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ORIGINAL ARTICLE

The Eating Assessment Tool-10 Predicts Aspiration in Adults with Stable Chronic Obstructive Pulmonary Disease

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Abstract Adults with COPD frequently present with dysphagia, which often leads to clinical complications and hospital admissions. This study investigates the ability of the Eating Assessment Tool (EAT-10) to predict aspiration during objective dysphagia evaluation in adults with stable COPD. Thirty adults (20 male, 10 female; mean age = 69.07 ± 16.82) with stable COPD attended an outpatient dysphagia clinic for a fiberoptic endoscopic evaluation of swallowing (FEES) in an acute teaching hospital (January 2015–November 2016). During evaluations, individuals completed an EAT-10 rating scale followed immediately by a standardised FEES exam. Aspiration status during FEES was rated using the penetration–aspiration scale by clinicians blinded to EAT-10 scores. Data were retrospectively analysed. Significant differences in mean EAT-10 scores were found between aspirators (16.3; SEM = 2.165) and non-aspirators (7.3; SEM = 1.009) ($p = 0.000$). The EAT-10 predicted aspiration with a high level of accuracy (AUC = 0.88). An EAT-10 cut-off value of >9 presented a sensitivity of 91.67, specificity of 77.78 with positive and negative likelihood ratios of 4.12 and 0.11, respectively. Positive and negative predictive values were 73.30 and 93.30, respectively. Diagnostic odds ratio was 38.50 ($p < 0.01$, CI 3.75–395.42). EAT-10 is a quick, easy to administer tool, which can accurately predict the presence of aspiration in adults with COPD. The scale can also very accurately exclude the absence of aspiration, helping clinicians to determine the need for onward referral for a comprehensive dysphagia evaluation. This may ultimately reduce clinical complications and hospital admissions resulting from dysphagia in this clinical population.

Keywords Dysphagia · Aspiration · Chronic obstructive pulmonary disease · EAT-10 · Screen · Diagnostic accuracy

Introduction

Chronic obstructive pulmonary disease (COPD) is a preventable lung disease characterised by chronic obstruction of lung airflow that interferes with normal breathing and is not fully reversible [1]. COPD affects over five percent of the population and it is the third leading cause of death worldwide [2]. Cardinal features include chronic cough, dyspnoea and sputum production. COPD is characterised by acute exacerbations and multiple comorbidities both of which often require hospital admissions. In fact, COPD is a leading cause of hospital admissions and it is associated with longer hospital stays, increased intensive care admissions and mortality [3, 4]. Given the high prevalence and the chronic course of COPD, the disease has a significant impact on healthcare systems globally [3]. Effective management of the condition in the community is therefore crucial both from the individual and healthcare system viewpoint.

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Limited research to date suggests that dysphagia frequently presents in adults with COPD both in a stable phase and during acute exacerbations [5, 6]. One cause of dysphagia in people with COPD is thought to be the disrupted coordination of the exhale-swallow-exhale respiratory cycle during deglutition [7, 8]. Adults with an exacerbation of COPD have been reported to swallow spontaneously during the inspiratory phase or during the transition between inspiration to expiration [7–9]. In terms of swallow safety, one study reported that seventy percent of adults with COPD with suspected swallowing problems aspirated during videofluoroscopy [10]. Silent aspiration has also been reported in this clinical group, which can complicate dysphagia detection and management [11]. Other physiological signs of dysphagia reported in people with COPD include reduced tongue control, a delayed pharyngeal swallow, reduced tongue base retraction, impaired hyolaryngeal excursion, cricopharyngeal dysfunction, impaired laryngopharyngeal sensitivity and slower bolus transit [5–10, 12–14]. The high prevalence of comorbidities in the COPD population including GORD, cachexia, poor nutritional status, cardiovascular disease and polypharmacy may also contribute to dysphagia in this clinical population [15, 16]. Methodological limitations are evident in research conducted to date in this area. Studies investigating dysphagia in adults with COPD typically have not involved control groups and methods to evaluate dysphagia and respiratory coordination have varied widely across studies with inconsistent use of validated rating scales. Perhaps unsurprisingly, findings with regard to the presence and nature of dysphagia and aspiration in adults with COPD vary across studies. Additionally, the interaction between respiratory coordination and swallowing and the role of dysphagia in acute exacerbations of COPD differs across studies.

