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Validity and reliability of the French version of Eating Assessment Tool (EAT-10)

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Abstract

Objective To develop a French version of the Eating Assessment Tool (Fr EAT-10) and to assess its internal consistency, reliability and clinical validity.

Methods Fifty-six patients referred in the Swallowing Clinics of CHU Saint-Pierre Hospital (Brussels) and EpiCURA hospital (Ath, Belgium) for dysphagia were enrolled and completed fiberoptic endoscopic evaluation of swallowing and videofluoroscopy. Seventy-three asymptomatic subjects were included in the study. To assess reliability, Fr-EAT-10 was completed twice within a 7-day period. Validity was assessed by comparing Fr-EAT-10 scores with the scores of dysphagia handicap index (DHI) in all individuals. Normative value of EAT-10 was calculated and the receiver operating characteristic (ROC) curve was used to determine the best Fr-EAT-10 threshold associated with aspiration.

Results Fifty-two patients completed the study. *Cronbach's alpha* was 0.95 indicating a high internal consistency. Test–retest reliability was high in the entire cohort ($r_s = 0.921$). The correlation between Fr-EAT-10 total scores and DHI was high ($r_s = 0.827$) indicating a high external validity. Patients had a significant higher score of Fr-EAT-10 than the controls ($p < 0.001$) exhibiting a high internal validity. The analysis of normative data reported that a score of Fr-EAT-10 > 3 should be considered as abnormal. The correlation between Fr-EAT-10 and the occurrence of aspiration is significant ($r_s = 0.327$, $p < 0.05$). According to the ROC curve; aspirations need to be highly suspected for patients with Fr-EAT-10 ≥ 17.

Conclusion The Fr-EAT-10 developed in this study is a reliable and valid self-administered tool in the evaluation of dysphagia in French-speaking patients.

Keywords Dysphagia · Swallowing · Disorder · Eating · Eat · Tool · EAT-10

Introduction

Dysphagia is a disability affecting 8–16% of the general population and may concern more than 50% of the elderly population [1–4]. Many medical conditions are known to lead to dysphagia, i.e., head and neck cancers, cerebral vascular accidents, laryngopharyngeal reflux, laryngopharyngeal

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allergy, presbyphagia, etc. [5–7]. The prevalence of dysphagia in most of these conditions increases with age [8]. Patients with dysphagia often have substantial impairments of physical, emotional and social quality of life [9] and they may encounter several comorbidities such as respiratory infections, aspiration pneumonia, functional disability and frailty, malnutrition and death [4, 10]. These complications can be associated with substantial morbidity and mortality and need to be early identified. In this way, many clinical tools have been developed to detect dysphagia in patients at risk; ensuring appropriate precautions and interventions.

In 2008, Belafsky et al. developed Eating Assessment Tool (EAT-10) that is a self-administered, symptom-specific outcome instrument for dysphagia [11]. According to some clinical studies, EAT-10 is a valid clinical tool with moderate-to-high internal consistency, reliability and discriminative validity [12–14]. Currently, EAT-10 is used for the initial assessment of dysphagia [11, 15], the detection of aspirations [16, 17], and the follow-up of patients with dysphagia benefiting from rehabilitation [15, 16].

To date, there is no validated French version of the EAT-10 available for use in French-speaking countries, which include more than 400 million inhabitants. In this paper, we present a version of EAT-10 adapted for French speakers (Fr-EAT-10), and we assess its test–retest reliability, internal consistency, and clinical validity with the aim of providing the French-speaking community with an effective tool for the detection of dysphagia, aspirations and the monitoring of therapeutic approaches in patients with swallowing disorders.

Materials and methods

The study protocol was approved by the local ethics committees of CHU Saint-Pierre [Brussels, Belgium (no B076201733642)] and EpiCURA Hospital [Baudour, Belgium (no A2014/001)]. Patients were invited to participate, and investigators obtained informed consent from patients enrolled in the study. The first author of the study (JRL) obtained the permission to develop and publish Fr-EAT-10 from Dr. Peter C. Belafsky (*The University of California, Davis, CA, USA*), the creator of the original EAT-10.

