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Three common nutritional screening tools in the light of the new ESPEN consensus definition of the diagnostic criteria for malnutrition among geriatric gastrointestinal cancer patients



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4 **Three common nutritional screening tools in the light of the new**
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6 **ESPEN consensus definition of the diagnostic criteria for**
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8 **malnutrition among geriatric gastrointestinal cancer patients**
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Abstract

Objective: The aim of this study was to evaluate and compare the three common nutritional screening tools with the new ESPEN diagnostic criteria for malnutrition among the elderly gastrointestinal cancer patients.

Research Methods & Procedures: Nutritional screening tools, including Nutritional Risk Screening 2002 (NRS 2002), Malnutrition Universal Screening Tool (MUST) and the Short Form of Mini Nutrition Assessment (MNA-SF), were applied to 255 patients with gastrointestinal cancer. We compared the diagnostic value of these tools for malnutrition, using the new ESPEN diagnostic criteria for malnutrition as the “gold standards”.

Results: According to the new ESPEN diagnostic criteria for malnutrition, 20.0% of the patients were diagnosed as malnourished. With the use of NRS 2002, 52.2% of the patients were found to be at high risk of malnutrition, with the use of MUST, 37.6% of the patients were found to be at moderate/high risk of malnutrition, and according to MNA-SF, 47.8% of the patients were found to be at nutritional risk. MUST was the best correlated with the ESPEN diagnostic criteria ($K = 0.530$, $p < 0.001$) compared with NRS 2002 ($K = 0.312$, $p < 0.001$) and MNA-SF ($K = 0.380$, $p < 0.001$). The ROC curve of MUST had the highest Area Under the Curve (AUC) compared with NRS 2002 and MNA-SF.

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4 Conclusions: MUST was found to perform the best to identify the
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6 malnourished elderly gastrointestinal cancer patients distinguished by the
7
8 new ESPEN diagnostic criteria for malnutrition. Nevertheless, further
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10 studies are needed to verify our findings.
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13
14 Keywords: Malnutrition, nutritional screening tools, ESPEN diagnostic
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16 criteria, elderly, gastrointestinal cancer
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19 **Strengths and limitations of this study**

- 20
21 ● To our best knowledge, this is the first study to evaluate the three
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23 screening tools in the specific geriatric gastrointestinal cancer
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25 patients.
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- 28
29 ● We compared the diagnostic value of the three screening tools, using
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31 the new ESPEN diagnostic criteria for malnutrition as the
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33 “gold standards”.
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37 ● the sample size is relatively small. However, this study was conducted
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39 in two centers with large surgical volume. To a certain extent, it
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41 overcame the smallness of the sample size.
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Introduction

As the life expectancy and world population ages increase, the proportion of elderly patients has been enlarged obviously. It is well known that the risk of cancer increases with age. More than half of the malignancies occur in people aged ≥ 65 years.[1, 2] Gastrointestinal cancer is one of the most common malignancies in the elderly,[3] and surgical excision remains the most effective therapy for gastrointestinal cancers.[4] Although the surgical techniques have been improved significantly, elderly gastrointestinal cancer patients still have a high frequency of complications and mortality.[4-8] This is partly due to the high prevalence of malnutrition, which is a common and serious problem in the elderly cancer patients.[9, 10, 11] Therefore, it is important to evaluate the nutritional risk of the geriatric gastrointestinal cancer patients before surgery.

To accurately assess the nutritional risk, it is important to choose an efficient nutritional screening tool. Although there are many widely used nutritional screening tools,[12] such as Nutritional Risk Screening 2002 (NRS 2002),[13] Malnutrition Universal Screening Tool (MUST)[14] and the Short Form of Mini Nutritional Assessment (MNA-SF),[15] it has not been established which is the most efficient and appropriate for nutritional screening in the elderly patients with gastrointestinal cancers.

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4 Moreover, there is a lack of universal definition of malnutrition, which
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6 may lead to an inaccurate assessment and comparison of the nutritional
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8 screening tools.
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11 Recently, a diagnostic criteria for malnutrition has been proposed by
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13 the ESPEN,[16] and it had been validated by some studies.[17, 18] As the
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15 new criteria of defining malnutrition being proposed, it provides a
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17 reference standard for the evaluation and comparison of the nutritional
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19 screening tools. Therefore, our study was developed to evaluate the
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21 consistency of the three common nutritional screening tools with the new
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23 ESPEN diagnostic criteria for malnutrition and make a comparison of
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25 them among geriatric gastrointestinal cancer patients.
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34 **Materials and Methods**

35 **Patients**

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38 Between January 2016 and May 2017, 255 patients who underwent
39
40 curative surgery for gastrointestinal cancer in two hospitals from
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42 Shanghai and Wenzhou were included in this study. The inclusion criteria
43
44 included: (1) those underwent elective curative surgery for
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46 gastrointestinal cancer; (2) those aged ≥ 70 years; (3) those signed the
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48 informed consent and agreed to participate in this study. The exclusion
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50 criteria included: (1) those performed a palliative or emergency operation;
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60 (2) those aged < 70 years; (3) those cannot be assessed by NRS 2002,

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4 MUST and MNA-SF for the difficulty of data collection; (4) those
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6 refused to take part in this study.
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9 This study was approved by the ethics committees of the Tenth
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11 Affiliated Hospital of Tongji University and the First Affiliated Hospital
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13 of Wenzhou Medical University.
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15 16 **Data collection**

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18 The general and anthropometric data of the patients were collected. The
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20 general data contained the parameters of age, sex, diagnosis, morbidity,
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22 the change of appetite and physical activity. The anthropometric
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24 parameters included weight, height, unintentional weight loss, and body
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26 mass index (BMI).
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30 31 **Reference standard: the new ESPEN diagnostic criteria for** 32 33 **malnutrition**

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35 According to the new ESPEN diagnostic criteria [16], malnutrition was
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37 diagnosed when the patients met one of the following two options. Option
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39 one required BMI < 18.5 kg/m². Option two required unintentional
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41 weight loss > 10% indefinite of time or > 5% over the last three months
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43 combined with reduced BMI (< 20 kg/m² in patients younger than 70
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45 years or < 22 kg/m² in patients older than 70 years).
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50 51 **Assessment of nutritional risk**