Dysphagia has been identified as a risk factor for acute exacerbations of COPD [17]. This has implications not just for the individual, but also for the healthcare system worldwide [18]. Despite this, it is often only when the person with COPD is admitted into hospital with an acute exacerbation that they are referred for an objective dysphagia evaluation. Early and accurate identification of adults with COPD who require more in-depth dysphagia assessment is critical in order to minimise clinical complications and hospital admissions. While videofluoroscopy and fiberoptic endoscopic evaluation of swallowing (FEES) are the reference standard tests used to instrumentally evaluate oropharyngeal dysphagia, objective evaluation of all adults with COPD is not feasible. As dysphagia is so often under-reported in adults with COPD, identification of those who require an in-depth dysphagia evaluation can be problematic.

The Eating Assessment Tool (EAT)-10 is a validated, quick and easy to administer self report scale [19]. In brief, patients are presented with 10 statements regarding their swallowing (e.g. "My swallowing problem has caused me to lose weight"), and are asked to rate themselves on a 5-point scale of severity for each statement (from "no problem" to "severe problem"). A score of 0 indicates no problem where as a score of 4 indicates a severe problem. An overall EAT-10 score of ≥ 3 is deemed abnormal and suggests the presence of dysphagia. The tool has been reported to have excellent internal consistency, test–retest reproducibility and criterion-based validity [19]. The EAT-10 has been found to be predictive of aspiration in adults with motor neurone disease, head and neck cancer and in heterogeneous clinical populations with dysphagia [20–23]. EAT-10 scores have also been associated with nutritional status and activities of daily living in elderly in long term care settings [24]. The predictive value of the EAT-10 in identifying adults with COPD who are aspirating has not been investigated to date.

The purpose of this pilot research is to begin an investigation into the ability of the EAT-10 to accurately identify adults with stable COPD who are aspirating during swallowing. Identification of a quick, easy to administer scale which can be administered in outpatient respiratory clinics may help to identify adults with COPD who need to be referred on for more in-depth dysphagia evaluation. Authors hypothesise that the EAT-10 will present with acceptable diagnostic accuracy to predict aspiration in this clinical population.

Methods

Participants

All adults with a diagnosis of COPD made by a respiratory physician who attended a dysphagia clinic within an acute teaching hospital for a FEES evaluation over a twenty-two month period (January 2015–November 2016) were included in this study. COPD severity for each participant was obtained from medical notes. Severity ratings were made by medical physicians based on post-bronchodilator forced expiratory volume $(FEV)_1$/forced volume vital capacity (FVC) spirometry scores.

All patients had a clinical swallow evaluation by a speech and language therapist and were attending for a FEES exam. Exclusion criteria included an acute exacerbation of COPD in last six weeks, an inability to complete the EAT-10 rating scale, if a FEES examination was contra-indicated or not tolerated, diagnosis of a respiratory disease other than COPD (e.g. lung cancer, asthma) or

history of stroke within the last six months. Data collected were analysed retrospectively.

Protocol

EAT-10 Scale (Index Test)

At the beginning of each procedure, a postgraduate student assisted participants with the completion of the EAT-10 screening tool [19]. The postgraduate student was subsequently not present during the FEES evaluation.

FEES (Reference Standard)

Immediately after the completion of the EAT-10, all patients sat upright in a chair in a clinic room. A standardised FEES examination was completed by one of two experienced clinicians who were blinded to the EAT-10 scores. Patients sat upright in a chair and a Kay Pentax 2.4 mm FEES scope was passed trans-nasally for direct visualisation into the pharynx. Local anaesthetic was not used. As per the department protocol, anatomical structures were initially evaluated as were secretions and airway protection. All participants were subsequently administered fluids from a cup, spoonful of puree and solid consistencies to swallow, unless deemed unsafe by the endoscopist. When the exam was complete, the scope was removed. All exams were recorded and saved on a Kay Pentax Digital Swallow Workstation (Kay Pentax, Lincoln Park, NJ, USA).

