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REVIEW

Clinical Approaches to Assess Post-extubation Dysphagia (PED) in the Critically Ill

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Abstract

Swallowing disorders and respective consequences (including aspiration-induced pneumonia) are often observed in extubated ICU patients with data indicating that a large number of patients are affected. We recently demonstrated in a large-scale analysis that the incidence of post-extubation dysphagia (PED) is 12.4% in a general ICU population and about 18% in emergency admissions to the ICU. Importantly, PED was mostly sustained until hospital discharge and independently predicted 28- and 90-day mortality. Although oropharyngeal/laryngeal trauma, neuromuscular ICU-acquired weakness, reduced sensation/sensorium, dyssynchronous breathing, and gastrointestinal reflux, are all considered to contribute to PED, little is known about the underlying pathomechanisms and risk factors leading to PED in critically ill patients. Systematic screening of all potential ICU patients for oropharyngeal dysphagia (OD) seems key for early recognition and follow-up, as well as the design and testing of novel therapeutic interventions. Today, screening methods and clinical investigations for dysphagia differ considerably. In the context of a recently proposed pragmatic screening algorithm introduced by us, we provide a concise review on currently available non-instrumental techniques that *could* potentially serve for non-instrumental OD assessment in critically ill patients. Following systematic literature review, we find that non-instrumental OD assessments were mostly tested in different patient populations with only a minority of studies performed in critically ill patients. Due to little available data on non-instrumental dysphagia assessment in the ICU, future investigations should aim to validate respective approaches in the critically ill against an instrumental (gold) standard, for example, flexible endoscopic evaluation of swallowing. An international expert panel is encouraged to addresses critical illness—related definitions, screening and confirmatory assessment approaches, treatment recommendations, and identifies optimal patient-centered outcome measures for future clinical investigations.

Keywords Swallowing disorder · ICU-ASD · ICU-AW · Neuromuscular · Sepsis · Non-instrumental

Background

Oropharyngeal dysphagia (OD) denotes any difficulty or inability to effectively and safely transfer liquids, and food from the mouth during the oral preparatory, oral transit, and pharyngeal stages of swallowing. The oral and pharyngeal phase is ended when the bolus enters the esophagus. OD may lead to various complications in critically ill patients including dehydration/malnutrition, increased (and/or prolonged) feeding tube need, increased incidence of aspiration-induced pneumonia, airway incompetency with need for re-intubation or tracheostomy, impaired recovery from critical illness, prolonged mechanical ventilation, increase intensive care unit (ICU) resource use, decreased quality of life, prolonged ICU- and hospital length of stay [1–9], and increased 28-day and 90-day mortality [8]. Dysphagia is thus recognized to impose a considerable burden on public health care systems and data indicate that up to 10 billion dollars in health care costs are being spent annually in the U.S. alone for treatment of respective patients [10, 11].

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Epidemiology of Dysphagia

From a clinical perspective, the above listed consequences of dysphagia (for example, aspiration-induced pneumonia) can often be observed on ICUs. Nevertheless, the incidence of dysphagia in mixed, non-selected populations of critically ill patients was unknown until recently [7]. In fact, previous smaller analyses in selected high-risk ICU populations (post cardio-surgery patients or acute stroke patients) reported incidence rates ranging from 3 to 62% [1, 7, 12–15]. Our own data from a recent larger observational study performed in two independent academic centers show that the overall incidence is 12.4% in mixed ICU populations with about 18% of patients with (initial) emergency admission affected [8]. In general, patients with emergency admission and/or neurological disease at baseline may be considered high-risk patients [8, 16–18]. Importantly, the available data suggest that the majority of dysphagia positive ICU patients have sustained dysphagia until hospital discharge [8]. The observation that dysphagia is mostly persisting is supported by data from selected high-risk populations, such as survivors of the acute respiratory distress syndrome (ARDS). Recently published data indicate that recovery from dysphagia may take up to several years [19]. Importantly, however, dysphagia after mechanical ventilation was identified as an independent predictor of short-term (28-day) and mid-term (90-day) mortality after adjustment for typical confounders in mixed ICU populations [8].

Etiology of Dysphagia

Six potential key mechanisms leading to development of post-extubation dysphagia (PED) in critically ill patients were suggested [1, 2]: oropharyngeal and/or laryngeal trauma (for example, induced by the ventilation tube), neuromuscular (ICU-acquired) weakness [20, 21], reduced laryngeal sensation (due to either critical illness polyneuropathy or to local edema), altered sensorium related to delirium or sedation, gastroesophageal reflux, and dyssynchronous breathing/swallowing [2]. Nevertheless, it seems important to note that the underlying mechanisms leading to dysphagia in extubated ICU patients are only partly understood. Although some dysphagia cases appear clearly attributable to the underlying disease (for example, in acute stroke patients), dysphagia can be observed in a wide range of critically ill patients including patients post elective cardio-surgery [8, 12–15].