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53 The assessment was performed by using the following nutritional
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55 screening tools: NRS 2002, MUST, and MNA-SF.
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4 NRS 2002 is proposed by the ESPEN guidelines based on an
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6 analysis of controlled clinical trials [13]. It is designed to identify who
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8 would benefit from nutritional supporting. This tool contains a severity of
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10 disease score, a nutritional score and an age score. Severity of disease
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12 score: one point for hip fracture, long-term hemodialysis, diabetes
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14 mellitus, or chronic disease with acute complications; two points for
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16 major abdominal surgery, hematological malignancies, stroke, or severe
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18 pneumonia; three points for head injury, bone marrow transplantation, or
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20 intensive care patients with APACHE more than 10. Nutritional score:
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22 one point for weight loss > 5% in 3 months or food intake 50-75% of the
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24 common condition; two points for weight loss > 5% in 2 months or BMI
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26 18.5-20.5 kg/m² with impaired general condition or food intake 25-60%
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28 of the general condition; three points for weight loss > 5% in 1 month or
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30 BMI less than 18.5 kg/m² with impaired general condition or food intake
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32 reduced by 25% compared with normal condition. Age score: one point
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34 for age ≥ 70 years. Nutritional risk was assessed by summarizing the
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36 severity disease score, nutritional score and the age score. Patients with
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38 total score < 3 are at no or low risk, and with score ≥ 3 are at high risk.
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49 MUST is developed to assess the nutritional risk for adults [14]. It
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51 consists of parameters of BMI, unintentional weight loss and any acute
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53 disease which compromises nutritional intake for more than 5 days. The
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55 three parameters are rated as 0, 1, or 2 as follows: BMI > 20 kg/m² = 0;
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3 18.5-20 kg/m² = 1; < 18.5 kg/m² = 2; unintentional weight loss in the past
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6 3-6 months < 5% = 0; 5-10% = 1; > 10% = 2; acute disease: absent = 0;
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8 present = 2. Overall risk of malnutrition is assessed by adding all the
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10 points together. 0 is at low risk; score 1 is at medium risk; and score 2 is
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12 at high risk.
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16 MNA-SF is the short form of MNA, and it is designed especially for
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18 the elderly. It contains six questions selected from MNA.[15] These
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20 questions are about BMI, recent weight loss, change of appetite, mobility,
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22 psychological stress and neuropsychological problems. Each question is
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24 rated from 0 to 2 or 3 and the total score of MNA-SF is 14. Patients with
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26 12-14 points are at normal nutritional status. And patients with scores ≤
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28 11 are at risk of malnutrition.
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33 **Statistical analysis**

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36 Statistical analysis was performed using SPSS software version 23.0 for
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38 windows. Normally distributed continuous variables were expressed as
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40 mean values and standard deviations (SD), categorical variables were
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42 presented as absolute and relative frequencies. Independent t test and the
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44 Pearson χ^2 test (or Fisher's exact test) were applied to the appropriate
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46 comparison of variables. All reported P-values were compared to a
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48 significance level of 5% based on two-sided tests. To determine
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50 diagnostic concordance between the three assessment tools and the new
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52 ESPEN diagnostic criteria for malnutrition, Cohen's kappa (κ) statistic
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was calculated. K coefficient reflects the consistency for qualitative variables. $K = 1$ means completely consistency between the variables. And if there is no consistency among the variables then $K \leq 0$. Positive likelihood ratios (LR+) and negative likelihood ratios (LR-) were calculated for all three tools.

Sensitivity and specificity values for the three nutritional screening tools with the new ESPEN diagnostic criteria for malnutrition were calculated. Receiver operating characteristic curves (ROC) of the three screening tools were also used to evaluate the ability to accurately distinguish the malnourished patients. Area under the ROC curve (AUC) equal to 0.5 indicates that a tool has no diagnostic value, AUC equal to 0.5-0.7 indicates a tool has a low diagnostic value, AUC equal to 0.7-0.9 indicates a tool has a moderate diagnostic value, and AUC equal to 0.9-1 means a tool has a high diagnostic value.

Results

Two hundred and fifty five patients were enrolled in this study (103 patients underwent gastric cancer surgery and 152 patients underwent colorectal cancer surgery). The characteristics of the sample were presented in Table 1.

Table 1. Characteristics of the total patients.

Patient Characteristics	Total (n=255)	GC (n=103)	CRC (n=152)	P value
Age ^a (years)	76.5±4.8	76.1±4.6	76.8±4.9	0.318
Sex ^b				
Male	160(62.7%)	78(75.7%)	82(52.1%)	<0.001*
Female	95(37.3%)	25(24.3%)	70(47.9%)	

Height ^a (m)	1.61±0.08	1.61±0.07	1.60±0.09	0.269
Weight ^a (kg)	59.20±10.73	59.67±10.26	58.90±11.07	0.597
BMI ^a (kg/m ²)	22.93±3.55	22.93±3.50	22.96±3.59	0.994
BMI ^b (<18.5kg/m ²)	26(10.2%)	11(10.7%)	15(9.9%)	0.834
Weight loss ^b (>5% in 3 months or >10% indefinite of time)	74(29.0%)	31(30.1%)	43(28.3%)	0.755

BMI: body mass index. GC: gastric cancer. CRC: colorectal cancer. *Statistically significance ($p \leq 0.05$).

^a Values expressed as mean \pm standard deviation(SD) .

^b Values expressed as frequencies and percentages.

P values were determined with the use of independent t test and the Pearson χ^2 test.

Table 2 listed the characteristics and anthropometric data of the patients summarized and stratified according to the nutritional status. There were no difference in age or sex between the two groups classified by the three screening tools and the new ESPEN criteria for malnutrition. However, the BMI and weight loss (> 5% in 3 months or > 10% indefinite of time) differed between the groups.

Table 2. Characteristics and anthropometric data stratified by the nutrition status of total patients.

	ESPEN criteria			NRS 2002			MUST			MNA-SF		
	Not malnourished (n=204)	Malnourished (n=51)	P value	No or Low risk (n=122)	High risk (n=133)	P value	Low risk (n=159)	Moderate/High risk (n=96)	P value	No risk (n=133)	Risk of malnutrition (n=122)	P value
Age ^a (years)	76.3±4.8	77.4±4.9	0.148	75.9±4.5	77.0±5.0	0.059	76.1±4.6	77.1±5.1	0.097	76.0±4.6	77.0±5.0	0.102
Sex ^b												
male	124(60.8%)	36(70.6%)	0.195	73(59.8%)	87(65.4%)	0.357	101(63.5%)	59(61.5%)	0.741	90(67.7%)	70(57.4%)	0.089
female	80(39.2%)	15(29.4%)		49(40.2%)	46(34.6%)		58(36.5%)	37(38.5%)		43(32.3%)	52(42.6%)	
Height ^a (m)	1.60±0.08	1.63±0.08	0.046*	1.60±0.08	1.61±0.09	0.155	1.60±0.08	1.61±0.09	0.511	1.61±0.08	1.60±0.08	0.112
Weight ^a (kg)	61.55±10.00	49.80±8.17	<0.001*	60.23±10.04	58.26±11.29	0.142	62.46±9.55	53.80±10.45	<0.001*	63.32±9.56	54.72±10.16	<0.001*
BMI ^a (kg/m ²)	23.98±3.01	18.76±2.20	<0.001*	23.56±3.27	22.36±3.70	0.006*	24.28±2.95	20.71±3.34	<0.001*	24.30±2.98	21.45±3.52	<0.001*
BMI ^b (<18.5kg/m ²)	1(0.5%)	25(49.0%)	<0.001*	4(3.3%)	22(16.5%)	0.001*	1(0.6%)	25(26.0%)	<0.001*	1(0.8%)	25(20.5%)	<0.001*
Weight loss ^b (>5% in 3 months or >10% indefinite of time)	34(16.7%)	40(78.4%)	<0.001*	4(3.3%)	70(52.6%)	<0.001*	14(8.8%)	60(62.5%)	<0.001*	4(3.0%)	70(57.4%)	<0.001*

*Statistically significance ($p \leq 0.05$).