Translation and development of Fr-EAT-10

A multidisciplinary team composed of an otolaryngologist, two psychologists, one statistician, two speech therapists and one linguist worked on the French adaptation of the American version of EAT-10 [11]. All members of the team were native French speakers. The team carefully analyzed misunderstandings and the Fr-EAT-10 has been improved to remain as the current version of Fr-EAT-10 (Fig. 1).

Participants

Fifty-six patients with oropharyngeal dysphagia were enrolled from March 2017 to April 2018 from the Departments of Otolaryngology–Head & Neck Surgery of CHU Saint-Pierre (Brussels, Belgium) and EpiCURA Hospital (Ath, Belgium). Patients had a medical indication for an instrumental evaluation of swallowing and benefited from fiberoptic endoscopic evaluation of swallowing (FEES) and videofluoroscopy. There were 41 males and 11 females with a mean age of 66.4 ± 13.7 (ranged from 44 to 93 years old). Patients with dementia, severe neurological diseases limiting the understanding of the study protocol, severe respiratory

Fig. 1 French version of Eating Assessment Tool (EAT-10). The French version of EAT-10. A multidisciplinary team mainly composed of French native speakers translated the American version of EAT-10

Entourez la réponse appropriée à chacune des propositions ci-dessous. La cotation des symptômes se fait en fonction de la gêne que le problème occasionne chez vous:	
0 = pas de problème **4 = problème important**	
1. Mes problèmes de déglutition m'ont causé une perte de poids.	0 - 1 - 2 - 3 - 4
2. Mes problèmes de déglutition m'empêchent de prendre des repas à l'extérieur de chez moi.	0 - 1 - 2 - 3 - 4
3. Avaler des liquides me demande un effort supplémentaire.	0 - 1 - 2 - 3 - 4
4. Avaler des solides me demande un effort supplémentaire.	0 - 1 - 2 - 3 - 4
5. Avaler des pilules ou des gélules me demande un effort supplémentaire.	0 - 1 - 2 - 3 - 4
6. Avaler/déglutir est douloureux.	0 - 1 - 2 - 3 - 4
7. Mes problèmes de déglutition réduisent mon plaisir de manger	0 - 1 - 2 - 3 - 4
8. Lorsque j'avale, des morceaux restent coïncés dans ma gorge.	0 - 1 - 2 - 3 - 4
9. Je tousse quand je mange.	0 - 1 - 2 - 3 - 4
10. Avaler est quelque chose qui me stress.	0 - 1 - 2 - 3 - 4

disease and a high risk of superinfection, as well as those who were not native French-speaker were carefully excluded. Four patients were excluded due to Illiteracy. Fifty-two patients completed the study. The characteristics of patients included in this study are available in Table 1. The etiology of oropharyngeal dysphagia mainly included head and neck carcinoma, esophageal neoplasia, neurological disorders and psychological dysphagia (Table 1). Seventy-three healthy subjects composed the control group. The mean age was 27.0 ± 9.1 (ranged from 20 to 67 years old) and there were 24 females. Healthy subjects were recruited from the Université Libre de Bruxelles and they had no history of any swallowing disorders, laryngopharyngeal reflux disease (according to French version of Reflux Symptom Score [18]), smoking habits, medical history impacting swallowing or any history of head and neck surgery.

Questionnaires and swallowing examinations

Patients and controls completed Fr-EAT-10 twice over a 7-day period (Fr-EAT-10 d0 and Fr-EAT-10 d7). Moreover, patients and controls fulfilled French version of dysphagia handicap index (DHI), a validate self-estimated questionnaire constructed in French [19] at baseline and an the same time benefited from FEES and videofluoroscopy. FEES included a static and dynamic evaluation of the structures in the upper aerodigestive tract and an examination of laryngopharyngeal sensitivity (by directly stimulating the various pharyngeal–laryngeal areas with the tip of the rhinopharyngolaryngoscope). We used water colored with methylene blue and/or blue-dyed food for the assessment of swallowing. The videofluoroscopy was performed with the following material: Siemens Axion Luminos dRF (Siemens, Healthcare, GMBH, Erlangen, Germany). Full-face and profile video were analyzed by two experienced physicians in a blind manner using the Group for Learning Useful and Performant Swallowing (GLUPS) score (Appendix 1) and the Penetration–Aspiration Scale (PAS) of Rosenbek et al. [20] Questionnaires with missing items were not accepted.

