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Original article

Feeding tube transparietal thickness – A promising anthropometric parameter for nutritional assessment of endoscopic gastrostomy fed patients

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SUMMARY

Background & aims: Malnutrition is common in patients eligible for percutaneous endoscopic gastrostomy (PEG). Feeding tube transparietal thickness (TT) may contribute to assess nutritional status. This study aims to: 1) Characterize TT in PEG patients. 2) Determine the association between TT and the currently used tools 3) Define TT best cut-offs to predict undernutrition 4) Assess the correlation between TT and survival.

Methods: Prospective cohort study including patients who underwent PEG. Nutritional assessment was performed using NRS 2002, anthropometry and serum proteins. Anthropometry included body-mass index (BMI), mid upper arm circumference (MUAC), triceps skinfold (TSF) and mid arm muscle circumference (MAMC). TT was measured immediately after PEG and survival was recorded. TT cut-offs were established by comparison with other anthropometric parameters and using the ROC analysis. The correlation between TT and survival was assessed.

Results: 227 patients (161 men and 66 women) aged 23–96 years. Most presented head or neck cancer (51.1%). Undernutrition was identified in 57.7% according with BMI. Median TT was 25 mm (IQR = 10). TT was correlated with BMI (R = 0.5), MUAC (R = 0.5), TSF (R = 0.5) and MAMC (R = 0.4) ($p < 0.01$), respectively, being accurate in predicting undernutrition (AUROC 0.71 ± 0.033, $p < 0.01$). TT <20 mm showed positive predictive value of 81.6% and specificity of 84.4% to detect undernutrition. TT was correlated with survival (R = 0.1) ($p = 0.05$). Head or neck cancer patients' survival was significantly lower if TT ≤ 25 mm ($p = 0.03$).

Conclusions: TT is variable among PEG patients but values below 20–25 mm are suggestive of undernutrition. TT defined in the day of the gastrostomy procedure is the easiest anthropometric parameter that can be obtained from a PEG patient. Due to its higher positive predictive value and correlation with survival, TT should be viewed as an additional anthropometric tool specific for PEG patients, with diagnostic and prognostic value.

1. Introduction

Percutaneous endoscopic gastrostomy (PEG) is a safe and well tolerated method for long-term enteral feeding. It is recommended when a period of inadequate oral intake exceeding 3–4 weeks is expected [1]. The main indication for PEG is prolonged dysphagia caused by cancer (especially head and neck) or in the course of a wide range of neurologic disorders (such as cerebrovascular stroke, amyotrophic lateral sclerosis or dementia) [2].

Abbreviations: AUROC, area under the receiver operating; BMI, body mass index; ESPEN, European Society for Clinical Nutrition and Metabolism; MAMC, mid arm muscle circumference; MUAC, mid upper arm circumference; NRS 2002, nutritional risk screening 2002; PEG, percutaneous endoscopic gastrostomy; TSF, triceps skinfold; TT, feeding tube transparietal thickness.

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The European Society for Clinical Nutrition and Metabolism (ESPEN) define undernutrition as a state resulting from lack of uptake of nutrition that leads to altered body composition (decreased fat free mass and body cell mass) leading to reduced physical and mental function with impaired clinical outcome [2,3]. Body mass index (BMI) is a simple and widespread tool, used as nutritional parameter, which is present in the recent published ESPEN criteria of undernutrition. Although low values indicate underweight, BMI has some major limitations as it does not consider body composition and may be difficult to apply in bedridden and immobile patients [4,5].

Mid upper arm circumference (MUAC), triceps skinfold (TSF) and mid arm muscle circumference (MAMC) are non-expensive anthropometric parameters that should be combined to predict fat and fat-free mass. When used together with BMI and laboratorial data such as serum proteins, they may provide a more accurate characterization of nutritional status [6,7]. However, despite their painless and non-invasive nature, these tools are highly prone to interobserver variation, require specific instruments and should be applied by experienced and trained staff to avoid measure and interpretation mistakes [6]. Also, electrical bioimpedance (BIA), another emerging tool for nutritional assessment that allows the evaluation of body composition require expensive equipment that is not often available [8].

All patients eligible for PEG should have their nutritional status assessed and be regularly monitored during PEG-feeding to prevent or correct malnutrition. In our centre, patients usually perform anthropometric (mainly BMI, TSF, MUAC and MAMC), laboratory (mostly serum proteins and electrolytes) and functional evaluation (hand-grip strength) [9,10]. However, new trustful and practical nutritional assessment tools are desirable for these patients.

