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ORIGINAL ARTICLE

The predictive dysphagia score (PreDyScore) in the short- and medium-term post-stroke: a putative tool in PEG indication

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Abstract

Purpose We performed an evaluation of dysphagia in an unselected series of strokes to identify factors causing persisting dysphagia at 1 month after onset and to formulate a predictive score.

Methods We evaluated the association between dysphagia and clinical aspects (univariate analysis) at the 7th and 30th days after admission. We performed a multivariate logistic regression at the 30th day on the factors that were significant. We computed a simple score for predicting persistent dysphagia.

Results We recruited 249 patients. At the 7th day, 94 patients were dysphagic (37.75%). Factors associated with dysphagia included TACI (OR 3.85), mRS ≥ 3 (OR 4.45), malnutrition (OR 2.69), and BMI ≥ 20 (OR 0.52). At the 30th day, 217 patients remained in the study, and dysphagia persisted in 75 (36.76%). The factors that were associated with dysphagia were age > 74 years (OR 1.99), TACI (OR 5.82), mRS score ≥ 3 (OR 4.31), malnutrition (OR 3.27), and BMI ≥ 20 (OR 0.45). The multivariate analysis indicated that mRS ≥ 3 (OR 1.80) and BMI ≥ 20 (OR 0.45) remained significantly associated with dysphagia. The best correlation with dysphagia was the sum of mRS and the reciprocal of the BMI multiplied by 100 ((mRS + 1 BMI) × 100). We named this score PreDyScore that ranged between 3.7 and 10.47. Using < 6 and > 8 as cutoffs, the sensitivity was 67.03%, and the specificity 95.65%.

Conclusion BMI < 20 and mRS ≥ 3 are easily measurable bedside predictive factors of persistent dysphagia. PreDyScore showed good sensitivity and very good specificity and enables the prediction of persistent dysphagia with great accuracy in any clinical setting.

Keywords Stroke · PEG · Dysphagia · BMI · Aspiration pneumonia · mRS

Introduction

Dysphagia prevalence in stroke patients differs according to the evaluation mode (clinical or instrumental). According to Martino et al., the incidence of dysphagia in acute stroke patients is approximately 37 to 45%. In patients screened by clinical tests, this incidence is approximately 51 to 55%, and in patients submitted to videofluoroscopic and fibroendoscopic examinations, this incidence is approximately 64 to 78% [1].

Dysphagia implicates negative consequences in clinical and functional outcomes as well as hospitalization length with a high risk of aspiration pneumonia and an increased mortality rate [2].

The incidence of aspiration pneumonia in dysphagic patients ranges between 16 and 33% [1], and 14.5% of the patients with stroke show signs of lower respiratory tract infections [3, 4]. The risk of aspiration pneumonia is greater in dysphagic patients (RR = 3.17; 95% CI = 2.07–4.87), particularly in those patients with documented aspiration compared with those without (RR = 11.56; 95% CI = 3.36–39.77) [1].

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Notably, the development of pneumonia is sevenfold more frequent in stroke patients who aspirate than in those who do not [5].

The difficulty or total incapability of swallowing causes a reduction in food intake (hypophagia), followed by progressive body weight loss and deficiencies of vitamins and mineral salts, which lead to patent protein-calorie malnutrition [6, 7].

Therefore, malnutrition is another important prognostic factor in stroke patients [8, 9], representing an independent factor that is associated with lower long-term survival rate (OR = 2.32; 95% CI = 1.78–3.02) [10]. Thus, artificial nutrition could represent an important tool in stroke therapy. A 5-year study by Ickenstein [11] on 664 acute stroke patients reported a better prognosis in those who received an early nutritional support via percutaneous endoscopic gastrostomy (PEG). Notably, 64% of these patients were alive 2 years after the stroke, while only 45% of those who received late nutritional support remained alive.