Reliability was assessed through internal consistency and test–retest reliability for all subjects ($N = 125$). Internal consistency of Fr-EAT-10 was measured using Cronbach's alpha for the 10 items of the questionnaire. Test–retest reliability between Fr-EAT-10 d0 and Fr-EAT-10 d7 was assessed for each item and for the total score using Spearman's correlation coefficient. External validity was measured by a correlation study between EAT-10 d0 and DHI using Spearman's correlation coefficient. Internal validity was measured by a comparison of Fr-EAT-10 d0 of patients and healthy controls using Mann–Whitney *U* test.

The normative value of Fr-EAT-10 was calculated on the data of the healthy individuals determining the superior threshold of two standard deviations below the mean ($N = 73$). FEES and videofluoroscopy were used to detect aspiration. To assess the ability of Fr-EAT-10 to detect aspiration, we firstly studied the association between Fr-EAT-10 (items and total score) and the occurrence of aspiration during videofluoroscopy according to the PAS (Spearman's correlation test). A PAS score ≥ 4 was considered as abnormal [20]. Secondly, we performed a receiver operating characteristic (ROC) curve with regard to the sensitivity and the specificity of each potential threshold values of Fr-EAT-10. The area under the curve was measured to obtain the best threshold value associated with the higher sensitivity and specificity.

Statistical analyses

Statistical Package for the Social Sciences for Windows (SPSS version 22.0; IBM Corp, Armonk, NY, USA) was used to perform the statistical analyses. A level of significance of $p < 0.05$ was used. The difference in Fr-EAT-10 score between patients and controls was evaluated using the Mann–Whitney *U* test (internal validity). According to the distribution of data, Spearman's correlation test was used to perform the different correlation analyses (test–retest reliability, external validity). ROC curve was performed by the same software.

Results

Cronbach's alpha for the 10 items of Fr-EAT-10 d0 for patients and controls was 0.95 indicating high internal consistency. According to the Spearman correlation test, the test–retest reliability was high for total scores ($r_s = 0.921$, $p < 0.001$) and moderate-to-high for all item scores (Table 2). External validity analyses reported a high correlation between Fr-EAT-10 total score and DHI (Table 3) indicating high external validity.

Concerning internal validity, the mean Fr-EAT-10 scores of patients and controls were 16.33 ± 10.90 and 0.55 ± 1.26 respectively (Table 4); the difference between group being significant ($p < 0.001$, Mann–Whitney *U* test). About the normative data, a cut-off score of 3 was considered to be reflective of abnormalities. The mean Fr-EAT-10 scores of patients with Head and Neck cancer (HNC) and patients without HNC were respectively 18.9 ± 10.5 and 11.3 ± 10.1 and aspiration prevalence were 40% and 9.1%, respectively.

The characteristics of patients according to FEES and GLUPS score (videofluoroscopy) are described in Table 5. The mean Fr-EAT-10 score of patients with aspiration was 21.4 ± 9.93, while the mean Fr-EAT-10 score of those without aspiration was 14.2 ± 11.2. The correlation between Fr-EAT-10 score and the occurrence of aspiration is moderate but is still significant ($r_s = 0.327$,

Table 1 Patient characteristics

Age	
Mean ± SD	66.40 ± 13.70
Range	44–92
Gender	
Male	41 (79%)
Female	11 (21%)
Etiology of dysphagia	
Head and neck cancer	30 (58%)
Stroke	6 (11%)
Cervical esophageal cancer	4 (8%)
Cricopharyngeal muscle Spasm	2 (4%)
Multiple sclerosis	1 (2%)
Anterior cervical interbody fusion	1 (2%)
Muscle tension dysphonia	2 (4%)
Undetermined	6 (11%)