Data Analysis

Total EAT-10 scores were calculated by adding scores across the ten questions (maximum 40). After the FEES procedure, two clinicians who were blinded to EAT-10 scores used frame by frame analysis to rate aspiration across consistencies during FEES using the validated Penetration–Aspiration Scale (PAS) [25]. Briefly, the PAS is an eight point ordinal rating scale which captures aspiration status and an individual's response to aspiration (from 1 = no aspiration up to 8 = silent aspiration). While the PAS was originally designed to measure aspiration during videofluoroscopy [25], it has since been validated for use during FEES [26]. In fact, recent research suggests that PAS ratings have better reliability based on FEES compared to videofluoroscopy [27, 28]. In this study, the worst PAS score across all consistencies and trials was selected for analysis from each examination. As per previous research [20], aspirators were defined as those who received a PAS score of ≥6 on any consistency during the FEES examination, while non-aspirators scored from 1 to 5 on the PAS scale.

Statistical Analysis

EAT-10 scores and worst PAS ratings were entered into an Excel document. Statistical analysis was completed using the statistical processing software MedCalc, Version 16.4.3 (MedCalc Software, Ostend, Belgium) [29]. Mean EAT-10 scores for those who aspirated (EAT-10 score ≥6) were compared to those who did not (EAT-10 score ≤5) using an independent samples t test. A Mann–Whitney U test was used to verify if there were differences in COPD severity between aspirators and non-aspirators. A Kruskal–Wallis test was used to establish if patients with different levels of COPD severity presented differences in their EAT-10 scores. To determine the diagnostic accuracy and optimal cut-off point for the EAT-10, receiver operating characteristic (ROC) curves were created. This allowed the calculation of the area under the curve (AUC), sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio, as well as 95% confidence intervals (CIs) associated with these values.

Results

Thirty adults with stable COPD met inclusion criteria over the twenty-two month period and were included in this study (20 male, 10 female, mean age = 69.071 ± 16.818). Participants presented with mild (FEV_1 ≥ 80% predicted; $n = 6$), moderate (50% ≤ FEV_1 < 80% predicted; $n = 14$) and severe (30% ≤ FEV_1 < 50% predicted; $n = 10$) COPD.

EAT-10 Scores in Aspirators and Non-aspirators

Using the criterion of PAS score ≥6, it was established that 12 participants aspirated during FEES and 18 did not. Mean EAT-10 scores were significantly lower for safe swallowers (PAS score <6) (7.278, SEM = 1.009) compared to aspirators (mean EAT-10 = 16.333, SEM = 2.165) ($t(28) = -4.216$, $p = 0.000$) (see Fig. 1). No significant differences were found in COPD severity between aspirators and non-aspirators ($Z = -1.167$, $p = 0.288$). No significant differences in EAT-10 scores were found between the three COPD severity groups ($X^2(2) = 1.031$, $p = 5.97$).
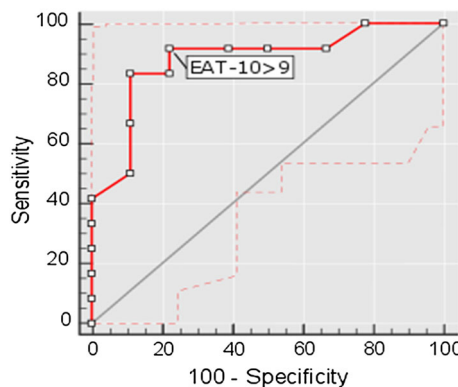
Diagnostic Accuracy of EAT-10 in Detecting Aspiration