Diagnostic Approaches to Dysphagia

For a reliable diagnosis of dysphagia following stroke, a stepwise approach was suggested [22] in which a baseline screening tool is used to identify patients *at risk*, followed by a comprehensive bedside assessment by a swallowing specialist (such as physiotherapist, PT or speech language therapist, SLT). If available, this specialist confirmatory exam should be complemented by use of instrumental approaches, such as flexible endoscopic evaluation of swallowing (FEES) or VFSS (videofluoroscopic swallowing studies), which could be regarded as the gold-standard examination [23]. A stepwise approach may be of particular importance when larger cohorts of patients shall be screened, as in large cohorts of critically ill patients [8]. Such an approach may allow both identification of patients at risk (screening, optimally with a very high sensitivity) and establishing of the diagnosis confirming the presence of OD (confirmatory assessment).

In extubated critically ill patients on the ICU, a systematic bedside screening algorithm using the water swallow test (WST) followed by expert comprehensive swallowing assessments of screening positive patients was recently recommended by us and others [2, 8]. As stated, the clinical approach should best be complemented by instrumental diagnostic approaches (such as FEES) in ICU populations. It should, however, be noted that invasive measures to diagnose dysphagia require additional training, resources, and may thus not be easily available on today's ICUs and, as of today, availability of FEES may mostly be limited to tertiary care ICUs. A major advantage of FEES consists in direct evaluation of swallowing with respect to penetration and/or aspiration [24]. However, it seems important to acknowledge, that no screening tool shows near-perfect test performance with regard to sensitivity and/or specificity. Especially in OD diagnostics, for example, reliability and validity for WST and BSE are debated with regard to the reliability and validity of the evaluation [25–29]. Thus, future research should validate respective clinical screening algorithms in the target population, which is in critically ill patients. Nevertheless, the WST may serve as a pragmatic screening tool in larger cohorts of ICU patients [8] despite its lack of *being* adequately validated in ICU populations with potential PED [1, 2, 6, 7, 30]. Most importantly, however, it seems that a systematic approach should be installed on ICUs which seems key to identify all affected patients and to consider respective available treatment strategies [31].

Aims and Objectives of this Article

The objective of this article is to review currently available non-instrumental techniques for assessment of oropharyngeal dysphagia (i.e., presence of OD, diagnosing OD) that *could* serve for non-instrumental post-extubation dysphagia (PED) assessment in critically ill patients.

Methods

Literature Search

Online databases of MEDLINE/PubMed, the Cochrane Library, and Cinahl database were searched using the following terms: deglutition disorders OR dysphagia AND (diagnos* OR assessment OR evaluation) AND valid* NOT reflux NOT esophag*. Literature until 31st of July, 2017 was included. Additional articles were searched for non-instrumental dysphagia assessments in respective reference lists/citations of identified articles.

In- and Exclusion Criteria

Articles available in English, German, French, Italian, Spanish, and Portuguese documenting and/or validating non-instrumental dysphagia assessments in adult subjects with OD (intended for dysphagia specialists) were eligible for inclusion. Articles were reviewed by the team of authors who had sufficient language skills/knowledge regarding respective languages. Authors were unblinded for this process. Articles based on the following approaches were excluded: instrumental assessments to diagnose dysphagia, general screening tools [32] clearly aiming for dysphagia risk evaluation, other diagnostic approaches such as rating scales/quality of life evaluations, clinical assessments without any test validation, articles studying pediatric populations, articles not assessing OD, questionnaires, and single dysphagia test-items (for example, cervical auscultation) considered as screening tools for OD risk assessment (Fig. 1). Due to the fact that data on non-instrumental OD assessment in hospitalized patients are limited (especially with regard to critically ill patients on the ICU), we extended our focus and included assessment tools used and validated in other patient populations (including outpatient cohorts).

Analysis and Interpretation of Available Data

All OD assessment tools presented in the included articles were analyzed for test performance by comparing sensitivity (true positive rate, TPR), specificity (true negative rate, TNR), positive and negative predictive values (PPV, NPV),

