ANTHROPOMETRY

Predictive and concurrent validity of the Malnutrition Universal Screening Tool using mid-upper arm circumference instead of body mass index

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Abstract

Background: Considering the difficulty in obtaining weight and height measurements of patients at hospital admission, the Malnutrition Universal Screening Tool (MUST) proposes the use of mid-upper arm circumference (MUAC) instead of body mass index (BMI) as an alternative for screening of malnutrition risk. The present study aimed to evaluate the performance of MUST with MUAC in place of BMI to identify nutritional risk and predict prolonged hospitalisation and mortality in hospitalised patients.

Methods: The prospective cohort study involved ambulant patients aged ≥18 years who were admitted to the emergency department of a public hospital. A questionnaire concerning clinical and socio-demographic data was applied and anthropometric measurements were performed (weight, height, BMI and MUAC). Nutritional risk screening was performed using the original MUST (BMI) and MUST-MUAC tools. The outcomes were length of hospital stay and death.

Results: Seven hundred and fifty-two patients were included and followed-up for 13.5 (interquartile range 3.00–19.00) days. The frequency of patients at nutritional risk was higher according to MUST-MUAC (48.9%) compared to the original MUST (37.1%). MUST-MUAC showed concurrent validity, demonstrating good agreement with the original MUST ($k = 0.690$), high sensitivity (95.3%) and accuracy (area under the curve = 0.868; 95% confidence interval = 0.841–0.895) with respect to identifying nutritional risk. The presence of nutritional risk detected by the MUST-MUAC increased the chance of prolonged hospital stay by 1.9 (95% CI. 1.4–2.7)-fold and mortality by 3.2 (95% CI. 1.1–9.4)-fold.

Conclusions: MUST-MUAC showed satisfactory concurrent and predictive validity. Considering that MUAC measurement is easier to perform than BMI, the MUST-MUAC should be used for screening of nutritional risk in hospitalised patients.

Introduction

Malnutrition is observed in approximately 50% of hospitalised patients [1,2]. The cause of malnutrition is multifactorial, resulting from inadequate food intake, loss of nutrients and/or increased nutritional requirements because of an increased metabolic demand [3]. It has a considerable impact on the morbidity and mortality of hospitalised patients. Although the factors that cause mortality and long hospital stay are diverse, observational studies have shown that malnourished patients have a higher risk of infection, higher hospital readmission rates and a longer hospital stay, indicating that this condition contributes to increased mortality and has a negative impact on hospital costs [4–6].

In view of this, the early screening of hospitalised patients at risk of malnutrition becomes of great importance. Nutrition risk screening aims to early detect the presence of nutritional risk in hospitalised patients in the first 24–72 h of their admission [7,8].

Several tools have been developed to detect nutritional risk in hospitalised patients. Among these instruments, the Malnutrition Universal Screening Tool (MUST), developed by the British Association of Parenteral and Enteral Nutrition, has been considered a screening method of easy application, high reproducibility and reliability [9]. It assesses nutritional status [body mass index (BMI) and weight loss] and disease-related dysfunction aiming to identify patients at low, medium or high risk of malnutrition. Initially, the instrument was validated for use in communities, and later for use in hospitals [10]. Studies have shown that MUST has a satisfactory performance in predicting clinical outcomes, such as length of hospital stay and mortality [6,11].

As a result of difficulty in measuring weight and height at hospital admission of patients and in community settings and, consequently, calculating BMI, MUST proposes the measurement of the mid-upper arm circumference (MUAC) as a simpler, easier alternative to BMI for the assessment of current nutritional status. MUAC cut-off points for identification of malnutrition and overweight are <23.5 cm and >32 cm, respectively [9].

There is a correlation between BMI and MUAC described in the literature. A retrospective study [12] carried out in a Spanish hospital showed a good correlation between MUAC and BMI, independent of gender and age of patients. This study established a cut-off point of <20.5 cm for the accurate identification of patients with BMI <18.5 kg m^{-2}. A cross-sectional study conducted in Bangladesh also showed a strong correlation between MUAC and BMI in men and women, suggesting that MUAC can be used as a substitute for BMI when it is not possible to measure the weight and height of the patients [13]. However, the use of MUAC in the MUST (MUST-MUAC) as an alternative to BMI has been little explored. As far as we know, it has not tested in emergency rooms to date. A cross-sectional study involving elderly people in Italy showed a moderate agreement in the identification of nutritional risk by original MUST and by MUST-MUAC [14]. Therefore, the present study aimed to evaluate the performance of the MUST-MUAC with respect to identifying nutritional risk and predicting prolonged hospital stay and mortality in patients admitted to the emergency room.

