consistent with the results of Osbeck Sandblom et al. [13] and suggest that the viscosity of the ingested food significantly affects swallowing safety in these patients. This finding agrees with Clavé et al. [23] who found that in patients with neurogenic dysphagia, increasing viscosity brought about a dramatic improvement in safety by minimising penetration and aspiration during swallow. It is possible that neuromuscular weakness, injuries in the larynx or hypopharynx caused by the endotracheal tube or heavy reflux, discoordination of swallowing and breathing, and poor sensation in the larynx and pharynx could have played a role in determining the high prevalence of penetration and aspiration [13].

No differences in swallowing safety between the first and second FEES examinations were detected. This should not be interpreted as a stable severity of dysphagia over time, rather it is more probably related to the fact that during the second examination only patients with a FOIS score ≤ 4 were evaluated.

Swallowing efficacy

Residues after swallow in the valleculae and piriform sinuses were frequently detected, particularly with the semisolid consistency. In addition, inefficient swallow was found in a high percentage of patients regardless of the consistency of the ingested food, thus suggesting impairment in the bolus propelling from the oropharynx to the oesophagus.

During the second FEES examination, the efficiency of swallow worsened but this is probably related to the fact that patients with better swallowing abilities and who were considered eligible for a total oral diet were not evaluated again.

Laryngeal evaluation

Abnormal laryngeal findings were quite uncommon in the patients included in this study. Active adduction during expiration, vocal folds oedema and vocal folds erythema were never documented. Oedema of the ventricular folds or arytenoids were found in 41.2% and 70.6% of the sample, while impaired vocal folds movement was found in 3 of 17 patients (17.6%). Osbeck Sandblom et al. [13] reported impaired vocal folds movement in 76%, active adduction of the vocal folds during inspiration in 83%, slight-to-moderate vocal folds oedema and erythema in 12% and 60% of patients respectively. Brodsky et al. [24] in their systematic review of the literature on laryngeal injury after ICU care concluded that vocal folds immobility was present in 21%, vocal folds erythema and oedema in 82% and 70% respectively, and arytenoids oedema in 71% of the total sample of patients. It is possible that these diverging results may be related to the different timing of laryngeal evaluation. In the study of Brodsky et al. [24] laryngeal evaluation was performed in the majority of cases within 72 hours from extubation; in the study by Osbeck Sandblom et al. [13] the first FEES was performed in the ICU in 10 patients and in 15 patients after discharge from the ICU. In the present study, the first FEES examination was performed at 43 days after hospital admission. It is possible that laryngeal injuries and functions improve over time, which could explain the lower prevalence of these findings in our study. This hypothesis is supported by the results of Rouhani et al. [25] who analysed voice and swallow outcomes in 41 patients with COVID-19 who required tracheal intubation at two months after hospital discharge. The authors found that 81% of these patients had normal endoscopic examination of the larynx, while impaired vocal folds movement was detected in 22%.

Study limitations

There are several limitations of this study. First, the number of enrolled patients is quite small, even if in line with previous studies. Consequently, the results reported herein should be considered with caution. In addition, no control subjects were included (i.e. patients without COVID-19 admitted to pneumology unit after discharge from the ICU where they have been intubated). It is therefore impossible to disambiguate between the role of COVID-19 and that of prolonged oral intubation and ICU stay in the development of OD. In addition, a possible selection bias should be considered given that the cohort enrolled may not be representative of the entire COVID-19 patient population. Similar to the study by Osbeck Sandblom et al. [13] patients were referred for FEES by the pneumology unit and it is possible that those who were referred had greatest difficulties. Moreover, dysphagia phenotypes were judged as present or absent, according to the classification proposed by Desuter [17], whose psychometric properties still need to be analysed.

Conclusions

Swallowing impairment in patients with severe COVID-19 after discharge from ICU is characterised by propulsive deficit and delayed pharyngeal phase. Most of these patients required feeding restrictions even if feeding abilities seem to improve over time. For this reason, the evaluation of swallowing abilities in such patients should be performed before initiation of oral feeding in order to prevent dysphagia-related complications.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

SR, MG, DR, PS, NP: material preparation, data collection and analysis; FM, AS: first draft of the manuscript. All authors contributed to the study conception and design, commented on previous versions of the manuscript, read and approved the final manuscript. All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethical consideration

This study was approved by the Institutional Ethics Committee (Ospedale L. Sacco, approval number 17263/2020). The research was conducted in accordance with the requirements of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from each participant/patient for study participation and data.

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