Nevertheless, the timing and nutrition methods used for post-stroke dysphagia patients vary widely, and artificial nutrition is often late and low in protein-calorie content [12, 13]. Moreover, the modality by which artificial nutrition is to be administered remains under debate.

In particular, early enteral nutrition by a nasogastric tube was associated with a 5.8% (95% CI = 0.8–12.5; $P = 0.09$) reduction in the absolute risk of death and a 1.2% (95% CI = 4.2–6.6; $P = 0.7$) reduction in mortality rate and poor outcome in the FOOD International Trial [14], an important multicentric investigation that included 3012 patients. However, PEG placement in the immediate period after an acute event was associated with a 1.0% (95% CI = 10.0–11.9; $P = 0.9$) increased absolute risk of death and a 7.8% (95% CI = 0.0–15.5; $P = 0.05$) increased rate of mortality and poor outcome.

Notably, there is a mismatch between practical implementations and stroke guidelines, which recommend time-limited trials of nasogastric feeding for > 2 to 3 weeks prior to placing a surgical feeding tube [15]. A recent retrospective survey found that the feeding tube was placed within 7 days of stroke admission in 53% of 34,623 stroke patients receiving a PEG from 2001 to 2011 [16].

Furthermore, many patients with a nasogastric tube are obliged to undergo PEG placement because the prevalence of dysphagia in the 30 days following stroke is 2–21%, and the prevalence of dysphagia lasting 3 months following stroke is 7% [17–20]. PEG placement could be used to avoid the side effects of a nasogastric tube; however, little is known regarding (1) the current practices of PEG tube placement timing for stroke admissions and (2) which factors impact the timing of PEG placement [16].

Moreover, none of the current predictive scores to evaluate the risk of long-term dysphagia can be simply used in a bedside clinical setting, in particular during the first week following stroke [21–23]. Therefore, it could be very useful to predict the persistence of dysphagia in stroke patients when deciding upon PEG placement.

Aim of the study

An Italian multicenter study was carried out from 2013 to 2016 to identify the predictive parameters for dysphagia persistence over 30 days following stroke, which provides information on possible nutrition therapy modes. The goal of this observational study was to identify a predictive score for persistent dysphagia in stroke patients based on the associated factor results observed at an early phase of the disease.

Materials and methods

This was a multicenter observational study. Each observation center had online access, and all data could be recorded anonymously. Each center has its own password and PIN code.

Dysphagia was evaluated using the 3-oz water swallow test. The 3-oz water swallow test is widely used to screen individuals who are at risk for oropharyngeal dysphagia and aspiration [24, 25]. The test result can demonstrate normal function (i.e., the patient can swallow a single sip of 10 ml of water), mild dysphagia (i.e., the patient can swallow less than 5–10 ml of water), or severe dysphagia (i.e., the patient is unable to swallow the water). The test was performed on the first day as well as on the 7th and 30th days after admittance to the stroke unit.

The Bamford classification was used to define the vascular territory of ischemic stroke (LACI, lacunar infarct; PACI, partial anterior circulation infarct; POCI, posterior circulation infarct; and TACI, total anterior circulation infarct).

The study focused on patients with a recent onset (less than 48 h) stroke who were consecutively admitted to Italian stroke units. The first follow-up evaluation (T7) was performed on the seventh (± 2) day after the stroke. All surviving patients received a follow-up evaluation after 30 days (± 5) following the onset of stroke (T30). We excluded from the study patients who died in the first 7 days after stroke onset.

We developed a complete semi-structured medical record to be compiled by the attending neurologist regarding the following points: personal medical history, associated diseases, stroke characteristics (type, site lesion, etiology), Bamford's classification (7th and 30th days after admission), detection and evaluation of the degree of dysphagia (7th and 30th days after admission), evaluation of malnutrition (subjective global assessment, SGA), nutritional therapy (parenteral/enteral), and type of products used for artificial feeding.

