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Malnutrition in cardiac surgery: food for thought

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Abstract

Background: Undernourished patients treated in general surgery departments suffer from prolonged and complicated hospitalizations, and higher mortality rates compared with well nourished patients. Pivotal information regarding patients' nutritional status and its effect on clinical outcome is lacking for cardiac surgery patients. We investigated the prevalence of malnutrition risk and its association with 30-day hospital mortality and postoperative complications.

Methods and results: Four hundred and three patients who underwent cardiac surgery during 2008 and were screened with the Malnutrition Universal Screening Tool (MUST) on admission were enrolled. Univariate and multivariate logistic regression analyses compared the association of high and low risk for malnutrition with length of hospitalization (LOS), in-hospital and 30-day mortality, and postoperative complications. Almost 20% of the patients were found to be at high risk for malnutrition. Univariate analyses revealed higher in-hospital mortality rates ($p = 0.03$) and greater incidence of LOS and antibiotic treatment longer than 21 days ($p = 0.002$ and $p = 0.04$, respectively), vasopressor treatment longer than 11 days ($p = 0.02$), and positive blood cultures ($p = 0.02$) in patients belonging to the high-risk MUST group. Incorporation of the MUST in a multivariate model with the European System for Cardiac Operative Risk Evaluation (EuroSCORE) significantly improved postoperative complications prediction, as well as in-hospital and 30-day mortality, compared with the EuroSCORE alone.

Conclusions: Malnutrition is prevalent in patients undergoing cardiac surgery, associated with higher postoperative mortality and morbidity. Preoperative MUST screening has emerged as highly relevant for enabling early diagnosis of patients at malnutrition risk, predicting postoperative mortality and morbidity, thus promoting well timed treatment. Prospective studies are needed to explore whether intervention can decrease malnutrition risk.

Keywords

Malnutrition Universal Screening Tool, European System for Cardiac Operative Risk Evaluation, mortality, morbidity, cardiac surgery

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Introduction

Malnutrition is a state in which nutritional needs are not being met. Patients with malnutrition have a multitude of complications, both infectious and non-infectious, including mechanical ventilation and renal insufficiency, prolonged hospital length of stay (LOS), and higher mortality rates.[1,2] The etiology of disease-related undernutrition (DRU) is complex and includes a rise in proinflammatoy cytokines which causes loss of appetite.[2,3] Iatrogenic malnutrition, that is, protein-calorie undernourishment, may be brought on by treatment, medication, hospitalization, fasting in preparation for a clinical procedure, or may be due to rejection of unappealing food.[2]

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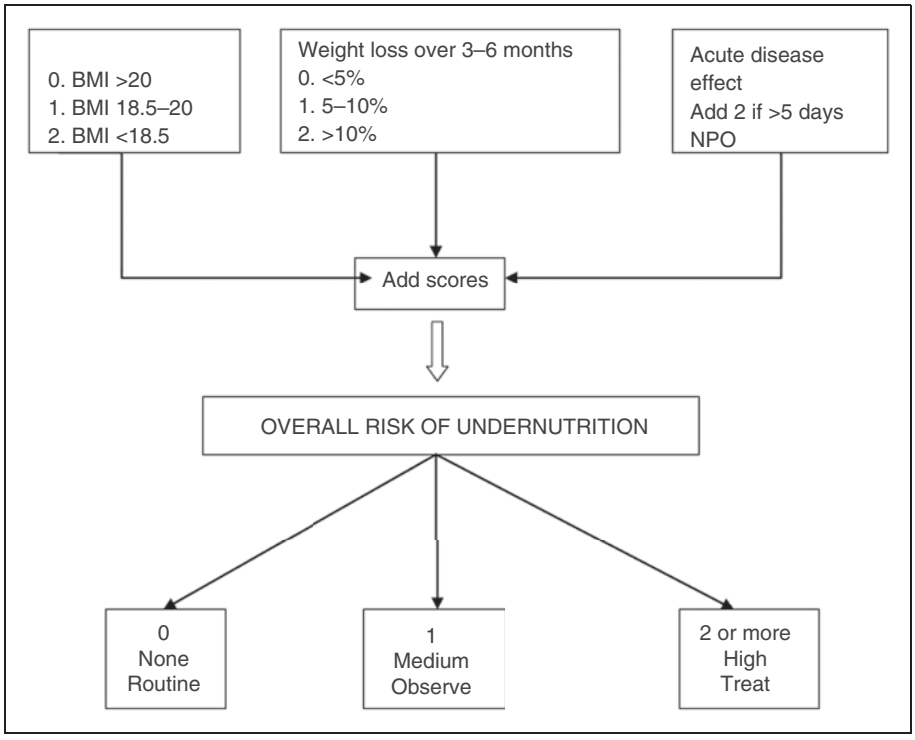

Figure 1. Algorithm describing MUST score calculation based on BMI, weight loss, and acute disease effect. Groups 0 and 1 are collectively defined as the low-risk MUST group, while group 2 is defined as the high-risk MUST group. BMI: body mass index; MUST: Malnutrition Universal Screening Tool; NPO: Nil per os (nothing by mouth).