The EAT-10 predicted aspiration with a very good level of accuracy (AUC = 0.880, $p < 0.0001$, SE = 0.070, CI 0.709–0.969). Diagnostic accuracy measures for each point in the EAT-10 scale represented in our sample are available in Table 1, and represented in the ROC curve in Fig. 2.
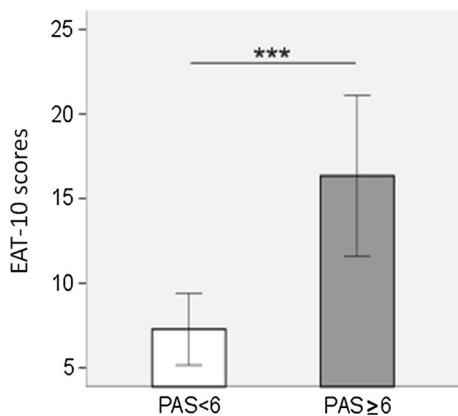
Fig. 1 EAT-10 scores across individuals who do not aspirate (PAS < 6) and those who do aspirate (PAS ≥ 6). ***p < 0.001

Fig. 2 Receiver operating characteristics (ROC) curve for the ability of the EAT-10 to detect aspiration in individuals with COPD (in *red*). The *dashed line* represents the 95% confidence interval of the *curve*. The *diagonal grey line* represents the line of no discrimination

Based on these measures, an optimal cut-off value of a score >9 for prediction of aspiration with the EAT-10 was proposed (Table 1). An EAT-10 cut-off value of >9 presented a sensitivity of 91.67 (CI 61.50–99.80), specificity of 77.78 (CI 52.40–93.60), a positive likelihood ratio of 4.12 (CI 1.70–10.00), a negative likelihood ratio of 0.11 (CI 0.02–0.70), a positive predictive value of 73.30 (CI 44.90–92.20), a negative predictive value of 93.30 (CI 68.10–99.80) and a diagnostic odds ratio of 38.50 (p < 0.01, CI 3.75–395.42).

Discussion

Findings from this initial pilot study suggest that the EAT-10 can accurately predict aspiration in individuals with COPD, as indicated by the diagnostic odds ratio of 38.50, for a cut-off value of 9. In particular, using a cut-off value of 9, aspiration was predicted accurately on 92% of adults with COPD. From the positive predictive value it can be estimated that 77% of individuals with COPD who obtain EAT-10 scores above 9 do, in fact, aspirate. However, this

Table 1 Diagnostic accuracy measures for each EAT-10 value

Criterion	Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	−LR (95% CI)	+PV (95% CI)	−PV (95% CI)	DOR (95% CI)
≥2	100.00 (73.5–100.0)	0.00 (0.0–18.5)	1.00 (1.0–1.0)		40.0 (22.7–59.4)		
>2	100.00 (73.5–100.0)	22.22 (6.4–47.6)	1.29 (1.0–1.6)	0.00	46.2 (26.6–66.6)	100.0 (39.8–100.0)	7.8 (0.4–158.7)
>4	91.67 (61.5–99.8)	33.33 (13.3–59.0)	1.37 (1.0–2.0)	0.25 (0.03–1.8)	47.8 (26.8–69.4)	85.7 (42.1–99.6)	5.5 (0.6–53.2)
>6	91.67 (61.5–99.8)	50.00 (26.0–74.0)	1.83 (1.1–3.0)	0.17 (0.02–1.2)	55.0 (31.5–76.9)	90.0 (55.5–99.7)	11.0 (1.2–103.9)*
>8	91.67 (61.5–99.8)	61.11 (35.7–82.7)	2.36 (1.3–4.3)	0.14 (0.02–0.9)	61.1 (35.7–82.7)	91.7 (61.5–99.8)	17.3 (1.8–165.0)*
>9	**91.67 (61.5–99.8)**	**77.78 (52.4–93.6)**	**4.12 (1.7–10.0)**	**0.11 (0.02–0.7)**	**73.3 (44.9–92.2)**	**93.3 (68.1–99.8)**	**38.5 (3.7–395.4)****
>10	83.33 (51.6–97.9)	77.78 (52.4–93.6)	3.75 (1.5–9.2)	0.21 (0.06–0.8)	71.4 (41.9–91.6)	87.5 (61.7–98.4)	17.5 (2.7–114.8)**
>12	83.33 (51.6–97.9)	88.89 (65.3–98.6)	7.50 (2.0–28.4	0.19 (0.05–0.7)	83.3 (51.6–97.9)	88.9 (65.3–98.6)	40.0 (4.8–331.0)***
>13	66.67 (34.9–90.1)	88.89 (65.3–98.6)	6.00 (1.5–23.5)	0.38 (0.2–0.8)	80.0 (44.4–97.5)	80.0 (56.3–94.3)	16.0 (2.4–106.7)**
>14	50.00 (21.1–78.9)	88.89 (65.3–98.6)	4.50 (1.1–18.7)	0.56 (0.3–1.0)	75.0 (34.9–96.8)	72.7 (49.8–89.3)	8.0 (1.3–51.1)*
>15	41.67 (15.2–72.3)	100.0 (81.5–100.0)		0.58 (0.4–0.9)	100.0 (47.8–100.0)	72.0 (50.6–87.9)	27.1 (1.3–554.3)*
>16	33.33 (9.9–65.1)	100.0 (81.5–100.0)		0.67 (0.4–1.0)	100.0 (39.8–100.0)	69.2 (48.2–85.7)	19.6 (0.9–406.5)
>18	25.00 (5.5–57.2)	100.0 (81.5–100.0)		0.75 (0.5–1.0)	100.0 (29.2–100.0)	66.7 (46.0–83.5)	13.6 (0.6–292.1)
>19	16.67 (2.1–48.4)	100.0 (81.5–100.0)		0.83 (0.6–1.1)	100.0 (15.8–100.0)	64.3 (44.1–81.4)	8.8 (0.4–201.4)
>28	8.33 (0.2–38.5)	100.0 (81.5–100.0)		0.92 (0.8–1.1)	100.0 (2.5–100.0)	62.1 (42.3–79.3)	
>32	0.00 (0.0–26.5)	100.0 (81.5–100.0)		1.00 (1.0–1.0)		60.0 (40.6–77.3)	