To simplify the statistical analysis, all of the underlying factors were dichotomized. Specifically, in relation to

Bamford's classification, TACI was compared with all other types of ischemic stroke together (LACI + PACI + POCI); the degree of dependence, assessed by the modified Rankin Scale (mRS) [26], was subdivided into a lower dependency (mRS 0 to 2) compared with a medium or high degree of dependence (mRS of 3 to 5); the hemispheric strokes were compared with brainstem or cerebellar sites; patients with malnutrition (mild and severe) were compared with well-nourished patients; and finally, patients with a BMI lower than 20 were compared with all others. Patients were also subdivided into higher and lower values according to median age (74 years).

We performed the statistical analysis using the chi-squared test with Yates' correction in the frequency evaluation with the computation of OR as well as 95% confidence intervals. We based the final evaluation on multivariate logistic regression analysis. The adopted significance level was always 0.05. We evaluated the clinical accuracy of a dysphagia predictive scoring system, which we named the Predictive Dysphagia Score (PreDyScore), based on our statistically significant results using an ROC curve evaluation. We computed the best correlation between dysphagia and significantly associated factors using Spearman's rank correlation.

Results

A total of 249 patients (126 males and 123 females) with a mean ± s.d. age of 72.6 ± 15.5 years were recruited. The median age was 74 years. Their anthropometric characteristics were as follows: mean height 165.4 ± 17.3 cm, mean body weight 69.8 ± 14.1 kg, and mean BMI 25.3 ± 4.1 kg/m^2. Among the patients enrolled, 45 (18%) were affected by hemorrhagic stroke and 204 (82%) by ischemic stroke.

According to Bamford's ischemic stroke classification, 54 (26%) patients had LACI (lacunar infarct), 90 (44%) PACI (partial anterior circulation infarct), 28 (14%) POCI (posterior circulation infarct), and 32 (16%) TACI (total anterior circulation infarct). Regarding the site of the lesion, 126 (51%) patients had right hemispheric lesions, 105 (42%) left hemispheric lesions, and 18 (7%) brainstem or/and cerebellar lesions. As a whole, 231 (93%) patients had supratentorial lesions.

According to comorbidities, the patients were subdivided as follows: 14 had renal failure (6%), 41 had heart failure (16%), 4 had liver failure (2%), and 84 had diabetes (34%).

The mRS showed the following patient distribution: 2.8% of patients were included in class 0, 14.1% in class 1, 19.3% in class 2, 19.3% in class 3, 18.9% in class 4, and 25.7% in class 5.

The SGA nutritional risk screening categorized 188 (75.5%) patients into the A stage (well nourished), 53 (21%) into the B stage (mildly malnourished), and 8 (3%) into the C stage (severely malnourished).

Nutritional treatment started within a median of 1.6 ± 1.1 days since admission in the stroke unit in 64 patients. 70.8% (46 patients) received enteral nutrition (100% by means of nasogastric tube), 18.5% (12 patients) received parenteral nutrition, and the remaining 9.2% (6 patients) received mixed parenteral/enteral nutrition.

Dysphagia was observed in 94 patients (38%). The degree of dysphagia was 1 in 20 patients (8%), 2 in 33 (13%), and 3 in 41 (16%). The 7-day mortality rate was 5.22% (13 patients) (3 of 13 with dysphagia), and the 30-day mortality rate was 10.04% (25 patients). Ninety-two percent (23) of the patients who died before 30 days were dysphagic, and 8% (2 patients) were not dysphagic ($P < 0.001$ dysphagia vs nondysphagia). The follow-up at 30 days post stroke showed persistence of dysphagia in 75 (35%) of the 224 surviving patients. The BMI was lower than 20 in 99 patients (40%), between 20 and 25 in 118 (< 47%), and higher than 25 in 32 patients (13%).