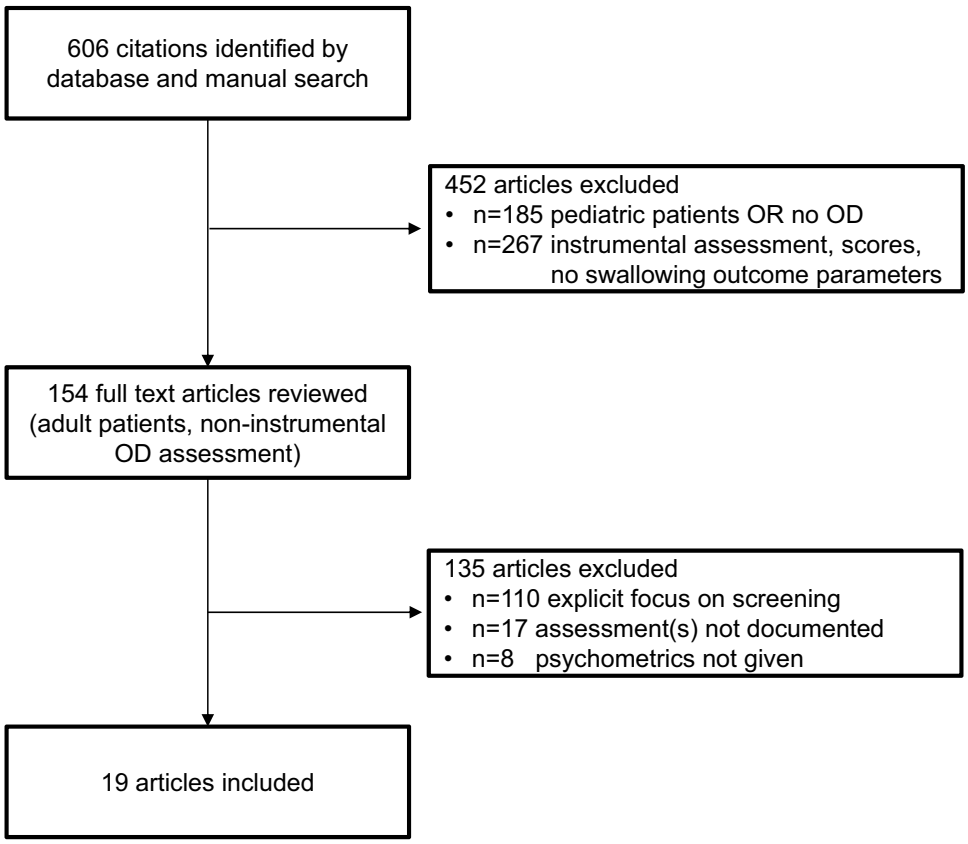

Fig. 1 Flow chart: search strategy. *OD* oropharyngeal dysphagia

and measurement properties reliability [inter-rater reliability (IRR), test–retest reliability (TRT)] and validity [construct, content and criterion-related validity (CRV)]. All identified assessment methods were evaluated regarding feasibility in the critical care environment. Feasibility for implementation on the ICU was judged by the authors, based on a simplified and adapted approach published elsewhere [33]. In brief, the following factors were assessed: (1) Efficiency (time per assessment), (2) comprehensibility (training efforts), (3) precision (clarity of wording/test definitions provided, reliability), (4) feasibility on ICU (patient positioning in bed), and (5) technical feasibility on ICU (need of technical aids or additional material). All assessments methods were graded by the authors on a five point scale (five being the maximum). Study quality was rated using the Cochrane Collaboration criteria [34].

Results

Nineteen articles were identified following the pre-specified in- and exclusion criteria (Fig. 1). In respective articles, twelve different non-instrumental oropharyngeal dysphagia assessments were investigated. Four approaches to assess OD [35–38] were validated in mixed cohorts of hospitalized patients (acute care setting). In general, patient populations varied considerably from mixed cohorts to selected patient groups with specific baseline medical conditions, such as acute respiratory failure, acute stroke, amyotrophic lateral sclerosis (ALS), head and neck cancer, and developmental disabilities (Table 1). Most OD assessments ($n = 13$, 68%) were performed in hospitalized patients; only two assessments investigated patients in nursing or residential homes (elderly people and patients with developmental disabilities). Clinical outcome parameter in the majority of the included studies ($n = 13$, 68%) was presence of dysphagia (D). Some methods assessed presence or absence of penetration (P) ($n = 4$, 21%), or aspiration (A) ($n = 9$, 47%). Few investigations graded dysphagia for disease severity ($n = 4$, 21%) and/or in regard to affected swallowing stages. Techniques and reference standards for non-instrumental OD assessment differed considerably between respective studies. In many investigations ($n = 14$, 74%), VFSS or FEES studies were considered as reference methods (i.e., the gold-standard approach for assessment of OD). Alternatively, the videofluoroscopic dysphagia scale (VDS), modified mini-mental-status evaluation (3MS), functional independence

Table 1 Characteristics of dysphagia studies

Study	Patients	Swallowing	Population	Setting	Swallowing dysfunction
	Included	Assessment method			Endpoints
Lynch et al. [37]	45	BSE	Mixed population, ICU	Acute	D
Maeda et al. [53]	115	KT index	Elderly	Chronic	D, risk for malnutrition
Lee et al. [54]	52	Practical Ass. of D	Stroke	Acute	A
Sheppard et al. [51]	654	DDS	Developmental retardation	Chronic	Severity of D
Rofes et al. [39]	120	V-VST	Mixed population	–	D
Guillén-Solà et al. [40]	79	V-VST	Stroke	Acute	P/A
Paris et al. [41]	20	V-VST	ALS	–	D
Clavé et al. [35]	85	V-VST	Mixed population	Acute	P/A
Oh et al. [43]	54	K-MASA	Stroke	–	D
Carnaby et al. [49]	58	MASA-C	ENT cancer, post-radiotherapy	Acute	Severity of D
Antonios et al. [50]	150	MMASA	Stroke	Acute	Severity of D
González-Fernández et al. [36]	133	MASA	Mixed population	Acute	A
Mann et al. [42]	128	MASA	Stroke	Acute	D/A
Hansen et al. [38]	110	MISA-DK	Elderly, mixed population	Acute	D
Lambert et al. [44]	102	MISA	Elderly	Acute/chronic	D
Zhou et al. [52]	107	PASS	Stroke	Acute	A
Warnecke et al. [47]	100	GUSS	Stroke	Acute	P/A
Trapl et al. [45]	50	GUSS	Stroke	Acute	P/A/severity of D
Logemann et al. [48]	200	NDPCS	Mixed population	–	A/D

A aspiration, *BSE* bedside swallowing examination, *D* dysphagia, *DDS* dysphagia disorder survey, *GUSS* Gugging swallowing screen, *KT index* Kuchi-kara Taberu index, *(M) MASA* (modified) Mann assessment of swallowing ability, *MISA (-DK)* McGill ingestive swallowing assessment (Denmark), *NDPCS* Northwestern Dysphagia patient check sheet, *OD* oropharyngeal dysphagia, *P* penetration, *PASS* CPSA + 3 oz-WST: practical aspiration screening scheme, *Practical Ass. of D* practical assessment of dysphagia, *WST* water swallow test, *V-VST* volume viscosity swallowing test

measure (FIM), or functional oral independence scale (FOIS) were used.