Feeding tube transparietal thickness (TT) is the distance between the internal and external bumper of the PEG tube. The correct position of the feeding tube requires that the internal bumper should be left in close contact with the internal gastric wall and the external bumper adjusted to the skin. TT is routinely checked at the end of the gastrostomy procedure to assess the correct position of the tube and alongside PEG feeding to monitor tube dislodgment and other potential complications. Clinical studies to validate TT assessment with different purposes are not available. A recently published retrospective study showed that TT below 20.2 mm at the time of PEG was associated with higher occurrence of post-procedural complications without a clear impact in patient mortality [11]. Actually, TT is equivalent to the gastric wall plus the abdominal wall thickness and therefore is dependent on muscle and subcutaneous fat amount in this anatomical area. This parameter could be simple, rapid and ready to use in PEG-fed patients immediately after gastrostomy, and also complement nutritional evaluation. To the best of our knowledge, the potential use of TT as a tool to identify undernutrition was never assessed in current literature.

The present study aims to:

1) Apply and characterize TT in patients eligible for PEG-feeding.
2) Determine the association between TT and the currently used anthropometric and laboratorial tools.
3) Define the best TT cut-offs for predicting undernutrition.
4) Determine if TT can be used to predict patient outcome and undernutrition-related mortality.

2. Material and methods

2.1. Study design

A single centre, observational and prospective cohort study was performed in a large hospital setting. This study was approved by the ethic committee of our institution.

2.2. Patients

Patients aged 18 years old or older, referred to the Artificial Feeding Team (GENE) of the Gastroenterology Department of Hospital Garcia de Orta, submitted to PEG from 2003 to 2015 due to prolonged dysphagia and that have died using PEG were eligible.

A prospectively collected database was implemented and the following data was collected for each patient: age, gender, clinical indication for PEG, length of transparietal thickness, anthropometric parameters, laboratorial data and date of gastrostomy and death. Survival was recorded in months after PEG until death. All information present in the study database was obtained using this prospectively collected database. Patients lacking any data were excluded.

All patients or their representatives have signed the informed consent for PEG. Patients underwent PEG after a 12-h of fasting. Antithrombotic therapy was managed according to guidelines [12]. Defects in coagulation were corrected prior to the procedure. All patients had to be stable before PEG. Unstable patients were refused or postponed.

Two gastroenterologists performed all procedures with patients under deep sedation with propofol, midazolam, fentanyl, and/or droperidol. During the procedure, oxygen saturation, heart rate and electrocardiographic signs were monitored. The “pull” method was used in most cases. The “push” method with gastropexy was applied routinely in potential curative head or neck cancer patients in order to avoid ostomy metastasis. This approach avoids the passage of the tube through the mouth, pharynx and esophagus, allowing a safe procedure without risk of seeding cancer cells in the gastrostomy tract [13,14].

2.3. Nutritional risk screening 2002 [15]

NRS 2002 was performed in every patient as part of the hospital routine.

2.4. Feeding tube transparietal thickness

TT was measured in millimeters immediately after gastrostomy by one of the gastroenterologists using the scale displayed on the PEG tube. It was performed placing the internal bumper in contact with the internal gastric wall through gentle manual traction and adjusting the external bumper to the skin not too tightly. The value obtained was rounded to the units using a minimal interval of 5 mm and recorded on the procedure report.

2.5. Anthropometric evaluation

Anthropometric evaluation was performed by a trained dietitian before the procedure, according with the ISAK manual of International Society for the Advancement of Kinanthropometry [16]. The average of three consecutive measurements was recorded on the patient clinical file.

1) BMI was obtained in most patients using the equation Weight/Height^2, measured in kilograms and meters, respectively. If patients were unable to easily stand up for weight and height evaluation, BMI was estimated using the MUAC and the regression equations described by Powell-Tuck and Hennessy, which were previously been used and proved to provide a reliable BMI estimation in PEG-fed patients [17]. Each patient was classified according to the age: having undernutrition if BMI <18.5 kg/m^2 or <22 kg/m^2, eutrophy if BMI 18.5–25 kg/m^2 or 22–27 kg/m^2 and overweight if BMI >25 or >27 kg/m^2 for patients under 65 years or 65 years old or older, respectively [18].