Table 1 shows the findings for the factors under analysis at the initial evaluation (T7) as well as the univariate comparison between non-dysphagic and dysphagic subjects. The factors significantly associated with dysphagia in the early phase (T7) were Bamford's classification ($P = 0.0009$; OR = 3.85; 95% CI = 1.64–9.09), a high dependence degree on mRS ($P = 0.00001$; OR = 4.45; 95% CI = 2.29–8.74), and the SGA-based malnutrition state ($P = 0.0015$; OR = 2.69 95% CI = 1.42–5.07). A BMI ≥ 20 was a significant protective factor against dysphagia ($P = 0.018$; OR = 0.52; 95% CI = 0.29–0.90). Table 2 shows the findings on the same factors under analysis at the end of the 30-day follow-up period (T30) as well as a univariate comparison between the dysphagic and non-dysphagic subjects.

The factors significantly associated with persistent dysphagia (T30) were age > 74 years ($P = 0.027$; OR = 1.99; 95% CI = 1.08–3.69), Bamford's classification ($P = 0.00005$; OR = 5.82; 95% CI = 2.2–15.81), a high dependence degree on the mRS ($P = 0.0005$; OR = 4.31; 95% CI = 2.04–9.25), and the SGA-based malnutrition state ($P = 0.0017$; OR = 3.27; 95% CI = 1.50–7.14). A BMI ≥ 20 was a significant protective factor against dysphagia ($P = 0.007$; OR = 0.45; 95% CI = 0.26–0.79).

Table 3 shows the multivariate logistics analysis of clinical factors related to persistent dysphagia at the 30-day follow-up evaluation. The only factors that remained significantly associated were the presence of a medium or high degree of dependence (mRS ≥ 3) ($P < 0.001$; OR = 1.8; 95% CI = 1.4–2.2) and a BMI ≥ 20 ($P < 0.001$; OR = 0.45; 95% CI = 0.30–068) as a protective factor.

Using the former two factors, it is possible to obtain a score significantly correlated with the persistency of dysphagia. This score results from the sum of the mRS value plus the reciprocal of the BMI multiplied by 100: (mRS + 1 BMI) × 100) (rank correlation coefficient 0.507, $P < 0.001$). This Predictive Dysphagia Score (PreDyScore) ranged between

Table 1 Basal characteristics (T7) and univariate analysis of factors associated with dysphagia

Evaluation at the 7th day ($N = 249$)				Non-dysphagic		Dysphagic		Univariate analysis (χ^2)
Factor	Category	*N*	%	*N*	%	*N*	%	
Sex	Male	126	50.60	81	64.29	45	35.71	*P* 0.59, OR 1.19
	Female	123	49.40	74	60.16	49	39.84	95% CI 0.69–2.06
Age	≤ 74 (median)	125	50.20	84	67.20	41	32.80	*P* 0.14, OR 2.21
	> 74 (median)	124	49.80	71	57.26	53	42.74	95% CI 0.88–2.65
Renal failure	No	235	94.38	150	63.83	85	36.17	*P* 0.07 OR 3.23
	Yes	14	5.62	5	35.71	9	64.29	95% CI 0.92–11.31
Heart failure	No	208	83.53	132	63.46	76	36.54	*P* 0.47, OR 1.36
	Yes	41	16.47	23	56.10	18	43.90	95% CI 0.65–2.82
Liver failure	No	245	98.39	153	62.45	92	37.55	*P* 0.99, OR 1.66
	Yes	4	1.61	2	50.00	2	50.00	95% CI N.V.
Antidiabetic therapy	No	165	66.27	99	60.00	66	40.00	*P* 0.37, OR 0.75
	Yes	84	33.73	56	66.67	28	33.33	95% CI 0.42–1.35
Stroke Type	Hemorrhagic	45	18.07	23	51.11	22	48.89	*P* 0.13, OR 0.57
	Ischemic	204	81.93	132	64.71	72	35.29	95% CI 0.23–1.15
Bamford's classif.	LACI + PACI + POCI	172	84.31	120	69.77	52	30.23	*P* 0.0009, OR 3.85
	TACI	32	15.69	12	37.50	20	62.50	95% CI 1.64–9.09
Lesion site	Hemispheric	231	92.77	143	61.90	88	38.10	*P* 0.88, OR 0.81
	Brainstem + cerebellar	18	7.23	12	66.67	6	33.33	95% CI 0.05–2.44
Event	First-ever stroke	212	85.14	131	61.79	81	38.21	*P* 0.86, OR 0.88
	Recurrent stroke	37	14.86	24	64.86	13	35.14	95% CI 0.39–1.92
mRS	0–2	90	36.14	74	82.22	16	17.78	*P* 0.00001, OR 4.45
	3–5	159	63.86	81	50.94	78	49.06	95% CI 2.29–8.74
SGA	Well nourished	188	75.50	128	68.09	60	31.91	*P* 0.0015, OR 2.69
	Malnourished	61	24.50	27	44.26	34	55.74	95% CI 1.42–5.07
BMI	< 20	99	39.76	52	52.53	47	47.47	*P* 0.018, OR 0.52
	≥ 20	150	60.24	103	68.67	48	31.33	95% CI 0.29–0.90