Materials and methods

The present study comprised a prospective cohort study involving patients who were admitted to the emergency department of a public tertiary hospital in Porto Alegre (Rio Grande do Sul, Brazil) and who were followed until discharge. The study was approved by the local Ethics Committee (number 360.639) and all patients provided their written informed consent.

The sample size was calculated using a computer program considering a type I error of 5%, a type II error of 80% and incidence of death of 9.1% in patients at nutritional risk according to a previous study conducted in Brazil [15]. A sample size of 746 patients was required considering an increase of 20% for potential loss of follow-up (http://www.openepi.com/Menu/OE_Menu.htm).

The sample was consecutively selected from the population of all patients admitted to this service between September 2013 and February 2015. Patients aged ≥18 years of age, who were conscious and able to walk without assistance, were included in the study. Patients with amputation of lower limbs, those with no possibility of anthropometric assessment or who were unable to communicate, and pregnant or lactating women, were excluded.

Three trained researchers collected the data using a standard form and performed the anthropometric measures. Socio-demographic characteristics including gender, age, ethnicity, marital status, level of education, lifestyle data, place of origin and socio-economic level were collected. Medical history and reason for admission were obtained from electronic medical records. Metabolic stress related to underlying disease was classified as mild, moderate or severe according to the Detsky proposal [16]. Anthropometric measures (weight and height) were obtained when the patients barefoot, wearing as few clothes as possible. Patients were asked about their usual weight and the percentage of weight loss [(current body weight – current body weight) × 100/current body weight] was calculated. BMI was calculated [weight/

(height × height)] and expressed in kg m^{-2}. MUAC was measured as suggested by the MUST screening tool [9].

Nutritional screening was performed using the original MUST tool (MUST-BMI), which estimated nutritional risk by the sum of the scores obtained from BMI classification, unplanned weight loss in the last 3–6 months and acute disease effect (i.e. if there has been or is likely to be no nutritional intake for more than 5 days). Patients were classified according to the nutrition risk in three categories as indicated in Table 1 [9]. For nutritional screening using the MUST-MUAC tool, MUAC was measured in place of BMI calculation. For data analysis, patients with medium and high nutritional risk according to the original MUST and MUST-MUAC tools were grouped in the category 'with nutritional risk' and those with low risk were categorised as 'without nutritional risk'.

The outcomes of interest were: length of stay in the emergency department (days), length of hospital stay (days) and death in hospital. Very long hospital stay was considered when the length of stay was longer than 15 days [15].

Descriptive statistics were performed and parametric and nonparametric quantitative variables were expressed as the mean (SD) or median and interquartile range, respectively. Normality of data distribution was tested by the Kolmogorov–Smirnov test. Absolute and relative frequencies were calculated for categorical variables. Agreement between original MUST and MUST-MUAC for nutritional risk identification was achieved using the kappa concordance coefficient. The area under the receiver operating characteristic (ROC) curve, sensitivity and specificity were determined to investigate the concurrent validity of the MUST-MUAC considering the original MUST as the reference method. Patients with and without nutritional risk according to MUST-MUAC were compared for anthropometric, clinical and general data using Student's *t*-test or the Mann–Whitney *U*-test, according to normality of the variables. Poisson regression, considering the length of hospital stay as the independent variable, and Cox regression, considering death as the independent variable, were performed to analyse the predictive validity of MUST-MUAC, adjusted for age and metabolic stress. Analyses were performed using SPSS, version 20.0 (IBM Corp., Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

The study was conducted using a total of 752 patients with a mean (SD) age of 53.59 (15.48) years (45% male and 86.1% white). The length of stay in the emergency department and the length of hospital stay were 3.54 (interquartile range 2.00–5.00) days and 13.47 (interquartile range 3.00–19.00) days, respectively. The median (interquartile range) number of years at school was 8.0 (4.0–11.0), 23.1% of patients were active smokers and 5.6% reported alcohol consumption. Twenty-eight patients (3.72%) died during hospitalisation. The main reasons for hospital admission were gastrointestinal disorders (21.3%) and cancer (19.7%). Some 11.3% of patients had cardiac diseases, 8.5% had kidney problems, 7.9% had neurological disorders, 6.8% had problems related to the respiratory system, 5.2% had vascular diseases and the other patients were admitted with less common disorders.

Mean (SD) weight and BMI of patients were 73.04 (17.75) kg and 28.13 (6.39) kg m^{-2}, respectively. Mean (SD) usual weight was 75.50 (17.04) kg and mean (SD) MUAC was 29.25 (4.91) cm. More than one-half of participants (57.4%) had a weight loss <5%; 18.5% had a weight loss between 5% and 10%, and 24.1% had a weight loss >10%. In only 5.0% of patients was there (or was there likely to be) no nutritional intake for more than 5 days.

According to the original MUST, 37.1% of patients were classified as having nutritional risk: 16.3% with medium risk and 20.8% with high risk. Considering the MUST-MUAC, 48.9% of patients were classified as having nutritional risk: 28.6% with medium risk and 20.3% with high nutritional risk.