Clinical Non-instrumental Dysphagia Assessment in Mixed Hospitalized Cohorts

Four non-instrumental assessments were investigated and validated in mixed populations of hospitalized patients [35–38]: the clinical bedside swallowing evaluation (BSE), the volume viscosity swallowing test (V-VST), the Mann Assessment of Swallowing ability (MASA), and the McGill Ingestive Swallowing Assessment (MISA). Respective approaches are discussed in the following.

The Bedside Swallowing Evaluation (BSE)

Lynch et al. [37] evaluated a proposed BSE in 45 extubated survivors of acute respiratory failure (ARF) within 3 days following extubation. The clinical evaluation consisted of examining lip seal, and tongue strength and movement, cough strength, dentition, voice quality and amount of assistance required for feeding. Evaluation of food ingestion was first performed by 1 teaspoon full of ice chips, 1 teaspoon of nectar liquids, 1 teaspoon of pureed solids, 5 ml thin liquids and solids. In cases of no safety concerns, the WST (3 oz. of water without interruption) was performed. During all examinations, clinical signs of coughing, throat clearing, a change in voice quality, wet breathing sounds, stridor, or a decrease in oxygen saturation $\leq 3\%$ were considered indicators for aspiration. Data on sensitivity (TPR), specificity (TNR), positive (PPV), and negative (NPV) predictive value are given in Table 2. Due to limited small sample size and incomplete data sets, the BSE should be interpreted with caution. 14% of patients previously considered negative on BSE aspirated on FEES, possibly underestimating silent aspiration. In addition, no consistency in the BSE served as a good predictor of aspiration in FEES examinations. Puree had the highest specificity at 93%, but a very low sensitivity at 64%.

Volume Viscosity Swallowing Test (V-VST)

The V-VST evaluates ingestion of food in different quantities and consistencies with predefined clinical signs of impaired swallowing or aspiration: impaired labial seal, oral or pharyngeal residue, multiple swallows per bolus, changes in voice quality (e.g., wet voice), cough, or decrease in oxygen saturation $\leq 3\%$. To ensure patient safety, a progressive approach with regard to test difficulty applies. Difficulty is progressively increased by starting with nectar consistency with quantities of 5, 10, and 20 ml, respectively. If swallowing appears safe, the evaluation may continue with liquids followed by pudding consistency in increasing amounts (5, 10, and 20 ml). In case of safety concerns, consistency is increased and liquids can be omitted [35]. The V-VST was validated in four studies (Table 1). In 2 out of 4 studies, $n = 85$ [35] and $n = 120$ [39] hospitalized patients (mixed patient population, acute setting) were investigated, whereas in the other 2 studies ($n = 79$ [40] and $n = 20$ [41]) a highly selected patient population was analyzed (stroke/amyotrophic lateral sclerosis). When VFSS is used as gold-standard, data show a sensitivity of 83.7–100% with negative predictive values ranging from 57.9 to 100% for the V-VST. Overall, the V-VST showed acceptable sensitivity and specificity [35, 39–41] (Table 1).

Mann Assessment of Swallowing Ability (MASA, K-MASA)

The MASA is a standardized swallowing assessment tool consisting of 24 test-items. Quantities and consistencies for evaluation of food ingestion are not defined. Each item is scored along predefined criteria; the sum score identifies the severity of dysphagia [36]. The MASA was initially validated for dysphagia in stroke patients [42] and a sensitivity of 73%, specificity 89% and NPV 65% were shown. Later, evaluation in a mixed population of hospitalized patients ($n = 133$) revealed a sensitivity of 39.6% and specificity 59% when VFSS is used as gold-standard [36]. The MASA is thus not recommended for use in mixed populations. A Korean version of the MASA (K-MASA) was developed and investigated by Oh et al. [43]. Indicating high test-re-test and inter-rater reliability (Table 1), and a significant correlation between the K-MASA and the Videofluoroscopic Dysphagia Scale (VDS), they conclude that the K-MASA may be used as an effective follow-up tool.

McGill Ingestive Swallowing Assessment (MISA, MISA-DK)

The MISA was developed for evaluating the ability of elderly people with neurologic impairments to consume foods and liquids safely and independently over an entire mealtime. 42 items divided into 5 sub-scales assessing positioning (4 items), self-feeding skills (7 items), oral motor skills for solid (12 items) and liquid consumption (7 items), and texture management (12 items). Items are scored on a 3-point ordinal scale in which higher scores indicate better function [44]. So far, criterion-related validation against a gold-standard method was not performed. The reliability was assessed indicating an acceptable test–retest reliability (ICC = 0.92–0.96) and Inter-rater reliability (ICC = 0.85) [44]. Hansen et al. [38] developed a Danish version (MISA-DK) and validated this version in a mixed population of acutely ill, hospitalized patients showing high internal consistency with a Cronbach's alpha of 0.95 for the entire MISA-DK scale; possibly indicating item redundancy or multidimensionality based on a difference in the samples.