2) MUAC was measured in centimeters, using a flexible measuring tape wrapped around the mid upper arm, halfway between the olecranon and the acromion process.
3) TSF was measured in millimeters, using a skinfold caliper on the mid-line of the posterior surface of the arm, halfway between the olecranon and the acromion process. It was considered an indicator of fat mass.
4) MAMC was estimated through MUAC and TSF according with the formula: MAMC (cm) = MUAC (cm) − [TSF (mm) × 0.314]. It was considered an indicator of fat-free mass.

For each patient, the anthropometric values of MUAC, TSF and MAMC were compared with the reference values of the *NHANES* (National Health and Nutrition Examination Survey), through comparison with the *Frisancho* tables [19,20]. The nutritional status was classified for each one of these individual anthropometric parameters as being undernourished, eutrophic and overweight, after percentile adequacy according with the criteria described by Blackburn & Thornton (Table 1) [9,19].

2.6. Laboratory evaluation

A blood sample was obtained just before the PEG procedure. Serum albumin and transferrin were measured as part of patient global nutritional evaluation. Values of albumin <3.5 g/dl and transferrin <200 mg/dl were considered low values, suggestive of malnutrition and/or poor prognosis.

2.7. Statistical analysis

The statistical analysis was performed using the Statistical Package for Social Sciences (SPSS® Inc., Chicago, IL) and Microsoft Office Excel Professional 2017®. Normality was assessed using the Kolmogorov–Smirnov test. Continuous variables were expressed as mean ± standard deviation or median ± interquartile range and categorical variables as percentage. Student's t-test or Mann–Whitney test were used for continuous variables and Chi-square test or Fisher test were used for categorical variables. Correlations were performed at each time using the Spearman's correlation test. TT's performance in predicting undernutrition according with BMI criteria adjusted to the age was analysed calculating the area under the receiver operating characteristics (AUROC) curve using DeLong method and the MedCalc software version 12.5. The curves were compared among the different anthropometric parameters (MUAC, TSF and MAMC) using Hanley & McNeil test and the best cut-off to predict undernutrition was selected using the Youden index test. All tests were performed at a 5% level of statistical significance.

3. Results

3.1. Patients

From all the adult patients that underwent PEG from 2003 to 2016 that died under PEG-feeding, 227 were included in the prospectively collected database and presented all the required data: 161 men and 66 women, aged between 23 and 96 years (mean 65.1 ± 13.9). One-hundred and twelve patients (48.7%) were below 65 years. The main characteristics of the population are described in Table 2. The most common clinical indication for PEG were head or neck cancer (51.1%) and neurologic disorders (44.9%), including post-stroke persistent dysphagia, amyotrophic lateral sclerosis and dementia. A minority of patients underwent PEG due to other less frequent causes (4%).

3.2. Nutritional assessment: NRS 2002, anthropometry and serum proteins

NRS 2002 was ≥3 points in all patients, signalling high nutritional risk.

BMI before PEG ranged from 13.6 to 43 kg/m^2 (mean 19.8 ± 4.4 kg/m^2) and was suggestive of undernutrition in 131 patients (57.7%). Undernutrition was also identified in 194 (85.5%), 207 (91.2%) and 160 (70.5%) patients according with MUAC, TSF and MAMC, respectively. BMI, MUAC and TSF were significantly lower in patients with head or neck cancer when compared to neurologic patients ($p < 0.01$).

Mean albumin was 3.38 ± 0.7 g/dl and mean transferrin was 175.9 ± 49 mg/dl. Serum albumin and transferrin at the day of the gastrostomy procedure were low in 117 (51.5%) and 159 (70%) patients, respectively. Low serum albumin was associated with low serum transferrin ($p < 0.01$). Albumin was significantly lower in neurologic patients ($p < 0.01$) and transferrin did not differ between groups ($p = 0.29$). Although albumin and transferrin are dependent of several factors, low serum proteins levels, together with NRS 2002 and anthropometric parameters suggested high nutritional risk and high baseline prevalence of undernutrition in most patients eligible for gastrostomy feeding. Those features were also highlighted in Table 2.