HNC patients characteristics

Tumor site	Stage	Treatment	Time since treatment
Larynx	T3N0M0	RCT	5 months
Oral	T3N0M0	Pre-treatment	NA
Larynx	T4N0M0	Surgery	10 months
Parotid	T3N2bM0	RxT	3 months
Oral	T4N0M0	RCT	7 years
Oral	T4N2cMx	Pre-treatment	NA
Larynx	Chondrosarcoma grade 2	Surgery	2 years
Oral	rpT2N0M0	Surgery	5 years
Larynx	T3N2cM0	RCT	1 year
Larynx	T4N0M0	Surgery	2 months
Oral	cT4N0M0	Pre-treatment	NA
Larynx	T3N0M0	surgery	12 years
Oral	cT4N1M0	Pre-treatment	NA
Larynx	T4aN0M0	Surgery + RCT	1 year
Oral	T1N0M0	Surgery	2 years
Oral	T3N2cM0	RCT	3 months
Oral	T1N0M0	Surgery	4 months
Hypopharynx	cT4bN2cM0	Pre-treatment	NA
Larynx	T2N0M0	RCT	16 years
Oral	cT4bN0M0	RCT	6 years
Oral	T3N0Mx	RCT	17 years
Hypopharynx	cT4aN2bM0	Pre-treatment	NA
Larynx	cT3N2cM0	Pre-treatment	NA
Oral	T1N2M0	Pre-treatment	NA
Larynx	cT3N0M0	Pre-treatment	NA
Hypopharynx	cT2N1M0	Pre-treatment	NA
Oral	cT4N0M0	Pre-treatment	NA
Oral	cT3N0M0	Pre-treatment	NA
Larynx	cT2N0M0	Pre-treatment	NA
Larynx	cT4N1M0	Pre-treatment	NA

SD standard deviation, *NA* not applicable, *RCT* radiochemotherapy; *RxT* radiotherapy

Table 2 Test retest reliability analysis

Fr-EAT-10 items	r_s	*p* value
Weight loss	0.885	< 0.001
Ability to go out for meals	0.844	< 0.001
Swallowing liquids disorder	0.874	< 0.001
Swallowing solids disorder	0.905	< 0.001
Swallowing pills disorder	0.878	< 0.001
Painful swallowing	0.828	< 0.001
Impaired pleasure of eating	0.919	< 0.001
Food sticks in the throat	0.901	< 0.001
Cough during eating	0.839	< 0.001
Stressful	0.748	< 0.001
Total score	0.921	< 0.001

This table exhibits the correlation analysis between Fr-EAT-10 d0 and Fr-EAT-10 d7 according to Spearman correlation test (Rho Spearman = r_s)

Table 3 External validity analysis

DHI	r_s	*p* value
Physical DHI	0.772	< 0.001
Functional DHI	0.792	< 0.001
Emotional DHI	0.810	< 0.001
DHI total score	0.827	< 0.001

This table exhibits the correlation between Fr-EAT-10 d0 total score and dysphagia handicap index (DHI) total and sub-scores (Rho Spearman = r_s)

Table 4 Internal validity analysis

Scores	Mean ± SD		*p* value
	Patients	Controls	
EAT-10 items			
Weight loss	1.54 ± 1.66	0.04 ± 0.26	< 0.001
Ability to go out for meals	1.54 ± 1.75	0.01 ± 0.11	< 0.001
Swallowing liquids disorder	1.52 ± 1.54	0.03 ± 0.23	< 0.001
Swallowing solids disorder	2.35 ± 1.57	0.05 ± 0.28	< 0.001
Swallowing pills disorder	1.62 ± 1.62	0.18 ± 0.45	< 0.001
Swallowing painful	1.19 ± 1.46	0.03 ± 0.23	< 0.001
Impaired pleasure of eating	2.06 ± 1.73	0.07 ± 0.30	< 0.001
Food sticks in the throat	2.02 ± 1.61	0.03 ± 0.16	< 0.001
Cough during eating	1.31 ± 1.38	0.04 ± 0.20	< 0.001
Stressful	1.19 ± 1.43	0.07 ± 0.38	< 0.001
EAT-10 total score	16.33 ± 10.90	0.55 ± 1.29	< 0.001
DHI items			
Physical DHI	12.67 ± 7.93	2.04 ± 2.21	< 0.001
Functional DHI	13.73 ± 9.27	1.03 ± 1.27	< 0.001
Emotional DHI	10.43 ± 10.84	0.05 ± 0.23	< 0.001
DHI total score	36.84 ± 25.13	3.12 ± 3.15	< 0.001