^a Values expressed as mean ± standard deviation(SD) .

^b Values expressed as frequencies and percentages.

P values were determined with the use of independent t test and the Pearson χ^2 test(or Fisher's exact test where appropriate). BMI: body mass index.

The classification of malnutrition according to the new ESPEN criteria and the classification of nutritional risk according to the three screening tools were shown in Table 3. Among the patients, the prevalence of malnutrition was 20.0% when determined by the ESPEN criteria. The rate of high risk of malnutrition was 52.2% when determined by NRS 2002,

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37.6% when determined by MUST, and 47.8% when determined by MNA-SF. Among patients who underwent curative gastrectomy, the prevalence of malnutrition was 22.3% when determined by the new ESPEN criteria. The rates of moderate or high risk of malnutrition were 52.4%, 45.6%, and 43.7% with NRS 2002, MUST, and MNA-SF respectively. Among colorectal surgery patients, the prevalence of malnutrition was 18.4% when determined by the new ESPEN criteria, the rates of moderate and high risk of malnutrition were 52.0%, 32.2%, and 50.7% with NRS 2002, MUST and MNA-SF, respectively.

Table 3. Classification of the risk of malnutrition with the ESPEN criteria and the three screening tools.

Risk of malnutrition	Total				GC (n=103)				CRC (n=152)			
	ESPEN criteria ^a	NRS 2002	MUST	MNA-SF	ESPEN criteria ^a	NRS 2002	MUST	MNA-SF	ESPEN criteria ^a	NRS 2002	MUST	MNA-SF
No/Low	80.0%	47.8%	62.4%	52.2%	77.7%	47.6%	54.4%	56.3%	81.6%	48.0%	67.8%	49.3%
	(204/255)	(122/255)	(159/255)	(133/255)	(80/103)	(49/103)	(56/103)	(58/103)	(124/152)	(73/152)	(103/152)	(75/152)
Moderate/High	20.0%	52.2%	37.6%	47.8%	22.3%	52.4%	45.6%	43.7%	18.4%	52.0%	32.2%	50.7%
	(51/255)	(133/255)	(96/255)	(122/255)	(23/103)	(54/103)	(47/103)	(45/103)	(28/152)	(79/152)	(49/152)	(77/152)

GC: gastric cancer. CRC: colorectal cancer.

^a Classification of malnutrition according to the ESPEN consensus definition of malnutrition.

Cross tabulation of the results of the three tools and the classification of malnutrition according to the ESPEN

consensus definition of malnutrition can be found in Table 4.

Table 4. Cross tabulation of the results of the three screening tools and the classification of malnutrition according to the ESPEN consensus definition of malnutrition.

		NRS 2002		MUST		MNA-SF	
		No/Low risk	Moderate/High risk	Low risk	Moderate/High risk	No risk	Risk
ESPEN criteria	Not Malnourished	118	86	156	48	130	74
	Malnourished	4	47	3	48	3	48

The consistency between the nutritional screening tools and the new ESPEN diagnostic criteria for malnutrition was different. Among the total patients, MUST and MNA had the same sensitivity (94.1%), and NRS 2002 had the lowest sensitivity (92.2%). Moreover, MUST had the highest specificity (76.5%) compared with NRS 2002 (57.8%) and MNA-SF (63.7%). MUST had the highest positive predictive value (50.0%) and the highest negative predictive value (98.1%).

In the total patients, MUST had the highest K value ($K = 0.530$, $p < 0.001$) compared with MNA-SF ($K = 0.380$, $p < 0.001$) and NRS 2002 ($K = 0.312$, $p < 0.001$). In the gastric group, MUST had the highest K value. In the colorectal group, MUST had a higher level of consistency ($K = 0.576$, $p < 0.001$) compared with the fair consistencies in NRS 2002 ($K = 0.243$, $p < 0.001$) and MNA-SF ($K = 0.361$, $p < 0.001$). Finally, the area under the curve (AUC) calculated by the ROC

indicated that all three screening tools had a moderate level of diagnostic value to distinguish a malnourished patient (AUC of NRS 2002, MUST and MNA-SF were found to be 0.750, 0.853 and 0.789, respectively). Results are presented in details in Table 5.

Table 5. Statistical evaluation of the malnutrition screening tools compared with the diagnostic criteria of the ESPEN consensus.

	Total			GC			CRC		
	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF
Sensitivity (%)	92.2	94.1	94.1	100.0	95.7	87.0	85.7	92.9	100.0
Specificity (%)	57.8	76.5	63.7	61.3	68.8	68.8	55.6	81.5	60.5
Positive predictive value (%)	35.3	50.0	39.3	42.6	46.8	44.4	30.4	53.1	36.4
Negative predictive value (%)	96.7	98.1	97.7	100.0	98.2	94.8	94.5	98.1	100.0
Positive likelihood ratio (LR+)	2.18	4.00	2.59	2.61	3.06	2.78	1.93	5.02	2.53
Negative likelihood ratio (LR-)	0.13	0.08	0.09	0.00	0.06	0.19	0.26	0.09	0.00
K value (p)	0.312(<0.001)	0.530(<0.001)	0.380(<0.001)	0.414(<0.001)	0.469(<0.001)	0.415(<0.001)	0.243(<0.001)	0.576(<0.001)	0.361(<0.001)
AUC	0.750	0.853	0.789	0.806	0.822	0.779	0.707	0.872	0.802

GC: gastric cancer. CRC: colorectal cancer.

K value derived from Cohen kappa statistics.

AUC: Area under the curve from ROC.

Discussion

This study is the first to apply the new ESPEN diagnostic criteria to the specific population of elderly gastrointestinal cancer patients, and 20.0% of the patients were classified as malnourished according to the new ESPEN diagnostic criteria for malnutrition. Another previous study has investigated the prevalence of malnutrition diagnosed by the new ESPEN criteria in four diverse populations.[19] In that study, 0.5% of the healthy elderly individuals and 6% of the geriatric outpatients were identified as malnourished. It is significantly lower compared with that of our study, which indicated that patients with gastrointestinal cancer might have a higher prevalence of malnutrition. The difference in the malnutrition rates also indicated that we should put emphasis on the requirement to assess the nutritional risk of the hospitalized elderly gastrointestinal cancer patients.