CI, confidence interval; *OR*, odds ratio; χ^2, chi-squared test with Yates' correction. Bamford's Classification: *LACI*, lacunar infarct; *PACI*, partial anterior circulation infarct; *POCI*, posterior circulation infarct; *TACI*, total anterior circulation infarct. *mRS*, modified Rankin Scale; *SGA*, status global assessment; *BMI*, body mass index

3.7 and 10.47 with a median value of 7.20. Figure 1 shows the ROC curve and the accuracy of the PreDyScore. The PreDyScore showed very good specificity (89.7%; 95% CI = 81.27–95.16) but low sensitivity (52.47%; 95% CI = 44.49–60.36), and the ROC curve showed a fitted area of 79%. When including only the patients with PreDyScore < 6 and > 8, the accuracy showed great improvement, attaining a sensitivity of 67.03% (95% CI = 56.39–76.53) and a specificity of 95.65% (95% CI = 87.82–99.09). Table 4 shows the accuracy parameters.

Discussion

Dysphagia is a symptom associated often with acute stroke and implicates an increased risk of aspiration pneumonia *ab ingestis* and of death. An earlier diagnosis of dysphagia leads to fewer complications and therefore a shorter hospitalization and fewer associated therapies.

The severity of dysphagia depends on the patient's age and on the extent of the lesion. Previous studies have identified dysphagia's predictive factors to be the patient's age (> 70 years), male sex, brain infarctions that are strongly invalidating (Barthel score < 60), palatal weakness and asymmetry, incomplete emptying of the oral cavity, and abnormal pharyngeal reflex. Moreover, dysphagia was significantly associated with stroke severity (multiple measures of stroke severity) but not with nutritional status [21–27].

The data in our study on the prevalence of dysphagia in the observed pool of patients (38%) is comparable with the data from the literature, which reports a rate of 37–45% in clinical studies [1]. The persistence of dysphagia at the 30-day follow-up session occurred in 35% of our stroke cases.

Regarding the predictive clinical factors, the univariate analysis showed that dysphagia at the 30th day did not correlate with liver failure, heart failure, diabetes, the site of the lesion, or recurrent stroke, while it did correlate (*P* 0.027) with age older than 74 years (median value) and, to a greater extent, with a Bamford's classification of TACI compared with other

Table 2 Patients' characteristics at follow-up (T30) and univariate analysis of factors associated with persitent dysphagia