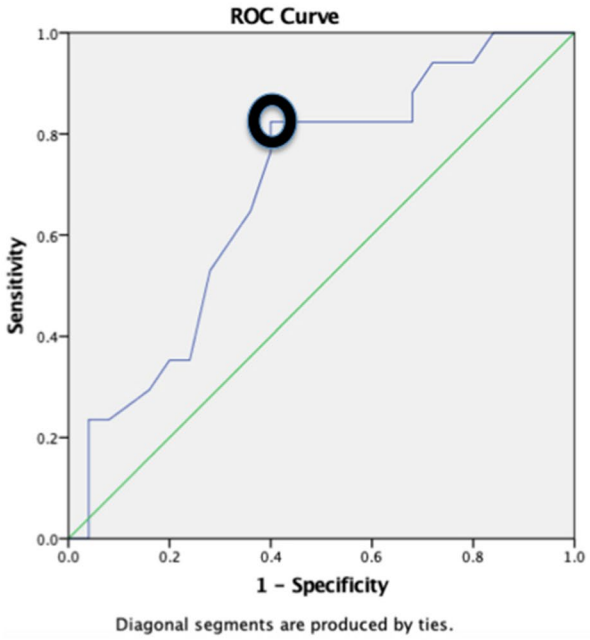
DHI dysphagia handicap index, *SD* standard deviation

Table 5 Videofluoroscopy and FEES characteristics of patients

Objective evaluations	Number of patients	
	Liquids	Solids
Videofluoroscopy characteristics (GLUPS score)		
Chewing disorder	NA	6
Tongue propulsion disorder	5	9
Oral posterior continence disorder	8	13
Oral stasis	4	8
Trigger swallowing disorder	6	6
Soft palate closure disorder	0	0
Tongue basis anterior–posterior movement disorder	2	2
Alimentary bolus progression disorder	6	6
Anterior–posterior movement of epiglottis disorder	3	2
Laryngeal elevation disorder	3	2
Apnea	1	1
Oropharyngeal stasis	22	21
Hypopharyngeal stasis	15	14
Direct aspiration	2	0
Indirect aspiration	7	5
Upper Esophageal Sphincter relaxation disorder	2	2
Esophageal peristalsis disorder	4	5
Esophageal stenosis/obstruction	4	6
Oral stasis	5	7
FEES characteristics		
Soft palate closure disorder	2	
Alimentary bolus progression disorder	3	
Tongue basis anterior–posterior movement disorder	1	
Abnormality of laryngeal mobility	4	
Laryngeal sensitivity	2	
Laryngeal elevation disorder	4	
Oropharyngeal stasis	18	
Hypopharyngeal stasis	18	
Aspiration	12	
Cough after aspiration	12	

FEES fiberoptic endoscopic evaluation swallowing, *NA* not applicable

$p < 0.05$). The correlation analysis between each item and aspiration reported that the stronger correlation concerns the item 9 (cough during the eating) of Fr-EAT-10 ($r_s = 0.506$). According to the ROC curve, the cut-off value that exhibited better sensitivity and specificity for patients with aspiration is 17/40 (sensitivity: 82.35% and specificity: 57.1%). This indicates that aspirations need to be highly suspected for patients with Fr-EAT-10 ≥ 17 (Fig. 2). According to the prevalence of aspiration in our study (32.7%), the positive predictive value (PPV) and negative predictive value (NPV) were 48.3% and 86.9%, respectively (Table 6).