In the present study, 52.2% and 37.6% of the patients were found to be at moderate or high risk of malnutrition according to NRS 2002 and MUST respectively. With the MNA-SF, 47.8% of the patients were found to be at a risk of malnutrition. The various prevalence of the risk of malnutrition can result from the differences between the nutritional screening tools. In our study, MUST had the greatest K value compared with the NRS 2002 and MNA-SF. It showed that a greater proportion of the elderly patients with gastrointestinal cancer who were distinguished to

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4 be at moderate or high risk of malnutrition with MUST could be
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6 identified as malnourished according to the ESPEN diagnostic criteria. In
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8 other words, MUST can perform the best to detect the specific
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10 malnourished individuals diagnosed by the new ESPEN criteria,
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12 compared with NRS 2002 and MNA-SF. Furthermore, MUST has the
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14 greatest AUC compared with NRS 2002 and MNA-SF in our study.
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19 Many previous studies compared the three nutritional screening tools
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21 in specific populations. Poulia et al. evaluated the efficacy of six
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23 nutritional screening tools in the elderly.[20] In Poulia's study, NRS 2002
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25 was found to overestimate nutritional risk, MNA-SF was proven to have a
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27 great validity, and MUST was found to have the best validity and the
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29 greatest consistency. Another study by Myoungha et al.[21] evaluated five
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31 nutritional screening tools, and suggested that MNA-SF overestimated
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33 the nutritional risk in the elderly, and NRS 2002 performed better than
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35 MNA-SF. However, MUST was also found to be the most efficient and
36
37 useful screening tool in this study. Both the previous studies compared
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39 the screening tools with a combined index suggested by Pablo et al.,[22]
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41 and they confirmed our results for the best performance of MUST
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43 compared with NRS 2002 and MNA-SF. While Donini et al. developed a
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45 study for the nutritional evaluation of the elderly nursing home
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47 residents[23] and found that MNA-SF presented a higher predictive value
48
49 compared with NRS 2002 and MUST. However, in the study by Donini et
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4 al., MNA was taken as the reference standard, which might induce an
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6 underpowered result. A previous study used the new ESPEN diagnostic
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8 criteria for malnutrition as a reference standard to compare nutritional
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10 screening tools.[24] However, MNA-SF was not included in this study,
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12 and the participators were not merely the elderly.
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16 The results of the comparison among NRS 2002, MUST and
17
18 MNA-SF showed different efficiency of the three screening tools in our
19
20 study. There might be an explanation for the differences. The original
21
22 designs of the three nutritional screening tools were different. NRS 2002
23
24 was developed to determine who would benefit from nutritional
25
26 supporting and it might distinguish an increased number of patients to be
27
28 at high risk of malnutrition. However, MUST was a screening tool to
29
30 identify adults who are at risk of malnutrition. MNA-SF, the short form of
31
32 MNA, was developed as a quick and easy nutritional screening tool and
33
34 was used for primary screening before further assessment. The different
35
36 results between our study and others can be attributed to the different
37
38 populations and reference standards, just as what Ma et al. had mentioned
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40 in their review.[25]
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49 Moreover, in our study, we evaluated the adequacy of the nutritional
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51 screening tools in the gastric cancer patients and the colorectal cancer
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53 patients, respectively. In the gastric cancer population, NRS 2002, MUST
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55 and MNA-SF all had a same moderate level of consistency with the new
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4 ESPEN diagnostic criteria for malnutrition ($K = 0.414$ for NRS 2002,
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6 0.469 for MUST and 0.415 for MNA-SF, respectively). While in the
7
8 colorectal population, MUST had the highest level of consistency ($K =$
9
10 0.576) compared with the fair level of consistency of NRS 2002 ($K =$
11
12 0.243) and MNA-SF ($K = 0.361$). Based on the result, we concluded that
13
14 MUST could perform the best in the specific colorectal cancer patients.
15
16 Further studies are needed to confirm our conclusion.
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21 It is of great significance to improve the nutritional status of the
22
23 elderly patients with gastrointestinal cancer if they are malnourished or at
24
25 risk of malnutrition. As the first step to identify who are malnourished or
26
27 at risk of malnutrition, nutritional screening should be reliable and easy to
28
29 perform. To the best of our knowledge, this is the first study to compare
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31 the three nutritional screening tools in the specific geriatric
32
33 gastrointestinal cancer population. Our study suggested that MUST is the
34
35 best choice in the three common nutritional screening tools. For the
36
37 accuracy and simplicity of MUST, both the patients and surgeons will
38
39 benefit from it. Furthermore, in our study, though there were some
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41 differences in sensitivity and specificity, the three tools were found to
42
43 have a same level of consistency in the gastric cancer population, while in
44
45 the colorectal cancer population, MUST had the highest level of
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47 consistency compared with the others. It indicated that we can choose one
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49 of three nutritional screening tools when assessing nutritional risk among
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4 the elderly patients with gastric cancer. However, when assessing
5
6 nutritional risk among the elderly patients with colorectal cancer, MUST
7
8 is the only choice for the highest accuracy.
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11 The present study has some limitations. Firstly, the sample size is
12
13 relatively small. However, this study was conducted in two centers with
14
15 large surgical volume. So we believe that the data in our study are more
16
17 representative. To a certain extent, it overcame the smallness of the
18
19 sample size. Secondly, according to the new ESPEN diagnostic criteria
20
21 for malnutrition, malnutrition can also be diagnosed by unintentional
22
23 weight loss combined with reduced fat free mass index (FFMI). So
24
25 another limitation of our study is the lack of data for fat free mass index.
26
27 However, the measurement of FFMI requires specific equipment and
28
29 extra costs. Moreover, Trummer et al. found that low BMI and low FFMI
30
31 were closely correlative.[25] In that study, FFMI less than 17 kg/m² for
32
33 men and less than 15 kg/m² for women were roughly equivalent to BMI
34
35 less than 18.5 kg/m² after determining the FFM levels.
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43 44 **Conclusions**

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46 To our knowledge, this is the first study to compare the three
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48 malnutrition screening tools (NRS 2002, MUST and MNA-SF) with the
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50 new ESPEN diagnostic criteria for malnutrition, and it is also the first
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52 study to evaluate the three screening tools in the specific geriatric
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54 gastrointestinal cancer patients. The prevalence of malnutrition was 20.0%
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4 with the ESPEN diagnostic criteria for malnutrition for patients with
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6 gastrointestinal cancer in the present study. MUST was found to perform
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8 the best to identify the malnourished elderly gastrointestinal cancer
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10 patients distinguished by the new ESPEN diagnostic criteria for
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12 malnutrition. Nevertheless, further studies are needed to verify our
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14 findings.
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Comparison of three common nutritional screening tools with the new European Society for Clinical Nutrition and Metabolism (ESPEN) criteria for malnutrition among geriatric gastrointestinal cancer patients: a prospective study in China

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Keywords:	Malnutrition, nutritional screening tools, ESPEN diagnostic criteria, elderly, gastrointestinal cancer

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Manuscripts

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4 **Comparison of three common nutritional screening tools with the**
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6 **new European Society for Clinical Nutrition and Metabolism**
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8 **(ESPEN) criteria for malnutrition among geriatric gastrointestinal**
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10 **cancer patients: a prospective study in China**
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42 **conflicts of interest.**
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Abstract

Objective: The aim of this study was to evaluate and compare the three common nutritional screening tools with the new European Society for Clinical Nutrition and Metabolism (ESPEN) diagnostic criteria for malnutrition among the elderly gastrointestinal cancer patients.