3.3. Feeding tube transparietal thickness

TT was evaluated in all patients ranging from 10 mm to 65 mm (median: 25 mm; IQR = 10). Table 3 displayed median values of TT according with nutritional status defined by each anthropometric tool. One hundred and thirty six patients (59.9%) presented TT equal or below 25 m. The number of patients who present TT = 25 mm and TT >25 mm was similar regardless of the clinical indication for PEG ($p > 0.05$). Patients who present TT = 25 mm tended to display malnutrition according with all used anthropometric tools ($p < 0.01$). TT was also significantly correlated with BMI ($R = 0.5$, $p < 0.01$), MUAC ($R = 0.5$, $p < 0.01$), TSF ($R = 0.5$, $p < 0.01$) and MAMC ($R = 0.4$, $p < 0.01$) (Fig. 1).

TT accuracy to predict undernutrition according with BMI adjusted to age assessed with ROC analysis (Fig. 2) showed an AUROC 0.71 ± 0.033 ($p < 0.01$) being not superior to MUAC (AUROC 0.81 ± 0.03, $p = 0.01$) and MAMC (AUROC 0.80 ± 0.03, $p = 0.02$) and not significantly different from TSF (AUROC 0.69 ± 0.03, $p = 0.7$). The optimal cut-off point of the TT selected by the Youden index was 20 mm with a positive predictive value of 81.6% and specificity of 84.4%, which were superior to the other anthropometric tools.

Table 1
Nutritional status according with the arm anthropometric parameters.

	Undernutrition	Eutrophy	Overweight	Obesity
Mid upper arm circumference (MUAC)	<90%	90–110%	110–120%	>120%
Triceps skinfold (TSF)	<90%	90–110%	110–120%	>120%
Mid arm muscular circumference (MAMC)	<90%	>90%		

Blackburn, G.L. & Thornton, P.A. 1979.

Table 2
Baseline characteristics of the patients.

Patient characteristics – count (%)	
Age	M = 65.1 ± 13.9 years
Gender	Male: 161 (70.9)
	Female: 66 (28.1)
Indication for PEG	Head and neck cancer: 116 (51.1)
	Neurologic disease: 102 (44.9)
	Others: 9 (4)
Body mass index	Low: 131 (57.7)
	Normal/High: 96 (42.3)
Mid upper arm circumference	Undernutrition: 194 (85.5)
	Eutrophy: 29 (12.8)
	Overweight: 4 (1.8)
Triceps skinfold	Undernutrition: 207 (91.2)
	Eutrophy: 8 (3.5)
	Overweight: 12 (5.3)
Mid arm muscular circumference	Undernutrition: 160 (70.5)
	Eutrophy: 67 (29.5)
Albumin	Low: 117 (51.5)
	Normal: 110 (48.5)
Transferrin	Low: 159 (70)
	Normal: 68 (30)
Feeding tube transparietal thickness	Median: 25 mm (IQR:10)
Overall survival	Median: 7 months (IQR 24)

Table 3
Median value for transparietal feeding tube thickness in each nutritional status category according with different anthropometric tool.

Anthropometry	Undernutrition	Eutrophy	Overweight
Body mass index	20	30	40
Mid upper arm circumference	25	30	45
Triceps skinfold	25	30	40
Mid arm muscular circumference	25	30	Not applicable

Table 4 highlights the performance of TT, MUAC, TSF and MAMC in predicting undernutrition.

Any significant association was found between TT and serum proteins ($p > 0.05$).

3.4. Survival

There were no major post-PEG adverse events and no death was attributable to a complication of the technique. All deaths were caused by the evolution of the underlying disorders and comorbidities. Survival after PEG ranged from less than one month to a maximum of 194 months (median 7 months; IQR = 24) being superior in neurologic patients ($p < 0.01$). Although TT was mildly positive correlated with patient survival ($R = 0.1$, $p = 0.05$), no significant difference was found between patients who presented TT = 25 mm or TT >25 mm ($p = 0.08$). However, considering the clinical indication for PEG, TT = 25 mm was associated with worse survival in patients with head or neck cancer ($p = 0.03$). Figure 3 represents Kaplan–Meier survival analysis according to the TT value and clinical indication for PEG.

4. Discussion

Malnutrition is a high prevalent condition in ambulatory and hospitalized patients, being strongly associated with prolonged hospital stay, higher healthcare costs and increased morbidity and mortality [21–23]. BMI is a simple and widespread used anthropometric tool to identify undernutrition, however measuring weight and height in bedridden patients might be challenging [24]. In fact, this is the case for a large number of patients with diseases requiring PEG feeding. MUAC, TSF and MAMC are other important anthropometric parameters that may help multidisciplinary teams to assess and monitor nutritional status of PEG-fed patients.