Curve coordinates

Fr-EAT_10 score	1-Specificity	Sensitivity
0.5	0.92	1
1.5	0.84	1
2.5	0.80	0.94
3.5	0.72	0.94
4.5	0.68	0.88
6	0.68	0.82
7.5	0.64	0.82
9.5	0.60	0.82
12	0.52	0.82
13.5	0.48	0.82
15	0.44	0.82
17	0.40	0.82
18.5	0.40	0.76
19.5	0.36	0.65
21	0.32	0.59
22.5	0.28	0.53
24.5	0.24	0.35
27	0.20	0.35
28.5	0.16	0.29
30	0.08	0.23
31.5	0.04	0.23
32.5	0.04	0.12

Fig. 2 ROC curve. The grayed value is the Fr-EAT-10 score showing the higher sensitivity and specificity; indicating that 17 is the most appropriate cut-off value for the detection of aspiration

Table 6 Contingency table

Fr-EAT-10	Penetrations/aspirations		Total
	Positive	Negative	
≥ 17 (positive)	14 (a)	15 (b)	29
< 17 (negative)	3 (c)	20 (d)	23
Total	17	35	52

a. True positives (TP); b. False positives (FP); c. False negative (FN); d. True negatives (TN), Prevalence of penetrations/aspirations = 17/52 = 32.7%, Sensibility (Se) = VP/(VP + FN) = a/(a + c) = 14/(14 + 3) = 82.3%, Specificity (Sp) = VN/(VN + FP) = d/(d + b) = 20/(20 + 15) = 57.1%, Positive predictive value (PPV) = TP/(TP + FP) = a/(a + b) = 14/(14 + 15) = 48.3%, Negative predictive value (NPV) = TN/(TN + FN) = d/(d + c) = 20/(20 + 3) = 86.9%

PPV and NPV especially for item 9 (cough during eating) of Fr-EAT-10 were 46.67% and 86.3%, respectively.

Discussion

Dysphagia is frequently encountered in otolaryngology and is associated with significant rates of morbidity and mortality. Early screening is, therefore, recommended to reduce the related risk of complications. The initial version of the EAT-10 reported high validity and reliability for the screening of dysphagia, aspiration and for the evaluation of treatment efficiency [11, 21]. EAT-10 is used worldwide and other translated versions of EAT-10 reported high validity and reliability [12, 13, 33].

In the present study, we sought to develop a French version of EAT-10 and to assess its internal consistency, test–retest reliability, clinical validity and its ability to detect aspirations.

Internal consistency was excellent (Cronbach's alpha 0.95) which is consistent with other versions of EAT-10 (Table 7) [11–13, 22–25]. Considering that the value of the coefficient should be above 0.70 to show sound reliability, our results reported a high reliability of the Fr-EAT-10.

The correlation coefficients for the test–retest reliability were high ($r_s = 0.921$) for both total and item scores, indicating a good external reliability. Our results are consistent with those described in other studies of EAT-10 validation, which were all ≥ 0.85 [12, 22–26]. External validity analysis reported a high correlation between Fr-EAT-10 total score and the DHI indicating high external validity. In other words, similar to DHI, Fr-EAT-10 appears to be able to detect and evaluate the severity of swallowing disorders. However, the comparison with other studies is difficult because no similar procedure of external validity assessment using DHI was conducted. In the literature, two authors assessed the external validity of EAT-10 throughout a statistical correlation analysis with another patient-reported outcome questionnaire [22, 24]. In the Portuguese version of EAT-10, Nogueria et al. found a significant correlation between EAT-10 and Quality of Life instrument EuroQoL (EQ-5D)

Table 7 Comparison of internal consistency of the different version of the EAT-10

EAT-10 version	Cronbach's alpha
EAT-10[11]	0.96
I-EAT-10[22]	0.90
SP-EAT-10[13]	0.87
S-EAT-10[12]	0.95
T-EAT-10[23]	0.90
P-EAT-10[24]	0.95
Fr-EAT-10	0.95
H-EAT-10[25]	0.95