Table 2 Detailed parameters of included dysphagia studies

Study	Patients included	Swallowing assessment method	CRV	TPR	TNR	PPV	NPV	LR+	TRT-R	Cronbach-alpha	IRR	Feasibility on ICU
Lynch et al. [37]	45	BSE	FEES	LS: 86	52	44	89	–	–	–		3/5
				A: 50	94	78	81	–	–	–		
Maeda et al. [53]	115	KT index	FOIS, Barthel index, MNA-SF, CPS	–	–	–	–	–	0.54–0.96	0.89	0.68–0.98	5/5
Lee et al. [54]	52	Practical Ass. of D	VFSS	51.1	100	100	30	–	–	–	0.95	4/5
Sheppard et al. [51]	654	DDS	BSE	100	81	44	100	–	–	0.93	$k=0.53$	5/5
Rofes et al. [39]	120	V-VST	VFSS	94	88	98	70	7.83	–	–	$k=0.628$	5/5[a]
Guillén-Solà et al. [40]	79	V-VST	VFSS	P: 91.3	P: 12.5	P: 66.7	P: 42.9	–	–	–	–	5/5[a]
				A: 100	A: 14.9	A: 37.5	A: 100					
Paris et al. [41]	20	V-VST	VFSS/ALSFRS	93	80	–	–	–	–	–	–	5/5[a]
Clavé et al. [35]	85	V-VST	VFSS	LS: 88.2	LS: 64.7	LS: 90.9	LS: 57.9	–	–	–	–	5/5[a]
				P: 83.7	P: 64.7	P: 87.2	P: 57.9					
				A: 100	A: 28.8	A: 28.8	A: 100					
Oh et al. [43]	54	K-MASA	VFSS/VDS	–	–	–	–	–	0.98	–	0.99	5/5
Carnaby et al. [49]	58	MASA-C	MASA, VFSS, FOIS	83	96	95	86	21.6	ICC: 0.92–0.96	0.94	ICC = 0.96	3/5
Antonios et al. [50]	150	MMASA	MASA	92.6/87	86.3/84.2	79.4/75.8	95.3/92	6.77/5.51	–	0.94	$k=0.76$	4/5
González-Fernández et al. [36]	133	MASA	VFSS	39.6	59	37.3	61.3	–	–	–	–	5/5
Mann et al. [42]	128	MASA	VFSS	D: 73	D: 89	D: 92	D: 65	–	–	–	D: $k=0.82$	5/5
				A: 93	A: 63	A: 41	A: 97				A: $k=0.75$	
Hansen et al. [38]	110	MISA-DK	MMSE, NOT-S, Barthel index, WST	–	–	–	–	–	–	0.95	–	3/5
Lambert et al. [44]	102	MISA	FIM, 3MS	–	–	–	–	–	ICC: 0.92–0.96	–	ICC = 0.85	3/5
Zhou et al. [52]	107	PASS	VFSS	89.1	80.8	83.1	87.5	–	–	–	–	4/5
Warnecke et al. [47]	100	GUSS	FEES	D: 98.5	D: 53.3	D: 83.1	D: 94.1	–	–	–	–	5/5
				A: 96.5	A: 55.8	A: 74.3	A: 92.3					
Trapl et al. [45]	50	GUSS	FEES	100	50/69	74/81	100	–	–	–	$k=0.835$	5/5
Logemann et al. [48]	200	NDPCS	VFSS	A: 78	A: 58	–	–	–	–	–	–	3/5
				OD: 64	OD: 75							
				PL: 69	PL: 71							
				PD: 72	PD: 67							

CRV criterion related validity, *IRR* inter-rater reliability, *ICC* intra-class correlation coefficient, *kappa* Cohen's kappa, *LS* limited security, *FEES* flexible evaluation of swallowing, *LR+* positive likelihood ratio, *NPV* negative predictive value, *PD* pharyngeal dysphagia, *PL* pharyngeal latency, *PPV* positive predictive value, *TPR* true positive rate (sensitivity), *TNR* true negative rate (specificity), *TRT-R* test–retest-reliability, *VFSS* videofluoroscopic swallowing study

[a]Feasibility rating relates to ICU patients requiring assessment at the point of resuming oral intake. For additional abbreviations please refer to Table 1

Clinical Non-instrumental Dysphagia Assessment in Selected Cohorts

Gugging Swallowing Screen (GUSS)

The GUSS is divided into two parts: preliminary assessment and direct swallowing tests. This evaluation starts with assessing vigilance, voluntary cough and/or throat clearing, and saliva swallowing. If a given patient passes this, the direct swallowing test is performed starting with semi-solid, then liquid, and finally solid textures evaluating the criteria deglutition and voice quality, involuntary cough, and drooling. Dysphagia severity, aspiration risk, as well as diet recommendations are provided according to the points reached in the GUSS [45]. Validity was analyzed assessing for criterion-related validity against FEES as gold-standard. 50 stroke patients were evaluated with a cut-off on the penetration-aspiration scale [46] between 4 and 5 (penetration of material reaching the vocal folds and not being ejected). The GUSS cut-off point for aspiration was chosen between the total scores of 14 and 15 (moderate dysphagia with risk of aspiration). The GUSS reached 100% sensitivity and 50–69% specificity when compared with FEES. Positive predictive values were 81% in the first, 74% in the second group with a negative predictive value of 100%. These findings were confirmed in 100 stroke patients (Table 1) [47].