Research Methods & Procedures: Nutritional screening tools, including Nutritional Risk Screening 2002 (NRS 2002), Malnutrition Universal Screening Tool (MUST) and the Short Form of Mini Nutrition Assessment (MNA-SF), were applied to 255 patients with gastrointestinal cancer. We compared the diagnostic value of these tools for malnutrition, using the new ESPEN diagnostic criteria for malnutrition as the “gold standards”.

Results: According to the new ESPEN diagnostic criteria for malnutrition, 20.0% of the patients were diagnosed as malnourished. With the use of NRS 2002, 52.2% of the patients were found to be at high risk of malnutrition, with the use of MUST, 37.6% of the patients were found to be at moderate/high risk of malnutrition, and according to MNA-SF, 47.8% of the patients were found to be at nutritional risk. MUST was the best correlated with the ESPEN diagnostic criteria ($K = 0.530$, $p < 0.001$) compared with NRS 2002 ($K = 0.312$, $p < 0.001$) and MNA-SF ($K = 0.380$, $p < 0.001$). The ROC curve of MUST had the highest Area Under the Curve (AUC) compared with NRS 2002 and MNA-SF.

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Conclusions: MUST was found to perform the best to identify the malnourished elderly gastrointestinal cancer patients distinguished by the new ESPEN diagnostic criteria for malnutrition. Nevertheless, further studies are needed to verify our findings.

Keywords: Malnutrition, nutritional screening tools, ESPEN diagnostic criteria, elderly, gastrointestinal cancer

Strengths and limitations of this study

- To our best knowledge, this is the first study to evaluate the three screening tools in the specific geriatric gastrointestinal cancer patients.
- We compared the diagnostic value of the three screening tools, using the new ESPEN diagnostic criteria for malnutrition as the “gold standards”.
- the sample size is relatively small. However, this study was conducted in two centers with large surgical volume. To a certain extent, it overcame the smallness of the sample size.

Introduction

As the life expectancy and world population ages increase, the proportion of elderly patients has been enlarged obviously. It is well known that the risk of cancer increases with age. More than half of the malignancies occur in people aged ≥ 65 years.[1, 2] Gastrointestinal cancer is one of the most common malignancies in the elderly,[3] and surgical excision remains the most effective therapy for gastrointestinal cancers.[4] Although the surgical techniques have been improved significantly, elderly gastrointestinal cancer patients still have a high frequency of complications and mortality.[4-8] This is partly due to the high prevalence of malnutrition, which is a common and serious problem in the elderly cancer patients.[9, 10, 11] Therefore, it is important to evaluate the nutritional risk of the geriatric gastrointestinal cancer patients before surgery.

To accurately assess the nutritional risk, it is important to choose an efficient nutritional screening tool. Although there are many widely used nutritional screening tools,[12] such as Nutritional Risk Screening 2002 (NRS 2002),[13] Malnutrition Universal Screening Tool (MUST)[14] and the Short Form of Mini Nutritional Assessment (MNA-SF),[15] it has not been established which is the most efficient and appropriate for nutritional screening in the elderly patients with gastrointestinal cancers.

Moreover, there is a lack of universal definition of malnutrition, which may lead to an inaccurate assessment and comparison of the nutritional screening tools.

Recently, a diagnostic criteria for malnutrition has been proposed by the European Society for Clinical Nutrition and Metabolism (ESPEN),^[16] and it had been validated by some studies.^[17, 18] As the new criteria of defining malnutrition being proposed, it provides a reference standard for the evaluation and comparison of the nutritional screening tools. Therefore, our study was developed to evaluate the consistency of the three common nutritional screening tools with the new ESPEN diagnostic criteria for malnutrition and make a comparison of them among geriatric gastrointestinal cancer patients.

Materials and Methods

Patients

Between January 2016 and May 2017, 255 patients who underwent curative surgery for gastrointestinal cancer in two hospitals from Shanghai and Wenzhou were included in this study. The inclusion criteria included: (1) those underwent elective curative surgery for gastrointestinal cancer; (2) those aged ≥ 70 years; (3) those signed the informed consent and agreed to participate in this study. The exclusion criteria included: (1) those performed a palliative or emergency operation;

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3 (2) those aged < 70 years; (3) those cannot be assessed by NRS 2002,
4 MUST and MNA-SF for the difficulty of data collection; (4) those
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6 refused to take part in this study.
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10 This study was approved by the ethics committees of the Tenth
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12 Affiliated Hospital of Tongji University and the First Affiliated Hospital
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14 of Wenzhou Medical University.
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17 **Data collection**

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19 The general and anthropometric data of the patients were collected. The
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21 general data contained the parameters of age, sex, diagnosis, morbidity,
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23 the change of appetite and physical activity. The anthropometric
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25 parameters included weight, height, unintentional weight loss, and body
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27 mass index (BMI).
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32 **Reference standard: the new ESPEN diagnostic criteria for**

33 **malnutrition**

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35 According to the new ESPEN diagnostic criteria [16], malnutrition was
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37 diagnosed when the patients met one of the following two options. Option
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39 one required BMI < 18.5 kg/m². Option two required unintentional
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41 weight loss > 10% indefinite of time or > 5% over the last three months
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43 combined with reduced BMI (< 20 kg/m² in patients younger than 70
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45 years or < 22 kg/m² in patients older than 70 years).
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52 **Assessment of nutritional risk**