Our group previously developed two predictive survival models for PEG patients: one to predict early mortality, sooner than 3 weeks after the gastrostomy procedure and other with a special focus in head and neck cancer PEG patients. Nevertheless, these are complex tools for daily use [7,10]. Also, we demonstrated the accuracy of MUAC in predicting the BMI of PEG patients using the regression equations described by *Powel Tuck Hennessy* [17]. However, despite the extensive research performed by our team, current literature data on alternative valid and practical ways to evaluate nutritional status and prognosis of enteral fed patients is still sparse [25,26].

In the present study, the authors aimed to evaluate if TT at the time of gastrostomy could be used as an innovative anthropometric parameter to easily identify patients with poor nutritional status and poor outcome, when combined with other commonly used tools already validated. Our results showed a positive and significant correlation of TT with BMI, MUAC, TSF and MAMC. Actually, TT was defined by the distance between the internal and external bumper of the PEG tube, being dependent on the thickness of gastric wall, abdominal muscle layers and subcutaneous adipose tissue. Since BMI relies on the relationship between height and weight, MUAC and MAMC predict muscle mass and TSF is used as a fat mass indicator, a correlation between TT and these tools was already expected and became evident with our analysis. We also found a wide range of TT values in our patients. Although no cut-off intervals were established in previous reports, a single retrospective study published by James MK et al. described a worse outcome for patients with TT <20.2 mm. However, in their approach TT was reported as an incidental marker of poor outcome and was not intended to be used as a nutritional status indicator in the study design [11]. The combination of TT with each anthropometric parameter in every included patient allowed us to define indicative values that could be used to assess the nutritional status. Our analysis showed that undernutrition diagnosed using MUAC, TSF and MAMC corresponds to a median TT value of 25 mm (or 20 mm if undernutrition was defined by BMI). In eutrophic patients a TT value of 30 mm was found regardless of the anthropometric tool used. TT values above 40–45 mm appeared to signal overweight/obesity. Since BMI is still the most validated tool to define undernutrition according with ESPEN guidelines, we compared the performance of TT, MUAC, TSF and MAMC to predict its occurrence. TT accuracy seems not to be superior to the other anthropometric parameters but a cut-off of 20 mm signals undernutrition with high specificity and PPV (above 80%). In fact, TT is the easiest anthropometric parameter to obtain in PEG patients and when used with other anthropometric tools, may increase undernutrition detection rate. Nevertheless, the risk of false negative results suggests the need to avoid its isolated application.

According with our results, TT may also be used to predict outcome in PEG-fed patients since a significant correlation with overall post-PEG survival was obtained. Also, survival was significantly lower if TT = 25 mm in patients with head and neck cancer but it was not observed for neurologic patients. Furthermore, TT as a rapid and immediately obtained parameter after PEG procedure, may easily stratify patients who will need more intensive monitoring and close follow-up.

Serum albumin and transferrin are also commonly used to evaluate nutritional status. However, as negative acute phase reactants, they should be viewed as outcome markers, which was previously demonstrated [10]. Any significant association was found neither between TT nor all other anthropometric parameters with serum proteins. Anthropometric and laboratorial tools are not