Northwestern Dysphagia Patient Check Sheet (NDPCS)

The NDPCS is a swallowing evaluation identifying patients with oral stage disorder, a pharyngeal delay, a pharyngeal stage disorder, or patients who aspirate. 28 clearly defined items divided into 5 categories are assessed: medical history (4 variables), behavior (6 variables), gross motor skills (2 variables), observation on oromotor testing (9 variables), and observations during trial swallows (7 variables). A dichotomous scoring was used for each test item (safe vs. unsafe). In addition, 3 summary variables were created reflecting (1) the total number of unsafe observations in all 5 categories, (2) the total number of unsafe observations in behavioral and gross motor function variables, and (3) the total number of unsafe observations during oral motor testing and trial swallows. 200 patients were screened with the NDPCS within 1 day of receiving a diagnostic radiographic evaluation (modified barium swallow, VFSS). This assessment showed sensitivities between 64 and 78%, and specificities between 58 and 75% identifying patients at risk for significant dysphagia [48].

MASA: Cancer Version (MASA-C)

A cancer version of the MASA (MASA-C) for patients with head and neck malignancy was developed and validated in 58 patients undergoing radiation therapy partly in addition to chemotherapy. For criterion-related concurrent validity, a comparison to the original MASA and VFSS was performed. The MASA-C includes 15 of the original 24 items from the MASA completed with cancer-specific items (e.g., neck palpation, mouth opening, taste, smell, current diet, oral mucous membranes, weight loss), as well as modified scoring conventions for the retained items "saliva" and "tracheostomy tube". Accuracy of the assessment method was analyzed in comparison to VFSS scores showing high sensitivity and specificity for detection of dysphagia (83% and 96%, respectively) [49].

Modified Mann Assessment of Swallowing Ability (MMASA)

The MMASA is a modified shortened version of the original MASA, providing a physician-administered screening tool for dysphagia in acute stroke. It includes 12 of the original 24 items from the MASA: alertness, cooperation, respiration, expressive dysphasia, auditory comprehension, dysarthria, saliva, tongue movement, tongue strength, gag, voluntary cough, and palate movements [50]. Criterion-related validity assessment was performed with $n = 150$ patients against the original MASA, not against a considered gold-standard procedure (i.e., FEES, VFSS). High test performance with a sensitivity ranging from 87 to 92% and specificity between 84.2 and 86.3% should therefore be interpreted with caution.

Dysphagia Disorder Survey (DDS)

The DDS is a clinical assessment to identify swallowing and feeding disorders in developmental disability (DD) and was validated against BSE. This assessment consists of two parts. First, related factors were assessed such as body mass index, independence with regard to eating, body-postural control during eating, dietary consistency restrictions, adaptive utensils, or compensatory techniques used to accommodate swallowing and feeding. Second, feeding and swallowing competency is assessed by structured analysis of sensory motor components of the phases of swallowing. The DDS was investigated and validated with $n = 654$ patients, showing evidence of being a reliable and valid test for clinical presentation of dysphagia and related feeding disorder (sensitivity 100%, specificity 81%, NPV 100%, PPV 44%). Although thoroughly validated using construct, convergent, and discriminant validity, showing strong factorial stability, there is lack of proper criterion-related validity [51], DDS performance was solely compared to BSE.

Practical Aspiration Screening Schema (PASS)

The PASS consists of two parts assessing patients for aspiration risk using the CPSA (Clinical Predictive Aspiration

Scale) and the 3-oz WST. The CPSA assesses 6 distinct clinical signs, i.e., absence of archaic reflexes (12 points), presence of velar reflex (8 points), voluntary swallowing (7 points), absence of dysphonia (6 points), presence of gag reflex (6 points), and voluntary glottic closure (3 points). A score > 28 indicates no risk of aspiration; a score result < 14 indicates a risk of aspiration with a level of uncertainty between these cut-offs. The WST is subsequently performed in patients with a CPSA score in the uncertain range for further aspiration risk assessment. 107 patients were enrolled for validation purposes showing a sensitivity of 89.1%, specificity of 80.8%, PPV of 83.1%, and NPV of 87.5% [52].

The Kuchi-Kara Taberu Index (KT Index)

The KT index was developed for caregivers to assess indices in elderly related to feeding support. It consists of 13 items reflecting physical, nutritional, and medical conditions related to swallowing (desire to eat, overall condition, respiratory condition, oral condition, cognitive function while eating, oral preparatory and propulsive phases, dysphagia severity, position and endurance while eating, eating behavior, activities of daily living (ADL), food intake level, food modification, and nutrition). Each item is scored on a numeric scale (1–5); no invasive or non-invasive tests are conducted. In a multicenter cross-sectional study [53], 115 individuals aged ≥ 65 served to verify the reliability and validity of the KT index. For assessment of reliability, both inter-/intra-rater reliability and internal consistency were assessed. Data show satisfactory item reliability (Table 2). Construct validity was assessed by performing correlation analyses (convergent validity, positive or negative) with four validated indices from different domains, such as eating and swallowing function, ADL, nutritional status, and cognitive status (FOIS, Barthel Index, MNA-SF, CPS). The KT index is lacking criterion-related validity against an instrumental gold-standard (e.g., FEES). The KT index score was significantly positively (FOIS, Barthel Index, MNA-SF) or negatively (CPS) correlated. The KT index thus is a geriatric assessment tool providing a comprehensive overview on oral intake and its related factors.