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54 The assessment was performed by using the following nutritional
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4 screening tools: NRS 2002, MUST, and MNA-SF.
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6 NRS 2002 is proposed by the ESPEN guidelines based on an
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8 analysis of controlled clinical trials [13]. It is designed to identify who
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10 needs nutritional supporting. This tool contains a severity of disease score,
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12 a nutritional score and an age score. Severity of disease score: one point
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14 for hip fracture, long-term hemodialysis, diabetes mellitus, or chronic
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16 disease with acute complications; two points for major abdominal surgery,
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18 hematological malignancies, stroke, or severe pneumonia; three points for
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20 head injury, bone marrow transplantation, or intensive care patients with
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22 APACHE more than 10. Nutritional score: one point for weight loss > 5%
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24 in 3 months or food intake 50-75% of the common condition; two points
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26 for weight loss > 5% in 2 months or BMI 18.5-20.5 kg/m² with impaired
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28 general condition or food intake 25-60% of the general condition; three
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30 points for weight loss > 5% in 1 month or BMI less than 18.5 kg/m² with
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32 impaired general condition or food intake reduced by 25% compared with
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34 normal condition. Age score: one point for age ≥ 70 years. Nutritional
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36 risk was assessed by summarizing the severity disease score, nutritional
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38 score and the age score. Patients with total score < 3 are at no or low risk,
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40 and with score ≥ 3 are at high risk.
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50 MUST is developed to assess the nutritional risk for adults [14]. It
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52 consists of parameters of BMI, unintentional weight loss and any acute
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54 disease which compromises nutritional intake for more than 5 days. The
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3 three parameters are rated as 0, 1, or 2 as follows: BMI > 20 kg/m² = 0;
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5 18.5-20 kg/m² = 1; < 18.5 kg/m² = 2; unintentional weight loss in the past
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7 3-6 months < 5% = 0; 5-10% = 1; > 10% = 2; acute disease: absent = 0;
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9 present = 2. Overall risk of malnutrition is assessed by adding all the
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11 points together. 0 is at low risk; score 1 is at medium risk; and score 2 is
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13 at high risk.
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18 MNA-SF is the short form of MNA, and it is designed especially for
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20 the elderly. It contains six questions selected from MNA.[15] These
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22 questions are about BMI, recent weight loss, change of appetite, mobility,
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24 psychological stress and neuropsychological problems. Each question is
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26 rated from 0 to 2 or 3 and the total score of MNA-SF is 14. Patients with
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28 12-14 points are at normal nutritional status. And patients with scores ≤
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30 11 are at risk of malnutrition.
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35 **Statistical analysis**

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37 Statistical analysis was performed using SPSS software version 23.0 for
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39 windows. Normally distributed continuous variables were expressed as
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41 mean values and standard deviations (SD), categorical variables were
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43 presented as absolute and relative frequencies. Independent t test and the
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45 Pearson χ^2 test (or Fisher's exact test) were applied to the appropriate
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47 comparison of variables. All reported P-values were compared to a
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49 significance level of 5% based on two-sided tests. To determine
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51 diagnostic concordance between the three assessment tools and the new
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4 ESPEN diagnostic criteria for malnutrition, Cohen's kappa (κ) statistic
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6 was calculated. K coefficient reflects the consistency for qualitative
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8 variables. $K = 1$ means completely consistency between the variables.
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10 And if there is no consistency among the variables then $K \leq 0$. Positive
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12 likelihood ratios (LR+) and negative likelihood ratios (LR-) were
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14 calculated for all three tools.
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18 Sensitivity and specificity values for the three nutritional screening
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20 tools with the new ESPEN diagnostic criteria for malnutrition were
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22 calculated. Receiver operating characteristic curves (ROC) of the three
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24 screening tools were also used to evaluate the ability to accurately
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26 distinguish the malnourished patients. Area under the ROC curve (AUC)
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28 equal to 0.5 indicates that a tool has no diagnostic value, AUC equal to
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30 0.5-0.7 indicates a tool has a low diagnostic value, AUC equal to 0.7-0.9
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32 indicates a tool has a moderate diagnostic value, and AUC equal to 0.9-1
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34 means a tool has a high diagnostic value.
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40 Results

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42 Two hundred and fifty five patients were enrolled in this study (103
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44 patients underwent gastric cancer surgery and 152 patients underwent
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46 colorectal cancer surgery). The characteristics of the sample were
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48 presented in Table 1.
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52 **Table 1. Characteristics of the total patients.**

Patient Characteristics	Total (n=255)	GC (n=103)	CRC (n=152)	P value
Age ^a (years)	76.5±4.8	76.1±4.6	76.8±4.9	0.318
Sex ^b				

Male	160(62.7%)	78(75.7%)	82(52.1%)	<0.001*
Female	95(37.3%)	25(24.3%)	70(47.9%)	
Height ^a (m)	1.61±0.08	1.61±0.07	1.60±0.09	0.269
Weight ^a (kg)	59.20±10.73	59.67±10.26	58.90±11.07	0.597
BMI ^a (kg/m ²)	22.93±3.55	22.93±3.50	22.96±3.59	0.994
BMI ^b (<18.5kg/m ²)	26(10.2%)	11(10.7%)	15(9.9%)	0.834
Weight loss ^b (>5% in 3 months or >10% indefinite of time)	74(29.0%)	31(30.1%)	43(28.3%)	0.755

BMI: body mass index. GC: gastric cancer. CRC: colorectal cancer. *Statistically significance ($p \leq 0.05$).

^a Values expressed as mean \pm standard deviation(SD) .

^b Values expressed as frequencies and percentages.

P values were determined with the use of independent t test and the Pearson χ^2 test.

Table 2 listed the characteristics and anthropometric data of the patients summarized and stratified according to the nutritional status. There were no difference in age or sex between the two groups classified by the three screening tools and the new ESPEN criteria for malnutrition. However, the BMI and weight loss (> 5% in 3 months or > 10% indefinite of time) differed between the groups.

Table 2. Characteristics and anthropometric data stratified by the nutrition status of total patients.

	ESPEN criteria			NRS 2002			MUST			MNA-SF		
	Not malnourished (n=204)	Malnourished (n=51)	P value	No or Low risk (n=122)	High risk (n=133)	P value	Low risk (n=159)	Moderate/High risk (n=96)	P value	No risk (n=133)	Risk of malnutrition (n=122)	P value
Age ^a (years)	76.3±4.8	77.4±4.9	0.148	75.9±4.5	77.0±5.0	0.059	76.1±4.6	77.1±5.1	0.097	76.0±4.6	77.0±5.0	0.102
Sex ^b												
male	124(60.8%)	36(70.6%)	0.195	73(59.8%)	87(65.4%)	0.357	101(63.5%)	59(61.5%)	0.741	90(67.7%)	70(57.4%)	0.089
female	80(39.2%)	15(29.4%)		49(40.2%)	46(34.6%)		58(36.5%)	37(38.5%)		43(32.3%)	52(42.6%)	
Height ^a (m)	1.60±0.08	1.63±0.08	0.046*	1.60±0.08	1.61±0.09	0.155	1.60±0.08	1.61±0.09	0.511	1.61±0.08	1.60±0.08	0.112
Weight ^a (kg)	61.55±10.00	49.80±8.17	<0.001*	60.23±10.04	58.26±11.29	0.142	62.46±9.55	53.80±10.45	<0.001*	63.32±9.56	54.72±10.16	<0.001*
BMI ^a (kg/m ²)	23.98±3.01	18.76±2.20	<0.001*	23.56±3.27	22.36±3.70	0.006*	24.28±2.95	20.71±3.34	<0.001*	24.30±2.98	21.45±3.52	<0.001*
BMI ^b (<18.5kg/m ²)	1(0.5%)	25(49.0%)	<0.001*	4(3.3%)	22(16.5%)	0.001*	1(0.6%)	25(26.0%)	<0.001*	1(0.8%)	25(20.5%)	<0.001*
Weight loss ^b (>5% in 3 months or >10% indefinite of time)	34(16.7%)	40(78.4%)	<0.001*	4(3.3%)	70(52.6%)	<0.001*	14(8.8%)	60(62.5%)	<0.001*	4(3.0%)	70(57.4%)	<0.001*

*Statistically significance ($p \leq 0.05$).