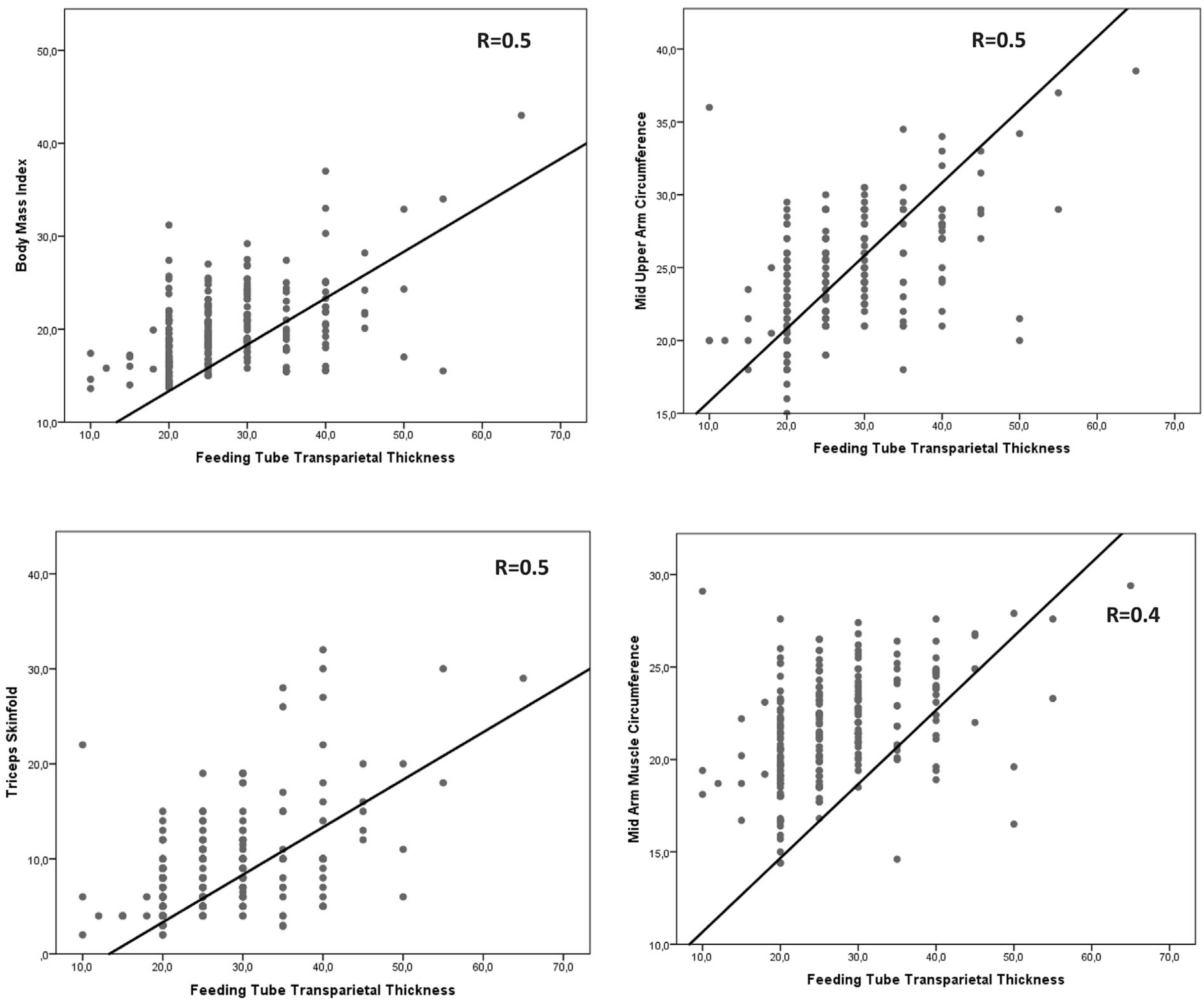

Fig. 1. Correlation analysis between feeding tube transparietal thickness and the different anthropometric parameters.

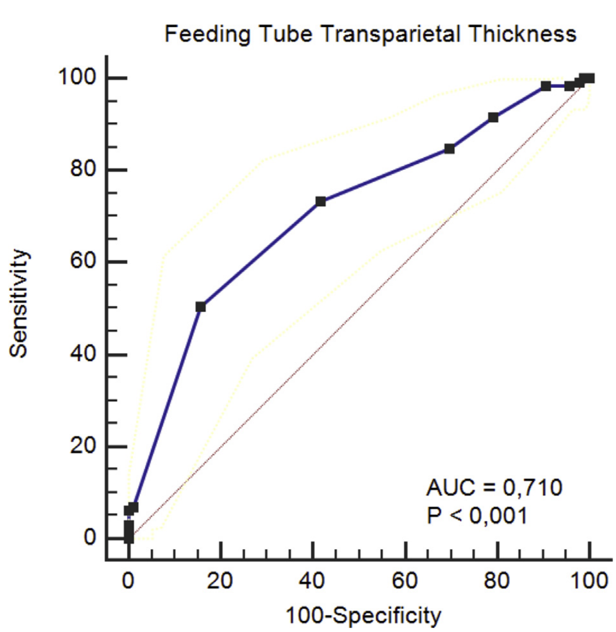

Fig. 2. AUROC of feeding tube transparietal thickness in predicting undernutrition according with BMI.

Table 4
Performance of the nutritional assessment tools in predicting undernutrition according with BMI.