I-EAT-10, Italian version of the EAT-10; S-EAT-10, Swedish version; SP-EAT-10, Spanish version; T-EAT-10, Turkish version; H-EAT-10, Hebrew version of EAT-10; P-EAT-10, Portuguese version; Fr-EAT-10, French version

[24]. Similarly, the Italian version of EAT-10 seemed to have high external validity in regard to a significant correlation between EAT-10 and Dysphagia Outcome Severity Scale (DOSS) [22]. The internal validity has been demonstrated using a statistical comparison between patient and control mean of Fr-EAT-10 scores. As expected, the analysis reported that Fr-EAT-10 score was significantly higher in patients in comparison with controls that are consistent with the results of previous studies [11, 13, 22, 24–26].

About the normative data, a score of Fr-EAT-10 > 3 has been identified as abnormal. During the development of the Hebrew version EAT-10, Abu-Ghanem et al. found a sensitivity of 92.3% and a specificity of 97.3% when EAT-10 score of 3 was used as the cutoff for dysphagia [25]. In both Swedish and Italian versions of EAT-10, authors also identified a threshold ≥ 3 to distinguish patients and controls [12, 22]. Finally, in a large cohort of patients with oropharyngeal dysphagia with or without aspiration, Giraldo-Cadavil et al. found a cut-off value ≥ 2 with a sensitivity of 93.6% and a specificity of 36.4% [13]. Overall, the majority of studies has identified a cut-off ≥ 3 as abnormal.

When EAT-10 was first established, one of the purposes of the questionnaire was to predict aspiration risk in patients with dysphagia [11, 21]. Our analysis reports a moderate but significant correlation between the Fr-EAT-10 and the occurrence of an aspiration ($r_s = 0.327$). Moreover, our ROC curve analysis suggests that aspirations should be highly suspected for patients with Fr-EAT-10 ≥ 17; this cut-off value exhibiting the higher sensitivity (82.3%) and specificity (57.1%). Two groups of authors performed similar procedures and obtained relatively similar results, respectively, $r_s = 0.273$ [21] and $r_s = 0.660$ [27]. The lower cut-off value of PAS score adopted in the study of Arrese et al. was substantially different from our (PAS ≤ 2 and PAS ≥ 3 versus PAS < 4 and PAS ≥ 4) that could explain the differences found between our correlation coefficient values. In a retrospective study, Kendall et al. did not find significant correlation ($r_s = 0.03$) between EAT-10 and aspiration [28]. Giraldo-Cadavil et al. also investigated the ability of EAT-10 to detect aspiration [13]. Using ROC curve, these authors support that EAT-10 ≥ 4 is associated with a sensitivity of 94.3% and a specificity of 49.5%. The etiology of dysphagia, the severity of the diseases and the related mean value of EAT-10 score substantially vary between studies that may explain some differences in our respective results. Thus, the proportion of patients with head and neck cancer in both the study of Kendall et al. [28] and in the present report was, respectively, 1.4% and 58%, limiting the comparison. In the same way, the cohort of Giraldo-Cadavil et al. [13] is mainly composed of patients with cerebrovascular disease who are characterized by different pathophysiological mechanisms underlying the development of dysphagia and aspiration in comparison with patients with head and neck cancers [29, 30]. In the context of very different populations, the comparison between studies focusing of the ability of EAT-10 to detect aspiration is still difficult and can lead to unclear conclusion. For this reason, the future establishment of cut-off values associated with a higher risk of aspiration could take into consideration the etiology of dysphagia, the pathophysiological mechanism of the disease, the clinical course of the disease and the related risks of aspiration.