The diagnostic odds ratio (DOR) was calculated separately for each point in the EAT-10 scale using MedCalc, and results are reported here with statistical testing (*p < 0.05; **p < 0.01; ***p < 0.001)

Optimal cut-off value (>9) are given in bold

±LR Positive/negative likelihood ratio, ±PV positive/negative predictive value

means that it is estimated that the presence of aspiration in this population with this criterion will be somewhat over-estimated, with a false positive rate of about 33%. In fact, the probability of a diagnosis of aspiration is 4.12 times higher in those who aspirate when compared to those who do not. This is a moderately positive likelihood ratio, which indicates that a positive diagnosis of aspiration due to a score above 9 in the EAT-10 is suggestive of true presence of aspiration, but insufficient to establish a definite diagnosis [30].

In addition, with this cut-off value, 78% of those who did not aspirate were correctly classified. This specificity value denotes some of the over-estimation of aspiration discussed above. However, from the negative predictive value of 93%, it is estimated that the test performs exceptionally well in excluding aspiration when it is indeed absent. This translates into a low rate of false negatives expected with this criterion (6.7%). In accordance, based on the negative likelihood ratio of 0.11, a score below the criterion value of 9 can be used to confidently exclude the diagnosis accurately [30]. Altogether, these diagnostic accuracy measures indicate that the EAT-10 has the features of an excellent screening test, as it determines the need for onward referral and additional assessment if scores are above the criterion, and can confidently exclude the diagnosis and determine that there is no need for additional assessment if scores are below the criterion.

Identification of outpatients with COPD who are aspirating, and hence onward referral for appropriate outpatient dysphagia management, may assist in the reduction of aspiration pneumonias and hospital admissions in this clinical group. Aspiration has frequently been reported in adults COPD [5, 10, 11], and it has been associated with acute exacerbations of COPD [17]. Dysphagia has been identified as a risk factor for community-acquired pneumonia in the elderly [31]. Furthermore, COPD is also a leading cause of hospital admissions and has been associated with longer hospital stays [3, 4]. Use of swallowing screening protocols have reduced pneumonia incidence in other clinical populations [32, 33]. As dysphagia is a precipitating factor for malnutrition in COPD, early detection of dysphagia and aspiration may also limit the impact of a swallowing disorder on nutritional status [34]. Despite these facts, awareness of the prevalence of dysphagia in people with COPD remains inconsistent. The inclusion of a short, easy to administer screen in outpatient clinics must surely be a worthwhile step from a respiratory and nutritional viewpoint.