Routine nutritional screening of patients is of recognized importance and is recommended by various national and international societies.[4,5] The Malnutrition Universal Screening Tool (MUST)[6,7] includes three components: body mass index (BMI), unintended weight loss (UWL), and the expectation that the presence of an acute disease will result in an absence of nutritional intake for 5 days or more (Figure 1). The patient is defined as being at low risk for malnutrition (MUST = 0), moderate risk for malnutrition (MUST = 1), or high risk for malnutrition (MUST $\geq$ 2).

Previous studies demonstrated that cardiac surgery patients who were malnourished (low BMI and/or low albumin level and/or UWL) had higher postoperative mortality rates, increased LOS, and increased in-hospital complications.[8–12] Currently, the European System for Cardiac Operative Risk Evaluation (EuroSCORE) is the predominant tool for predicting survival after cardiac surgery. Notably, the EuroSCORE does not take into consideration nutrition indices,[13–15] similar to other estimators of mortality risks associated with cardiovascular diseases.[16]

Importantly, the EuroSCORE and MUST scorings are used to reach two distinctive goals: while the EuroSCORE is used to decide whether a patient at risk should be operated on, and inform a patient about their risk for mortality, the MUST score is used to decide if a patient is highly likely to benefit from a nutritional intervention.

In our study, we assessed the MUST-based prevalence of malnutrition risk in the cardiac surgery department; explored the association of patients at risk for malnutrition with 30-day mortality and postoperative complications; and applied the MUST to patients undergoing cardiac surgery and subsequently examined whether its addition to the EuroSCORE better predicted postoperative mortality and morbidity.

Patients and methods

Patients

Our study was conducted in the Department of Cardiac Surgery at Rambam Health Care Campus in Haifa, Israel, a 1000-bed tertiary care hospital. Data were collected for all adult patients hospitalized in the unit during 2008. The inclusion criteria were patients who underwent surgery and for whom MUST data were collected on admission. MUST screening was routinely performed by nurses on admission to the ward and was

integrated into the patient's computerized file. Data were collected retrospectively from the patients' computerized files. The study adhered to the Helsinki Declaration and was approved by the Institutional Review Board of Rambam Health Care Campus.

EuroSCORE evaluation

The EuroSCORE is a risk model which allows the calculation of the risk of death after a heart operation.[17,18] The model asks for 17 pieces of information about the patient, the state of the heart, and the proposed operation, and uses logistic regression to calculate the risk of death.

Study variables

Independent variables included gender, age, EuroSCORE values (categorical and continuous), MUST groups (low and high risk), and the interaction between EuroSCORE values and MUST groups; a subgroup of patients with a EuroSCORE-based predicted mortality of $\geq$5% and a high risk for malnutrition according to the MUST were categorized as a double-risk group (DRG). Primary outcome measures included 30-day mortality and postoperative complications. The latter were defined as one or more of the following: in-hospital mortality, LOS longer than 21 days, antibiotic treatment longer than 21 days, positive blood culture (blood stream infection: BSI), vasopressor treatment longer than 11 days, and new onset of renal failure defined as a creatinine value of $\geq$1.5 mg% in patients with normal creatinine level on admission. The various durations incorporated in these criteria represent the corresponding mean plus 1 standard deviation (SD). Any hospitalization characterized by one or more of the above was denoted a complex hospitalization.

Statistical analysis

Statistical analysis was performed using SPSS (Statistics Products Solutions Services) 18.0 software for Windows. Data are presented as mean $\pm$ SD. Binary logistic regression was used for the calculation of the odds ratios (OR) with 95% confidence intervals (CIs) and p values in univariate analysis. Multivariate forward logistic regression analysis was performed to assess the relationship of the MUST score and the EuroSCORE value with complex hospitalization and 30-day mortality. The area under the receiver operating characteristic (ROC) curve was used as a measure of model discrimination. The Hosmer–Lemeshow test assessed the goodness of fit of logistic regression models. Statistical significance was set at $p \leq 0.05$.