^a Values expressed as mean ± standard deviation(SD) .

^b Values expressed as frequencies and percentages.

P values were determined with the use of independent t test and the Pearson χ^2 test(or Fisher's exact test where appropriate). BMI: body mass index.

Among the patients, the prevalence of malnutrition was 20.0% when determined by the ESPEN criteria. Among patients who underwent curative gastrectomy, the prevalence of malnutrition was 22.3% when determined by the new ESPEN criteria. And among colorectal surgery patients, the prevalence of malnutrition was 18.4% when determined by the

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new ESPEN criteria. The classification of nutritional risk according to the three screening tools were shown in Table 3.

Table 3. Classification of the risk of malnutrition with the ESPEN criteria and the three screening tools.

Risk of malnutrition	Total			GC (n=103)			CRC (n=152)		
	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF
No/Low	47.8% (122/255)	62.4% (159/255)	52.2% (133/255)	47.6% (49/103)	54.4% (56/103)	56.3% (58/103)	48.0% (73/152)	67.8% (103/152)	49.3% (75/152)
Moderate/High	52.2% (133/255)	37.6% (96/255)	47.8% (122/255)	52.4% (54/103)	45.6% (47/103)	43.7% (45/103)	52.0% (79/152)	32.2% (49/152)	50.7% (77/152)

GC: gastric cancer. CRC: colorectal cancer.

a Classification of malnutrition according to the ESPEN consensus definition of malnutrition.

Cross tabulation of the results of the three tools and the classification of malnutrition according to the ESPEN consensus definition of malnutrition can be found in Table 4.

Table 4. Cross tabulation of the results of the three screening tools and the classification of malnutrition according to the ESPEN consensus definition of malnutrition.

		NRS 2002		MUST		MNA-SF	
		No/Low risk	Moderate/High risk	Low risk	Moderate/High risk	No risk	Risk
ESPE criteria	Not Malnourished	118	86	156	48	130	74
	Malnourished	4	47	3	48	3	48

The consistency between the nutritional screening tools and the new ESPEN diagnostic criteria for malnutrition was different. Among the total patients, MUST and MNA had the same sensitivity (94.1%), and NRS 2002 had the lowest sensitivity (92.2%). Moreover, MUST had the highest specificity (76.5%) compared with NRS 2002 (57.8%) and MNA-SF (63.7%). MUST had the highest positive predictive value (50.0%) and the highest negative predictive value (98.1%).

In the total patients, MUST had the highest K value ($K = 0.530$, $p < 0.001$) compared with MNA-SF ($K = 0.380$, $p < 0.001$) and NRS 2002 ($K = 0.312$, $p < 0.001$). In the gastric group, MUST had the highest K value. In the colorectal group, MUST had a higher level of consistency ($K = 0.576$, $p < 0.001$) compared with the fair consistencies in NRS 2002 ($K = 0.243$, $p < 0.001$) and MNA-SF ($K = 0.361$, $p < 0.001$). Finally, the area under the curve (AUC) calculated by the ROC indicated that all three screening tools had a moderate level of diagnostic value to distinguish a malnourished patient (AUC of NRS 2002, MUST and MNA-SF were found to be 0.750, 0.853 and 0.789, respectively). Results are presented in details in Table 5.

Table 5. Statistical evaluation of the malnutrition screening tools compared with the diagnostic criteria of the ESPEN consensus.

	Total			GC			CRC		
	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF	NRS 2002	MUST	MNA-SF
Sensitivity (%)	92.2	94.1	94.1	100.0	95.7	87.0	85.7	92.9	100.0

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Specificity (%)	57.8	76.5	63.7	61.3	68.8	68.8	55.6	81.5	60.5
Positive predictive value (%)	35.3	50.0	39.3	42.6	46.8	44.4	30.4	53.1	36.4
Negative predictive value (%)	96.7	98.1	97.7	100.0	98.2	94.8	94.5	98.1	100.0
Positive likelihood ratio (LR+)	2.18	4.00	2.59	2.61	3.06	2.78	1.93	5.02	2.53
Negative likelihood ratio (LR-)	0.13	0.08	0.09	0.00	0.06	0.19	0.26	0.09	0.00
K value (p)	0.312(<0.001)	0.530(<0.001)	0.380(<0.001)	0.414(<0.001)	0.469(<0.001)	0.415(<0.001)	0.243(<0.001)	0.576(<0.001)	0.361(<0.001)
AUC	0.750	0.853	0.789	0.806	0.822	0.779	0.707	0.872	0.802

GC: gastric cancer. CRC: colorectal cancer.
 K value derived from Cohen kappa statistics.
 AUC: Area under the curve from ROC.

Discussion

This study is the first to apply the new ESPEN diagnostic criteria to the specific population of elderly gastrointestinal cancer patients, and 20.0% of the patients were classified as malnourished according to the new ESPEN diagnostic criteria for malnutrition. Another previous study has investigated the prevalence of malnutrition diagnosed by the new ESPEN criteria in four diverse populations.[19] In that study, 0.5% of the healthy elderly individuals and 6% of the geriatric outpatients were identified as malnourished. It is significantly lower compared with that of our study, which indicated that patients with gastrointestinal cancer might have a higher prevalence of malnutrition. The difference in the malnutrition rates also indicated that we should put emphasis on the requirement to assess the nutritional risk of the hospitalized elderly gastrointestinal cancer patients.

In the present study, 52.2% and 37.6% of the patients were found to be at moderate or high risk of malnutrition according to NRS 2002 and MUST respectively. With the MNA-SF, 47.8% of the patients were found to be at a risk of malnutrition. The various prevalence of the risk of malnutrition can result from the differences between the nutritional screening tools. In our study, MUST had the greatest K value compared with the NRS 2002 and MNA-SF. It showed that a greater proportion of the elderly patients with gastrointestinal cancer who were distinguished to