The Practical Assessment of Dysphagia

The development of this quantitative and organ-specific assessment of dysphagia in stroke patients was inspired by the MASA. 18 test-items in 8 different categories (cognition, respiration, lip, tongue, chin, soft palate, vocal cord, swallowing) were identified after a detailed factor analysis in a pilot phase assessing 52 stroke patients and after comparing the test against a gold-standard (VFSS) for criterion-related validity. As in the MASA, each item is scored along predefined criteria, the maximum sum score of 100 can be reached if no impairment is detected. Data provided by the authors show a high Spearman correlation coefficient (0.96, $p < 0.001$) between the total test score and the functional dysphagia scale indicating statistically significant positive correlation, an odds ratio of 12 of aspiration of fluids and VFSS results as well as a high inter-rater correlation performance (ICC 0.95). In total, the presented method may serve as a reliable validated tool for diagnosing dysphagia in stroke patients [54].

Feasibility of Assessment on ICU

Detailed information on feasibility of respective assessments is provided in few investigations only. Nevertheless, some criteria can be extrapolated from the information provided. With regard to time per assessment, data are available for 4 assessments: V-VST (max. 9 min), DDS (about 10–15 min), MASA (about 15–20 min). MISA is evaluated over a complete meal. Regarding comprehensibility, the training effort and time for training needed is reported for two assessments: DDS 5 h and MISA 4–8 h. DDS, MASA-C, MMASA, MASA, MISA, and GUSS include scoring scales with maximum scores given. With regard to feasibility on the ICU, all assessments can be performed on the ICU in bed. However, administration of the MISA in the ICU is judged difficult, due to its duration over an entire mealtime. Technical feasibility is sufficient for all assessments and no technical aids are required.

Discussion

Here we provide a systematic review on the currently available non-instrumental techniques for clinical assessment of oropharyngeal dysphagia that might serve as candidates for non-instrumental post-extubation dysphagia (PED) assessment in critically ill patients. We discuss the feasibility of respective approaches within an ICU environment and identify 19 articles investigating 12 different dysphagia assessments. A minority investigated a mixed population of hospitalized patients and only one investigation was performed in critically ill patients [37]. Due to lack of data on non-instrumental assessments of OD in the ICU, we extended our scope and included not only tools generally used for hospitalized patients but also incorporated methods applied and validated for outpatients. Comparing the identified assessments, it appeared that content/structure and applicable algorithms are highly heterogeneous (Table 1). Moreover, only few assessments include all phases of interest regarding swallowing (oral preparatory, oral, and pharyngeal phase), as suggested elsewhere [55]. When looking at the proposed approaches to non-instrumental dysphagia testing in the light of investigating critically ill patients, it appears that

use of the MISA cannot be advocated for this specific situation. This may be due to its lack in criterion-related validity against a gold-standard and its limitation not to adequately reflect the swallowing situation of ICU patients (most patients not yet fully orally alimented). As data reveal, the MASA—initially validated in stroke patients—is not recommended for use in mixed populations. The score extracted from the MASA did not have sufficient sensitivity or specificity to support its clinical use in a mixed population of hospitalized patients [36]. This clearly underlines the fact that tests and measures validated in distinct patient populations may not easily be transferred to other patient cohorts until further validation in this specific group was performed.

The MMASA does not assess oral intake or swallowing per se and should therefore only be used as a screening tool of patients (at risk) in need of a more extensive exam. Use of the NDPCS in a critical care environment seems limited also due to lower sensitivity and specificity when compared to other assessments. Moreover, regarding DDS, MASA-C, PASS, KT index, and the Practical Assessment of Dysphagia, it seems that implementation outside the analyzed population, e.g., in an ICU environment, can most likely not be supported either. Regarding the GUSS assessment, it seems worth to note that severity of dysphagia and risk of aspiration could be interesting parameters especially in a chronic setting, when documenting the evolution of dysphagia over time provides additional information, for example, OD evolution after treatment has started. However, further studies in a mixed population would strengthen this assessment method and improve generalizability.

The available data indicate that both the BSE and V-VST are the only non-instrumental OD assessments that could be considered for investigation of critically ill patients [35, 37]. The BSE was validated in ICU patients. The V-VST was validated in mixed populations of hospitalized patients, but not explicitly in critically ill patients. Although, regarding feasibility on ICU, the V-VST might be suggested for use in critically ill patients, it should be noted that the V-VST only consists of a structured evaluation of oral food intake and does not consider any other testing for OD. From an ICU point of view, we advise against its use in a critical care setting where testing of safe food intake might not be an adequate tool for assessing dysphagia, especially in the early post-extubational period. We thus advocate a pragmatic 2-step approach including WST for initial screening and a detailed clinical exam (supplemented by an instrumental testing when available) for OD confirmation.