Results

Patients

Four hundred and ninety-seven adult patients were hospitalized in the Department of Cardiac Surgery during 2008, 455 (92%) of whom underwent cardiac surgery. Four hundred and three patients (89%) were screened with the MUST on admission and were defined as the study population (72% men, 28% women). The mean and median age for the screened population was 64.5 $\pm$ 12.0 and 65.0, respectively. Patients were divided into three groups: 80.6% at low risk for malnutrition (MUST = 0), 1.5% at moderate risk (MUST = 1), and 17.9% at high risk (MUST $\geq$ 2). Patients at low and moderate risk were grouped together in data analysis since the British Association for Parenteral and Enteral Nutrition (BAPEN) does not recommend medical intervention in either group.[6,7] EuroSCORE values of 0–1.9% were reported in 12 patients, 14% of whom were categorized as being at high risk for malnutrition using the MUST; 2–4.9% in 25 patients, 12.8% of whom were categorized as being at high risk for malnutrition using the MUST; 5–5.9% in 15 patients, 25% of whom were categorized as being at high risk for malnutrition using the MUST; 6–12.9% in 23 patients, 14.9% of whom were categorized as being at high risk for malnutrition using the MUST; $\geq$ 13% in 38 patients, 32.8% of whom were categorized as being at high risk for malnutrition using the MUST.

Thirty-day mortality

Thirty-day mortality in the entire study group was 5.2% (21 patients). Table 1 describes the association between 30-day mortality and the investigated risk factors, namely gender, age, continuous EuroSCORE values, EuroSCORE categories, MUST groups, and inclusion in the DRG. Univariate analysis revealed that 30-day mortality was greater in the high-risk MUST group compared with the low-risk group (12.5% vs 3.6%, $p = 0.004$). Higher rates of 30-day mortality were associated with increased EuroSCORE values, both continuous ($p < 0.001$) and categorical ($p_{\text{Trend}} = 0.002$). Thirty-day mortality rate for patients with EuroSCORE values of 0–4.9% was 0.4%; the rate was 18% for patients with EuroSCORE values $\geq$13% ($p < 0.001$). Patients included in the DRG had a mortality rate of 23.1%. The risk of 30-day mortality in the high-risk MUST group was 3.8 times higher than in patients in the low-risk group, and 8.8 times higher for patients in the DRG compared with patients included in none of the high-risk groups.

Since the EuroSCORE accounts for gender and age, these factors were excluded from the initial multivariate prediction rule for 30-day mortality. To examine the

Table 1. Univariate association of risk factors and 30-day mortality

Variable	Category	% from total (*n*)	% 30-day mortality (*n*)	*p*	OR	95% CI
Sex	M	72 (290)	3.8 (11)	–	Ref.	–
	F	28 (113)	8.8 (10)	0.046	2.5	1.0–6.0
Age	≥64	50 (198)	2.5 (5)	–	Ref.	–
	65–69	12 (50)	4.0 (2)	0.577	1.6	0.3–8.5
	70–74	18 (71)	9.9 (7)	0.017	4.2	1.3–13.8
	75–79	11 (46)	8.7 (4)	0.060	3.7	1.0–14.3
	≥85	9 (38)	7.9 (3)	0.112	3.3	0.8–14.5
	–	–	–	0.138	p_{Trend}	–
EuroSCORE: continuous values	–	–	–	<0.0001	1.055	1.03–1.08
EuroSCORE: groups of predicted mortality	0–4.9%	61 (247)	0.4 (1)	–	Ref.	–
	5–5.9%	12 (48)	8.3 (4)	0.006	22.4	2.4–204.8
	6–12.9%	12 (47)	10.6 (5)	0.002	29.3	3.3–257.0
	≥13%	15 (61)	18.0 (11)	<0.001	54.1	6.8–428.7
				0.002	p_{Trend}	–
MUST groups	LR group	82 (331)	3.6 (12)	–	Ref.	–
	HR group	18 (72)	12.5 (9)	0.004	3.8	1.5–9.4
DRG group	No	90 (364)	3.3 (12)	–	Ref.	–
	Yes	10 (39)	23.1 (10)	<0.001	8.8	3.4–22.6

CI: confidence interval; DRG: double–risk group; EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR: high risk; LR: low risk; MUST: Malnutrition Universal Screening Tool; OR: odds ratio; Ref.: reference odds ratio of 1.

contribution of MUST to the prediction of 30-day mortality, three logistic regression models were constructed (Table 2). The first baseline model examined the contribution of continuous EuroSCORE values to prediction of 30-day mortality risk. The second model incorporated the EuroSCORE and the MUST grouping. The third model assessed the contribution of continuous EuroSCORE values and inclusion in the DRG to the prediction of 30-day mortality. Table 2 presents the ROC curves and Hosmer–Lamishow goodness-of-fit *p* values. The third model resulted in the greatest area of 0.858 (CI 0.79–0.92), for which the Hosmer–Lamishow goodness of fit was insignificant, suggesting a slightly less than perfect fit.