Follow-up evaluation at the 30th day ($n = 217$)				Non-dysphagic		Dysphagic		Univariate analysis (χ^2)
Factor	Category	*N*	%	*N*	%	*N*	%	
Sex	M	112	51.61	77	68.75	35	31.25	*P* 0.36, OR 1.35
	F	105	48.39	65	61.90	40	38.10	95% CI 0.74–2.47
Age	≤ 74 (median)	102	46.58	75	73.53	27	26.47	*P* 0.027, OR 1.99
	> 74 (median)	115	52.51	67	58.26	48	41.74	95% CI 1.08–3.69
Renal failure	No	206	94.06	136	66.02	70	33.98	*P* 0.65, OR 1.62
	Yes	11	5.02	6	54.55	5	45.45	95% CI 0.2–12.94
Heart failure	No	182	83.11	122	67.03	60	32.97	*P* 0.35, OR 1.53
	Yes	35	15.98	20	57.14	15	42.86	0.68–3.38
Liver failure	No	213	97.26	139	65.26	74	34.74	*P* 0.90, OR 0.63
	Yes	4	1.83	3	75.00	1	25.00	95% CI N.V.
Antidiabetic therapy	No	147	67.12	96	65.31	51	34.69	*P* 0.92, OR 0.93
	Yes	70	31.96	46	65.71	24	34.29	95% CI 0.52–1.86
Stroke type	Hemorrhagic	26	11.87	15	57.69	11	42.31	*P* 0.51, OR 0.69
	Ischemic	191	87.21	127	66.49	64	33.51	95% CI 0.28–1.71
Bamford's classif.	LACI + PACI + POCI	165	86.39	119	72.12	46	27.88	*P* 0.00005, OR5.82
	TACI	26	13.61	8	30.77	18	69.23	95% CI 2.2–15.81
Lesion site	Hemispheric	200	92.17	131	65.50	69	34.50	*P* 0.84, OR 1.04
	Brainstem + cerebellar	17	7.83	11	64.71	6	35.29	95% CI 0.37–2.92
Event	First-ever stroke	187	85.39	124	66.31	63	33.69	*P* 0.64, OR 1.31
	Recurrent stroke	30	13.70	18	60.00	12	40.00	95% CI 0.55–3.09
mRS	0–2	76	35.02	64	84.21	12	15.79	*P* 0.0005, OR 4.31
	3–5	141	64.98	78	55.32	63	44.68	95% CI 2.04–9.25
SGA	Well nourished	179	82.49	126	70.39	53	29.61	*P* 0.0017, OR 3.27
	Malnourished	38	17.51	16	42.11	22	57.89	95% CI 1.50–7.14
BMI	< 20	92	42.40	45	48.91	47	51.09	*P* 0.007, OR0.45
	≥ 20	125	57.60	85	68.00	40	32.00	95% CI 0.26–0.79

CI, confidence interval; *OR*, odds ratio; χ^2, chi-squared test with Yates' correction. Bamford's Classification: *LACI*, lacunar infarct; *PACI*, partial anterior circulation infarct; *POCI*, posterior circulation infarct; *TACI*, total anterior circulation infarct. *mRS*, modified Rankin Scale; *SGA*, status global assessment; *BMI*, body mass index

localizations (*P* 0.00005). It also correlated with the degree of dependence evaluated by mRS (*P* 0.0005).

We did not observe any relationship between the dysphagia and the site of stroke, and the prevalence was similar in hemispheric and brainstem-cerebellar lesions. Note that the international literature reports a prevalence of 39–40% in hemispheric strokes and 51–55% in brainstem-cerebellar strokes. The protocol foresaw the consecutive recruitment of stroke patients in cooperating centers in a short period of clinical activity; so, the sample of stroke patients may not exactly reflect the global territorial stroke incidence. Another possible reason for the small number of infra-tentorial stroke cases may be the frequently observed higher severity of this type of lesion that interfered with the need for consent to be recruited in the study.

Notably, we observed a highly significant correlation between BMI < 20 (*P* 0.0041) and dysphagia: 57% of patients whose BMI was < 20 were dysphagic versus 36% of subjects with a BMI ≥ 20. In addition to BMI, the degree of malnutrition evaluated by the SGA was significantly correlated with dysphagia, which was evident in 58% of subjects with malnutrition (SGA score 2 or 3) and in only 30% of the well-nourished patients (SGA score 1).