The sensitivity and specificity of MUST-MUAC with respect to identifying nutritional risk were 95.3% and 78.3%, respectively; the area under the ROC curve was 0.868 [95% confidence interval (CI) = 0.841–0.895]. Kappa concordance coefficient between the original MUST and MUST-MUAC was 0.690.

Mean (SD) age was not different ($P = 0.154$) between patients with and without nutritional risk: 54.41 (15.76)

Table 1 Nutritional risk criteria by the original Malnutrition Universal Screening Tool including body mass index calculation (MUST-BMI) and modified MUST including measurement of the mid-upper arm circumference (MUST-MUAC)

MUST-BMI	MUST-MUAC
1. BMI (kg m^{-2})	1. MUAC (cm)
>20 = 0 point	≥23.5 = 0 point
18.5–20 = 1 point	<23.5 = 1 point
<18.5 = 2 points	
2. Weight loss (%)	
<5 = 0 point	
5–10 = 1 point	
>10 = 2 points	
3. Acute disease effect (if there has been or is likely to be no nutritional intake for more than 5 days)	
No = 0 point	
Yes = 2 points	
Classification	
0 point = low nutritional risk → **WITHOUT** nutritional risk	
1 point = mild nutritional risk → **WITH** nutritional risk	
≥2 points = high nutritional risk → **WITH** nutritional risk	

Table 2 Anthropometric parameters of patients with and without nutritional risk according to the Malnutrition Universal Screening Tool with measurement of mid-upper arm circumference (MUST-MUAC)

Variable	With nutritional risk (*n* = 368)	Without nutritional risk (*n* = 384)	*P*
Current weight (kg)	66.90 (16.81)	78.4 (16.62)	<0.001*
Usual weight (kg)	74.39 (18.44)	76.56 (16.07)	0.085*
BMI (kg m^{-2})	25.75 (6.01)	30.42 (5.89)	<0.001*
MUAC (cm)	27.36 (4.86)	31.07 (4.22)	<0.001*
Weight loss (%)	8.97 (5.67–13.50)	−1.48 (−6.67–1.40)	<0.001†

BMI, body mass index.
*Student's *t* test.
†Mann–Whitney *U*-test.
Data were expressed as the mean (SD) or median and interquartile range (P25 - P75) (in parenthesis).

versus 52.80 (15.19) years, respectively). A higher frequency of patients at nutritional risk had high metabolic stress compared to those without nutritional risk (48.9% versus 33.2%, *P* < 0.001). No difference was found in sex or ethnicity distribution between patients with and without nutritional risk. Educational level was not different between the groups (data not shown). As expected, current weight, BMI and MUAC were higher in patients without nutritional risk compared to patients with nutritional risk, as shown in Table 2.

Both length of stay in the emergency department [3.0 (interquartile range 2.0–5.0) days versus 3.0 (interquartile range 2.0–4.0) days; *P* = 0.011] and length of hospital stay [10.5 (interquartile range 4.0–21.8) days versus 7.0 (interquartile range 3.0–15.0) days; *P* < 0.001] were significantly higher in patients with nutritional risk according to MUST-MUAC compared to patients without nutritional risk. The frequency of patients with nutritional risk with hospital stay longer than 15 days was higher compared to patients without nutritional risk (61.4% versus 38.6%; *P* < 0.001). The incidence of death was also significantly higher in patients with nutritional risk (6.5%) than in those without nutritional risk (1.0%).

According to multivariate analysis, the presence of nutritional risk identified by the MUST-MUAC was associated with a significant increase in the chance of a very long hospital stay (>15 days) and in the risk of death (Table 3).

Discussion

The present study aimed to evaluate the performance of the MUST, including MUAC measurement instead of calculating BMI, with respect to identifying nutritional risk

Table 3 Association between nutritional risk identified by the Malnutrition Universal Screening Tool with measurement of mid-upper arm circumference (MUST-MUAC) and clinical outcomes in hospitalised patients

Independent variable	RR/HR (95% CI)	*P*
Length of hospital stay >15 days*	1.908 (1.364–2.669)	<0.001
Death‡	3.169 (1.067–9.409)	0.038

CI, confidence interval; RR, relative risk; HR, hazard ratio.
*Poisson regression.
‡Cox regression; the analyses were adjusted for metabolic stress related to underlying disease and age.

and predicting morbidity and mortality. MUST-MUAC demonstrated concurrent validity, demonstrating good agreement with the original MUST, as well as high sensitivity and accuracy with respect to identifying nutritional risk. In addition, the presence of nutritional risk detected by MUST-MUAC increased the chance of a very long hospital stay by 1.9-fold and the risk of mortality by 3.2-fold, confirming its predictive validity.