In mixed heterogenous populations of critically ill patients, special considerations should apply. Importantly, not all studies employed FEES or VFSS as gold-standard and outcome measures range from impaired or unsafe swallowing to penetration and aspiration, all of which should be interpreted as different manifestations of dysphagia. Several other aspects may be important for dysphagia assessment in critically ill patients. As mentioned before, dysphagia in critically ill patients can be of various origins [2, 7, 8], which should be considered when assessing ICU patients. An important aspect is silent aspiration, which goes undetected unless consequences, i.e., aspiration-induced pneumonitis or pneumonia unmask its presence. Non-instrumental OD assessment methods lack the accuracy to detect this entity, which clearly supports the need for instrumental confirmatory approach, such as FEES. Moreover, severity of illness may affect the sensitivity and specificity of assessments, as recently discussed for stroke patients [47]. Additionally, we observed that critically ill patients may present with impaired alertness and/or cooperation following recent extubation [8]. As a consequence, it may be indispensable to evaluate the risk for aspiration prior to testing of food ingestion. Medical conditions such as respiratory status, strength, and cooperation should also be considered- which may furthermore increase the complexity considerably.

Our analysis has limitations that deserve discussion. First, following literature research, some investigations might have been missed due to specific characteristics of the search strategy. To minimize this risk, initial search strategies included searching for all tools for dysphagia assessment, including dysphagia screening tools. In cases of unclear definitions provided (i.e., whether the evaluation tool was aimed for risk detection or diagnosis) the tool was included in the review. Second, studies on single test-items were excluded and we are unable to discuss potential effects of a combination of single items. For example, combination of cervical auscultation [56], timed tests of swallowing capacity [57], and dye tests [58] may offer novel diagnostic possibilities. Third, due to a considerable heterogeneity of assessments and design of respective investigations, only descriptive analysis is possible and meta-analyses are most likely impeded at this stage.

Implications and Recommendations for Practice

In the light of the available data, we recently proposed a pragmatic two-step algorithm for screening followed by diagnosing (or ruling out) of dysphagia on the ICU [8]. Our two-step algorithm includes an initial systematic bedside screening procedure with a high sensitivity performed within 3 h after extubation by trained ICU nurses in all patients at OD risk. In cases of screening positivity, an expert bedside swallowing examination should be performed by non-instrumental measures. Optimally, the expert swallowing exam should be complemented by instrumental (i.e., FEES) assessment for OD confirmation. Whether individual institutions should employ instrumental or non-instrumental

testing may most likely depend on site-specific factors and may be a compromise between feasibility and specificity [8]. When considering a pragmatic and feasible two-step algorithm for dysphagia testing on the ICU, it should be kept in mind that dysphagia is a complex and dynamic disease that requires a highly structured approach. Further, in the light of currently available data, it appears that none of the above mentioned non-instrumental dysphagia assessments should be understood as a single perfect exam for assessment of swallowing disorders in critically ill patients. We suggest that in critically ill patients, the V-VST may be used for evaluation of safe/unsafe food ingestion. Based on the present current body of evidence it appears that there is no single validated non-instrumental approach in the ICU environment. In our point of view, this underlines the importance of a structured systematic two-step algorithm (as proposed by us) including instrumental means (FEES) for confirmatory OD testing until non-instrumental clinical assessments for OD are validated for use in the ICU.

Conclusions

Testing for dysphagia in mixed populations of critically ill patients on the ICU seems challenging with only few data available regarding mechanisms leading to dysphagia in this population. Regarding non-instrumental testing, it appears that the V-VST can be used to test for safe food ingestion, even in an ICU setting, but this appears only the case in highly selected patient cohorts. In the light of the fact that dysphagia affects a considerable number of ICU patients, we recently proposed a pragmatic two-step clinical approach that includes systematic dysphagia screening of all potential affected ICU patients followed by a confirmatory specialist exam [8]. If available, we advocate for additional instrumental testing and FEES appears to be the method of choice. Future research should aim to validate non-instrumental tests for use in mixed ICU populations against instrumental tests such as FEES.

We encourage a Delphi procedure by an international expert panel that addresses pressing matters regarding critical illness- related dysphagia definitions, screening measures and confirmatory approaches, as well as treatment recommendations. In addition, relevant patient-centered outcome measures should be defined for future clinical research.

Compliance with Ethical Standards

Conflict of interest Drs. Zürcher and Schefold disclose that the Department of Intensive Care Medicine has, or has had in the past, research contracts with Orion Corporation, Abbott Nutrition International, B. Braun Medical AG, CSEM SA, Edwards Lifesciences Services GmbH, Kenta Biotech, Maquet Critical Care AB, Omnicare Clinical Research AG and research and development/consulting contracts with Edwards Lifesciences SA, Maquet Critical Care AB, and Nestlé. The money was paid into a departmental fund, and no personal financial gain was received. The Department has also received unrestricted educational grants from the following organizations for organizing biannual postgraduate courses in the fields of critical care ultrasound, management of extracorporeal membrane oxygenation and mechanical ventilation: Pierre Fabre Pharma AG (formerly known as RobaPharm), Pfizer AG, Bard Medica SA, Abbott AG, Anandic Medical Systems, PanGas AG Healthcare, Orion Pharma, Bracco, Edwards Lifesciences AG, Hamilton Medical AG, Fresenius Kabi (Schweiz) AG, Getinge Group Maquet AG, Dräger Schweiz AG, Teleflex Medical GmbH. Mrs. Perren declares no conflicts of interest.

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