The univariate analysis of persistent dysphagia at the 30-day follow-up did not show a statistically significant correlation with the stroke type (hemorrhagic 42% vs ischemic 34%;

Table 3 Multivariate logistic regression analysis of clinical factors related with the persistent dysphagia at the 30th day follow-up evaluation

Independent Variable	OR (95% CI)	*P*
Medium or high degree of dependence (mRS ≥ 3)	1.8 (1.40–2.20)	< 0.001
BMI ≥ 20	0.45 (0.30–0.68)	< 0.001

CI, confidence interval; *OR*, odds ratio; *mRS*, modified Rankin Scale; *BMI*, body mass index

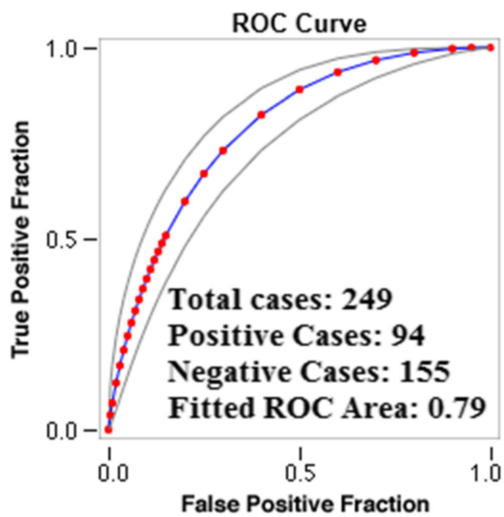

Fig. 1 ROC curve and accuracy of PreDysScore

P 0.5). The correlation between BMI and SGA on the one hand and dysphagia on the other hand confirms data from the FOOD study and other reports showing that malnutrition represents an independent negative prognostic factor in stroke [8–15]. This is in contrast with the data from Crary et al. [27], who observed that nutritional status is not related to the presence of dysphagia. The results of this last author must be due to the high prevalence of obese patients (31.6%) compared with malnourished patients (1.3%) in their clinical study.

Notably, in our experience, BMI ≥ 20 plays an important protective role in reducing dysphagia incidence. Table 4 reports the variables that were strongly correlated with dysphagia persistence at the 30-day follow-up according to the multivariate analysis. In particular, a high mRS score and low BMI were the most reliable clinical parameters for independently predicting the persistence of dysphagia in the present study. These data only partially confirm the few results reported by the literature, which identify older age (> 70 years), the extent of the stroke, and weakness of the palatal reflex (35) as predictive factors of post-stroke dysphagia. Based on our findings, we developed a simple scoring system that is useful for predicting post-stroke dysphagia that ranges from approximately 3.7 to 10; a PreDyScore < 6 shows a negative predictive value of approximately 70%, and a PreDyScore > 8 has a very high positive predictive value (approximately 95%). Old patients with malnutrition (BMI < 20) probably also have sarcopenia, which could worsen spontaneous oral feeding and induce dysphagia (sarcopenic dysphagia). The oldest patients could also be associated with presbyphagia. Moreover, a pre-stroke malnutrition state may be the expression of previous bi-hemispheric of brainstem vascular pauci-symptomatic little ischemic lesions that contributed to dysphagia also before the new, clinically evident, stroke episode.

Diagnoses of post-stroke dysphagia are currently based on clinical data that have poor sensitivity. A good clinical test to predict aspiration is the 3-oz water test described by Mari et al. [28], which has proven to be the most reliable test in predicting aspiration with 84% positive and 78% negative predictive values. Another good clinical test is the Gugging Swallowing Screen (GUSS), which is a dysphagia bedside screening tool that is tailored to predict aspiration risk with good sensitivity and specificity (69% and 50%, respectively) and which suggests dietary recommendations depending on the degree of dysphagia [29]. These methods are useful for detecting the risk of aspiration at the time of admission but are not able to predict the long-term persistence of dysphagia and therefore the timing of PEG placement.