The prevalence of aspirations in this study was 32.7%; PPV and NPV were, respectively, of 48.3% and 86.9%. If we look at the PPV and NPV using only the item 9 of the Fr-EAT-10, 46.6% and 86.3%, respectively, we found out that this item, "cough during eating", is a very strong item and has a huge impact on the detection of aspirations in our studied population. As exhibited in Table 8, these PPV and NPV were relatively close to those of the study of Cheney et al. but are slightly inferior to those of Rofes et al. [21, 31]. However, the cohort study of Cheney et al. is mainly composed of patients with head and neck cancer as our cohort; while the cohort of Rofes et al. is mainly composed of patients with neurodegenerative disorders and gastroesophageal reflux disease [31]. In addition to the potential impact of the type of the patient population on the establishment of cut-off value, it has been demonstrated that the method used to detect aspiration also has a significant impact on prevalence, sensitivity, specificity, positive and negative predictive values [32, 33]. In the present study, we used both videofluoroscopy and FEES for the detection of aspirations, while Rofes et al. only used videofluoroscopy. It is therefore possible that the only use of videofluoroscopy led to an underestimation of the aspiration; that could be highlighted by the different prevalences of aspiration reported in our two respective studies (18.9% *versus* 81%).

Table 8 Comparison of the studies using EAT-10 as screening tool for aspirations

Authors	Country	*N* and type of studies	Main etiologies of the swallowing disorder	Aspiration detection	EAT-10 threshold	Prevalence (%)	Sensibility (%)	Specificity (%)	PPV (%)	NPV (%)	LR+	LR−
Rofes et al. 2014 [31]	Spain	*N* = 134, prospective	Neurodegenerative disorders, age, strokes	VFSS	≥ 3	80.9	87	68	73	83	3.13	0.191
Cheney et al. 2012 [21]	USA	*N* = 360, retrospective	Gastro-esophageal reflux (28%), post irradiation (22%)	VFSS	≥ 16	18.9	71	53	26	89	1.51	0.55
Lechien et al. 2018 [35]	Belgium	*N* = 42, prospective	Head and Neck cancer (40.6%)	VFSS + FEES	≥ 17	32.7	82	57	48	87	2.05	0.3

VFSS videofluoroscopy study of swallowing, *FEES* fiberoptic endoscopic evaluation of swallowing; *PPV* positive predictive value; *NPV* negative predictive value; *LR+*, positive likelihood ratio = Se/(1 − Sp); *RV−*, negative likelihood ratio = (1 − Se)/Sp

In that respect, the main strength of our study is the use of both FEES and videofluoroscopy to detect aspirations. Indeed, on 17 aspirations, only one-third was detected by both videofluoroscopy and FEES, one-third by FEES, and the last third by videofluoroscopy. In practice, we did not find substantial difference between both methods in the detection of aspiration and they are complementary. We support that it is still important to perform both examinations to ensure a high detection rate of aspiration according to the physician experience, local availability and cost of videofluoroscopy because both methods are characterized by different sensitivity and specificity in the detection of aspiration [32, 33]. In summary, videofluoroscopy assesses oro-pharyngeal disorders in terms of coordination and provides information about esophageal disorders, while FEES provides information about the anatomical lesions, the sensitivity of the upper aerodigestive tract mucosa and the occurrence of potential anatomical abnormalities [32–34].

The present study has some limitations. Firstly, although some previous studies are characterized by similar number of patients [25], the low number of patients reduces the statistical power. Secondly, the large proportion of patients with head and neck cancer could limit the comparison of some analyses, (i.e., the establishment of a cut-off value for the detection of aspiration) with other studies that are characterized by patients with different etiologies of dysphagia.

Conclusion

The Fr-EAT-10 is a valid and reliable self-administered survey for the detection of dysphagia and aspiration. Fr-EAT-10 seems to be highly reproducible, with a good construct-based and criterion-based validity. Fr-EAT-10 > 3 can be considered as abnormal and suggestive of swallowing disorder. Particularly in patients with head and neck cancers, a cut-off value of Fr-EAT-10 of 17 or higher could be associated with a substantial risk of aspiration. However, the establishment of these thresholds should be influenced by the disease underlying the dysphagia and the characteristics of the patient population. Future studies should take into consideration these two parameters in the determination of adequate thresholds.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the insti-

tutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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