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3 be at moderate or high risk of malnutrition with MUST could be
4 identified as malnourished according to the ESPEN diagnostic criteria. In
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6 other words, MUST can perform the best to detect the specific
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8 malnourished individuals diagnosed by the new ESPEN criteria,
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10 compared with NRS 2002 and MNA-SF. Furthermore, MUST has the
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12 greatest AUC compared with NRS 2002 and MNA-SF in our study.
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18 Many previous studies compared the three nutritional screening tools
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20 in specific populations. Poulia et al. evaluated the efficacy of six
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22 nutritional screening tools in the elderly.[20] In Poulia's study, NRS 2002
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24 was found to overestimate nutritional risk, MNA-SF was proven to have a
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26 great validity, and MUST was found to have the best validity and the
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28 greatest consistency. Another study by Myoungha et al.[21] evaluated five
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30 nutritional screening tools, and suggested that MNA-SF overestimated
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32 the nutritional risk in the elderly, and NRS 2002 performed better than
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34 MNA-SF. However, MUST was also found to be the most efficient and
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36 useful screening tool in this study. Both the previous studies compared
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38 the screening tools with a combined index suggested by Pablo et al.,[22]
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40 and they confirmed our results for the best performance of MUST
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42 compared with NRS 2002 and MNA-SF. While Donini et al. developed a
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44 study for the nutritional evaluation of the elderly nursing home
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46 residents[23] and found that MNA-SF presented a higher predictive value
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48 compared with NRS 2002 and MUST. However, in the study by Donini et
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3 al., MNA was taken as the reference standard, which might induce an
4 underpowered result. A previous study used the new ESPEN diagnostic
5 criteria for malnutrition as a reference standard to compare nutritional
6 screening tools.[24] However, MNA-SF was not included in this study,
7 and the participators were not merely the elderly.
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11 The results of the comparison among NRS 2002, MUST and
12 MNA-SF showed different efficiency of the three screening tools in our
13 study. There might be an explanation for the differences. The original
14 designs of the three nutritional screening tools were different. NRS 2002
15 was developed to determine who needs nutritional supporting and it
16 might distinguish an increased number of patients to be at high risk of
17 malnutrition. According to the diagnosis criteria of NRS 2002, 1 score
18 was added to patients aged ≥ 70 years, it might contribute to the higher
19 prevalence of patients at nutritional risk diagnosed by NRS 2002.
20 However, MUST was a screening tool to identify adults who are at risk of
21 malnutrition. MNA-SF, the short form of MNA, was developed as a quick
22 and easy nutritional screening tool and was used for primary screening
23 before further assessment. The different results between our study and
24 others can be attributed to the different populations and reference
25 standards, just as what Ma et al. had mentioned in their review.[25]
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52 Moreover, in our study, we evaluated the adequacy of the nutritional
53 screening tools in the gastric cancer patients and the colorectal cancer
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3 patients, respectively. In the gastric cancer population, NRS 2002, MUST
4 and MNA-SF all had a same moderate level of consistency with the new
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6 ESPEN diagnostic criteria for malnutrition ($K = 0.414$ for NRS 2002,
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patients, respectively. In the gastric cancer population, NRS 2002, MUST and MNA-SF all had a same moderate level of consistency with the new ESPEN diagnostic criteria for malnutrition ($K = 0.414$ for NRS 2002, 0.469 for MUST and 0.415 for MNA-SF, respectively). While in the colorectal population, MUST had the highest level of consistency ($K = 0.576$) compared with the fair level of consistency of NRS 2002 ($K = 0.243$) and MNA-SF ($K = 0.361$). Based on the result, we concluded that MUST could perform the best in the specific colorectal cancer patients. Further studies are needed to confirm our conclusion.

It is of great significance to improve the nutritional status of the elderly patients with gastrointestinal cancer if they are malnourished or at risk of malnutrition. As the first step to identify who are malnourished or at risk of malnutrition, nutritional screening should be reliable and easy to perform. To the best of our knowledge, this is the first study to compare the three nutritional screening tools in the specific geriatric gastrointestinal cancer population. Our study suggested that MUST is the best choice in the three common nutritional screening tools. For the accuracy and simplicity of MUST, both the patients and surgeons will benefit from it. Furthermore, in our study, though there were some differences in sensitivity and specificity, the three tools were found to have a same level of consistency in the gastric cancer population. While in the colorectal cancer population, MUST had the highest level of

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3 consistency compared with the others($K = 0.576$). MUST also had the
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5 significant highest specificity, positive predictive value, and the greatest
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7 AUC. It indicated that we can choose one of three nutritional screening
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9 tools when assessing nutritional risk among the elderly patients with
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11 gastric cancer. However, when assessing nutritional risk among the
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13 elderly patients with colorectal cancer, MUST is the only choice for the
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15 highest accuracy.
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21 The ESPEN guideline used to promote NRS 2002 as a tool to screen
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23 hospitalized patients. While with the results of this study, MUST was
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25 found to be better to screen gastrointestinal cancer patients. This may
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27 result from several aspects. MUST was developed as a valid tool to
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29 identify nutritional risk of specific patients population, and it is the
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31 unique tool that was designed for screening of malnutrition.[26]
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33 Therefore, MUST might perform best according to the ESPEN diagnostic
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35 criteria for malnutrition. Moreover, MUST has straight forward and
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37 objective questions, with which is easier to be performed. It can be a
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39 useful nutritional screening tool when there is no redundant time and no
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41 professional medical staff.
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48 It is well-known that malnourished patients or patients at risk of
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50 malnutrition would have a poor clinical outcome. Therefore, it is of great
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52 significance to improve the nutritional status of these patients. The
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54 indices of these three screening tools have common characteristics. With
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3 the results of our study, the parameters of MUST suggest that we could
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5 intervene malnutrition by improving BMI, avoiding weight loss and
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7 curing the acute disease. In fact, this is partly similar with the parameters
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9 of EPSEN diagnostic criteria, NRS 2002 and MNA-SF. It means that if
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11 the result of MUST was improved, the consequence of EPSEN diagnostic
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13 criteria and other screening tools would also be improved. Further studies
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15 should be developed to investigate implications of the intervention for
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17 malnutrition.
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23 The present study has some limitations. Firstly, the sample size is
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25 relatively small. However, this study was conducted in two centers with
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27 large surgical volume. So we believe that the data in our study are more
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29 representative. To a certain extent, it overcame the smallness of the
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31 sample size. Secondly, according to the new ESPEN diagnostic criteria
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33 for malnutrition, malnutrition can also be diagnosed by unintentional
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35 weight loss combined with reduced fat free mass index (FFMI). So
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37 another limitation of our study is the lack of data for fat free mass index.
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39 However, the measurement of FFMI requires specific equipment and
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41 extra costs. Moreover, Trummer et al. found that low BMI and low FFMI
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43 were closely correlative.[27] In that study, FFMI less than 17 kg/m² for
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45 men and less than 15 kg/m² for womFen were roughly equivalent to BMI
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47 less than 18.5 kg/m² after determining the FFM levels.
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54 **Conclusions**

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4 To our knowledge, this is the first study to compare the three
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6 malnutrition screening tools (NRS 2002, MUST and MNA-SF) with the
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8 new ESPEN diagnostic criteria for malnutrition, and it is also the first
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10 study to evaluate the three screening tools in the specific geriatric
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12 gastrointestinal cancer patients. The prevalence of malnutrition was 20.0%
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14 with the ESPEN diagnostic criteria for malnutrition for patients with
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16 gastrointestinal cancer in the present study. MUST was found to perform
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18 the best to identify the malnourished elderly gastrointestinal cancer
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20 patients distinguished by the new ESPEN diagnostic criteria for
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22 malnutrition. Nevertheless, further studies are needed to verify our
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24 findings.
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