The prevalence of nutritional risk in hospitalised patients identified by the original MUST varies among the studies reported in the literature [14,15,17–19]. A cohort study conducted in Israel involving 215 elderly patients who underwent hip surgery identified nutritional risk in 20.4% of the sample [17]. Another prospective study involving 705 patients from Brazilian hospitals detected a prevalence of nutritional risk of 39.6% [15]. The age and severity of patients may explain the difference in the prevalence of nutritional risk between the studies (i.e. the frequency of nutritional risk is lower in younger patients and in those with lower metabolic stress).

In the present study, the MUST-MUAC identified a greater number of patients with nutritional risk than the original MUST (49% versus 37%). The cross-sectional study carried out in the Italian elderly showed a prevalence of nutritional risk of 18.21% and 20.12% when applying MUST-MUAC and the original MUST, respectively [14]. Possibly, the lower prevalence of nutritional risk is justified because patients were not hospitalised and had chronic diseases.

Several studies have investigated the applicability of MUAC as an alternative to BMI with respect to evaluating nutritional status [12–14,20,21]. A retrospective study involving 1373 patients conducted in a Spanish hospital showed satisfactory accuracy [area under the curve (AUC) = 0.92, 95% CI = 0.90–0.94] of MUAC with respect to identifying malnutrition (BMI <18.5 kg m^{-2}) considering the cut-off value of MUAC <22.5 cm, independent of the age and gender of participants [12]. In a cross-sectional study of 650 adults carried out in a hospital in Bangladesh, Sultana *et al.* [13] also demonstrated

satisfactory accuracy of MUAC with respect to identifying patients with BMI <18.5 kg m^{-2}, suggesting a cut-off point of MUAC <25 cm for men (AUC = 0.93, 95% CI = 0.90–0.96) and <24 cm for women (AUC = 0.92, 95% CI = 0.90–0.95). Furthermore, a systematic review of 47 studies suggests that a MUAC ranging from 22 to 24 cm may be a good substitute for BMI <18.5 kg m^{-2} [20]. In addition, it has been reported in the literature that MUAC is less affected by changes in fluid retention (oedema, ascites) than BMI, which increases its applicability in clinical practice [13].

MUST-MUAC showed satisfactory predictive validity in the present study because it was positively associated with length of hospital stay and mortality. Indeed, nutritional risk is a prognostic indicator in hospitalised patients and is associated with worse outcomes. In a study conducted with 409 adults and elderly patients in a Spanish tertiary hospital, individuals with nutritional risk (classified according to original MUST) had a longer hospital stay compared to patients without nutritional risk. The risk of death was also significantly higher in patients with nutritional risk (hazards ratio = 6.965, 95% CI = 2.048–23.961) [6]. A multicentre longitudinal study involving 564 063 patients admitted to Dutch hospitals also demonstrated a 1.4-day longer hospital stay in patients with nutritional risk compared to those without nutritional risk (also according to the original MUST) [19]. In addition, a prospective Brazilian study of 234 patients from the emergency unit of a general hospital showed that, for every 10 patients at nutritional risk, four stayed >10 days in the hospital [22]. Another prospective observational study involving 537 patients with stroke also showed a positive association between the presence of nutritional risk according to the original MUST and mortality; in patients with high nutritional risk, the risk of death was 5.6-fold higher (95% CI = 3.23–9.96) than in patients with low nutritional risk [23].

As a strength, the present study included a considerable number of hospitalised patients of different age groups, of both genders and with different clinical conditions. Furthermore, the study was conducted in the emergency department, which is where nutritional screening should be performed because this is the main 'front door' to the hospital, where patients may spend several days, particularly in public institutions (a median of 3 days in the present study). On the other hand, the sample included only patients who were conscious and able to walk without assistance and hence our results cannot be extrapolated to other hospitalised patients.

Considering that 54% of all patients admitted to the emergency department have moderate-to-high risk of falling [24], MUST-MUAC has high applicability because it is easy and fast, and involves anthropometric measures that require little manipulation of the patient, such as weight and height.

As a result of the concurrent and predictive validity of MUST-MUAC demonstrated in the present study, the modified MUST is a viable alternative to the original instrument for screening of emergency patients at nutritional risk. Considering that the MUAC is an easy and simple measure, it can be applied by any healthcare professional if have been suitably trained. It is recommended that a dietitian trains the healthcare professionals for MUAC so that they secure the accuracy of the measurement. Also, it is important that the hospital established a nutrition care plan for patients who are identified as being at nutritional risk: these patients should be evaluated by a dietitian for establishment of a nutritional diagnosis and dietary intervention. Patients without nutritional risk at hospital admission should be rescreened again after 7–10 days because nutritional risk can change during hospitalisation.

Acknowledgments

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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