Cut-off point	Sensitivity	Specificity	PPV	NPV	PLR	NLR
TT (20 mm)	50.4%	84.4%	81.5%	55.5%	3.22	0.59
MUAC (25 cm)	81.7%	68.8%	78.1%	73.3%	2.61	0.27
TSF (8 mm)	68.7%	60.4%	70.3%	58.6%	1.74	0.52
MAMC (21.9 cm)	73.3%	75%	80%	67%	2.93	0.36

PPV: positive predictive value. NPV: negative predictive value. PLR: positive likelihood ratio. NLR: negative likelihood ratio.

exclusive and should be combined to assess nutritional status and predict prognosis in PEG patients.

The present study displays some limitations. First, it is carried out in a single hospital and therefore will need external validation. Second, some information registered in the database may not always be completed. However, data was collected prospectively and our double registration in paper and informatics support helps to avoid missing information. Third, TT was viewed as a homogeneous parameter for each patient and some differences in body composition were not considered. As BMI, TT does not allow distinction of fat from fat-free mass. TT value may be similar in different patients with different abdominal wall fat and muscle mass, which may influence prognosis in different ways. Fourth, TT measure can be

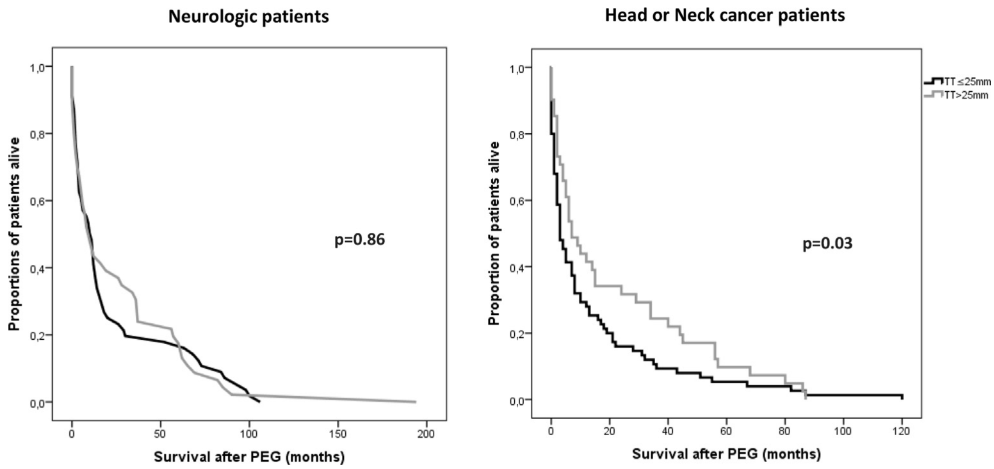

Fig. 3. Kaplan–Meier survival analysis according with feeding tube transparietal thickness and clinical indication for PEG.

variable depending on the exact site of the abdomen where gastrostomy is performed. Finally, TT cut-offs were grossly defined according with the median values obtained by comparison with other validated anthropometric tools, which may justify further prospective trials for validation.

5. Conclusions

Established malnutrition is common in patients undergoing PEG. Different anthropometric tools are available for nutritional assessment of PEG-fed patients. TT is a widely variable measure but it was significantly correlated with BMI, MUAC, TSF and MAMC. TT values below 25 mm appeared to identify undernutrition, 30–40 mm signalled eutrophy and values above 40 mm were suggestive of overweight. In the present study, TT = 20 mm achieved specificity and PPV above 80%, being the best cut-off to predict malnutrition as defined by BMI. TT at the time of PEG was significantly correlated with patient survival after PEG. Head and neck cancer patients' survival was significantly lower if TT = 25 mm.

TT defined in the day of the gastrostomy procedure is the easiest anthropometric parameter that can be obtained from a PEG patient. TT should be viewed as an additional tool, specific for these patients, with diagnostic and prognostic value. Furthermore, it may be complementary to the standard anthropometric tools and laboratorial data to improve nutritional assessment and identify PEG patients needing a more focused nutritional support. Further studies are desirable to validate this approach and evaluate the role of TT in overtime nutritional status monitoring.

Conflicts of interest

There are no conflicts of interest regarding this article.

Authors'contributions

Gonçalo Nunes: Conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript, final approval of the version to be published. **Tânia Meira, Marta Patita, Ana Teresa Barata** and **Carla Adriana Santos:** analysis and interpretation of data, critical revision of the article and final approval of the version to be published. **Jorge Fonseca:** analysis and interpretation of data, critical revision of the article, study supervision and final approval of the version to be published.

Disclaimers

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