Broadley et al. reported a significant correlation between prolonged dysphagia and clinical parameters (dysphasia, level of consciousness, Barthel index, and lesions of frontal and insular cortices) [22] and created the RAPIDS (Royal Adelaide Prognostic Index for Dysphagic Stroke) test [30]. However, this test has only been validated in patients with swallowing impairment 14 days after stroke and has not been used in the first acute period after stroke.

An improvement in sensitivity can be achieved using videofluorographic techniques. In a study by Mann and colleagues, some factors have been recognized as predictive of dysphagia in stroke patients: age > 70 years, female sex, severity of the post-stroke dependence (Barthel < 60), extension of the palatal lesions, and incomplete emptying of the oral cavity [21].

Han et al. [23] increased the capability of discriminating dysphagia by approximately 10–20% using a difficult score based on the following parameters: lip closure, bolus

Table 4 Analysis of accuracy of PreDyScore in prediting post-stroke dysphagia

	All cases (*N* = 249) %	95% C.I.	PreDyScore < 6 OR > 8 (*N* = 160) %	95% C.I.
Sensitivity	52.47	44.49 to 60.36	67.03	56.39 to 76.53
Specificity	89.66	81.27 to 95.16	95.65	87.82 to 99.09
Positive likelihood ratio	5.07	2.69 to 9.58	15.42	5.05 to 47.07
Negative likelihood ratio	0.53	0.44 to 0.63	0.34	0.26 to 0.46
Positive predictive value	90.43	83.34 to 94.69	95.31	86.95 to 98.41
Negative predictive value	50.32	45.91 to 54.73	68.75	62.04 to 74.76

N, number; *PreDyScore*, Predictive Dysphagia Score; *C.I.*, nonfidence interval formation, mastication, apraxia, tongue-to-palate contact, premature bolus loss, oral transit time, triggering of pharyngeal swallow, vallecular residue, laryngeal elevation, pyriform sinus residue, coating of the pharyngeal wall, pharyngeal transit time, and aspiration. Videofluorographic techniques are not routinely used, and an easy and sensitive test is needed to predict how swallowing could be impaired in the long term after stroke, particularly after 2–3 weeks.

The present study enables the discrimination of subjects with a relative risk of persistent post-stroke dysphagia at 2–3 weeks following stroke onset. A BMI < 20 and mRS score are bedside predictive factors of dysphagia that could be easily evaluated with the aim of correct nutritional support in stroke patients. This could be very useful considering that a recent retrospective observational study reported that the patients with an early PEG tube were more likely to have a shorter length of stay and had greater odds of discharge to home or acute rehabilitation [16].

Moreover, the PreDyScore represents a combination of BMI and mRS, has good sensitivity (67.03%) and specificity (95.65%), and enables the prediction of persistent dysphagia with great accuracy and limited clinical data in any clinical setting.

The mRS is the most prevalent functional outcome measure in stroke research [31], and BMI is an easier nutritional parameter that can be obtained bedside even if the patient cannot be weighed.

Therefore, the PreDyScore could represent an easy-to-use and simple bedside tool for predicting long-term dysphagia and can be proposed in screening for the placement of a PEG.

Randomized controlled trials must be performed to evaluate the efficacy of PreDyScore for indicating PEG placement independently from international guidelines that recommend nasogastric feeding versus PEG tube feeding after a period of 2 to 3 weeks after stroke onset [32, 33].

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Compliance with ethical standards

The study has been approved by the ethics committee of the Policlinico San Martino of Genoa and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Details that might disclose the identity of the subjects under study have been omitted before the analysis. All recruited persons gave their informed consent prior to their inclusion in the study.

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

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