These findings are in keeping with previous research, which investigated the value of the EAT-10 in detecting aspiration in different clinical groups [20, 21, 23]. In one study using a cut-off score of 16, the EAT-10 identified aspiration in a general dysphagia group with 71%

sensitivity and 53% specificity, with a positive likelihood ratio of 2.2 in this study [20]. In another study of a general dysphagia population, the EAT-10 predicted aspiration using a cut-off point of 3 with 83% sensitivity and 25% specificity [23]. More recently, in a study of adults with amyotrophic lateral sclerosis, EAT-10 predicted aspiration with 86% accuracy and 72% specificity using a cut-off point of 8. The positive likelihood ratio in this ALS study at 3.1 [21] provided a similar level of confidence to detect the presence of aspiration as the one in our sample (4.12). In this study of adults with COPD, sensitivity and specificity values for aspiration are higher than previous studies (92 and 78% respectively). Furthermore, our very negative predictive value (0.11) indicates that the particular strength of the EAT-10 is in the exclusion of aspiration, a feature that qualifies this test as a tool particularly useful for screening purposes.

Interestingly, all other studies examining the value of the EAT-10 in detecting aspiration or dysphagia have used videofluoroscopy as the reference standard test [20, 21, 23]. However, FEES is considered to be as robust as dysphagia reference standard test. This is the first study to use FEES as the reference standard dysphagia evaluation. Authors purport that FEES has a number of advantages over videofluoroscopy in the COPD population. Unlike videofluoroscopy, FEES does not involve radiation exposure, therefore allowing the effects of endurance or fatigue to be monitored over the course of a mealtime. This may be pertinent for people with COPD who may present with dyspnoea and increased respiratory rate during meals. Use of FEES in the COPD population has the added advantage that the pharyngeal mucosa, laryngopharyngeal sensitivity and vocal cords can be evaluated, which may be of relevance given the increased risk of GORD and lung cancer in this population. FEES has been shown to have better reliability than videofluoroscopy in rating penetration [26–28]. Aspiration tends to be scored higher on FEES exams compared to videofluoroscopy, which may be attributed to better visualisation of anatomical structures [28]. However, the potential influence of the nasopharyngeal scope on respiratory rate and coordination in adults with COPD should be a focus of future research in this area.

This research was an initial pilot study conducted to explore the role of the EAT-10 in predicting aspiration in adults with COPD. As such, further research with a larger sample size is required before recommending its integration into clinical practice. The retrospective design of this study was a drawback. However, patients were recruited consecutively and the reference standard test was interpreted without knowledge of EAT-10 scores and vice versa, which addressed the issues of patient selection and bias as per the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool [35]. The time interval between

the index (EAT-10) and reference (FEES) tests was also minimal which was of value from a flow and timing domain viewpoint [35]. The completion of an item analysis is recommended for future research to determine if specific questions within the EAT-10 differed between aspirators and non-aspirators.

Concerns regarding the structural validity and internal consistency of the EAT-10 have been put forward. The psychometric properties of the EAT-10 scored badly in a recent functional health status questionnaire systematic review, although authors did suggest that the rating system used was quite severe [36]. Additionally, a recent study using Rasch analysis uncovered the limitations of EAT-10 as a stand-alone tool [37]. While these concerns warrant attention in terms of using the EAT-10 as a stand-alone health status scale, they do not affect the use of EAT-10 as a screen to identify those at risk of aspiration who require more in-depth investigation.

In conclusion, EAT-10 scores predicted aspiration in adults with stable COPD during objective dysphagia evaluation in this study. The EAT-10 is a quick and easy to administer tool that it could, with further research, be employed by respiratory physicians in outpatient clinics to identify those who require a more in-depth instrumental dysphagia evaluation. Correct exclusion of aspiration in patients with COPD who are not at risk of aspiration reduces the number of patients attending for unnecessary videofluoroscopy or FEES exams. In addition, a tool that facilitates adequate onward referral in those who are indeed at risk may also assist in the prevention of aspiration pneumonia or an acute exacerbation of COPD, both of which require hospital admission and antibiotic cover.

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