Figure 2 depicts 30-day mortality among the high- and low-risk MUST groups, stratified by the EuroSCORE.

Postoperative complications

Among the low-risk MUST group, median values of LOS, antibiotic treatment, and vasopressor treatment were 11, 3, and 2 days, respectively. Among the high-risk MUST group, median values of LOS, antibiotic treatment, and vasopressor treatment were 14, 4, and 3 days, respectively. Table 3 includes descriptive statistics of the continuous variables that defined complications, namely LOS >21 days, antibiotic treatment >21 days, and vasopressor treatment >11 days, in the low- and high-risk MUST groups. As depicted therein, 28% of the study population ($n = 113$) had one or more of the following complications: LOS longer than 21 days (13.9%), antibiotic treatment longer than 21 days (8.7%), BSI (6%), vasopressor treatment longer than 11 days (7.9%), new onset of renal failure (9.2%), and in-hospital mortality (3.7%). All complications, except for new onset of renal failure, were significantly more prevalent in the high-risk MUST group compared with the low-risk group.

Univariate analysis revealed the following factors to be associated with postoperative complications: age >60 years, EuroSCORE continuous values and categories for EuroSCORE >5%, and high-risk MUST group ($P \leq 0.001$; Table 4). Complications were more common in the high-risk MUST group relative to the low-risk group (47.2% vs 23.9%, respectively, $p < 0.001$). Higher rates of complications were associated with increased EuroSCORE values, both categorical ($p_{Trend} < 0.001$) and continuous ($p < 0.001$). EuroSCORE values lower than 2% were associated with complication rates of 10.5%; however, EuroSCORE values of 13% and greater were associated with a substantially greater complications rate of 62.3%.

Table 2. Prediction of 30-day mortality risk

Model	Variables	Coefficient	*p*	Adjusted OR	OR 95% CI	ROC area	ROC area 95% CI	Hosmer–Lameshow
Model I: EuroSCORE	EuroSCORE	0.054	<0.0001	1.06	1.03–1.08	0.834	0.77–0.89	0.03
	Constant	−3.518	<0.0001	0.03	–			
Model II: EuroSCORE and MUST	EuroSCORE	0.051	<0.0001	1.05	1.03–1.08	0.815	0.73–0.89	0.145
	HR MUST	1.188	0.013	3.28	1.28–8.39			
	Constant	−3.837	<0.0001	0.02	–			
Model III: EuroSCORE and DRG	EuroSCORE	0.044	0.002	1.05	1.02–1.07	0.858	0.79–0.92	0.16
	DRG	1.75	0.001	5.76	2.14–15.51			
	Constant	−3.799	<0.0001	0.02	–			

CI: confidence interval; DRG: double-risk group; EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR: high risk; MUST: Malnutrition Universal Screening Tool; OR: odds ratio; ROC: receiver operating characteristic.

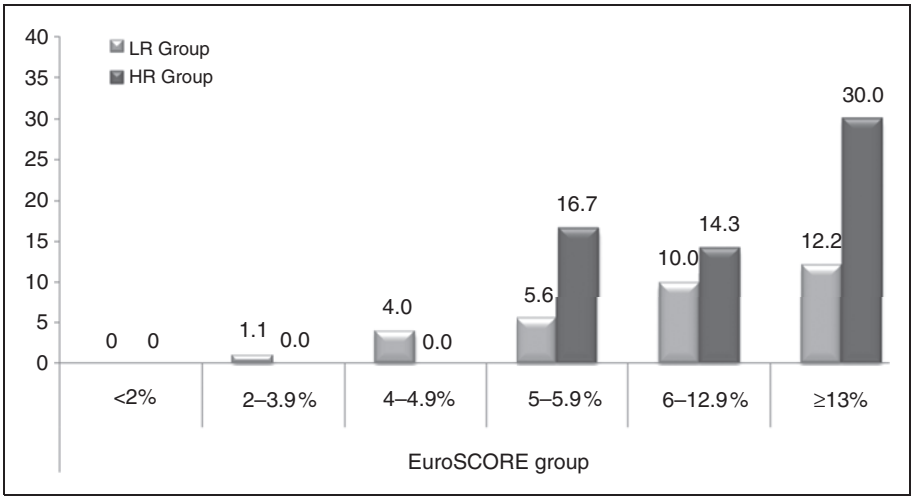

Figure 2. Description of 30-day mortality among the high-risk and low-risk MUST groups, stratified by EuroSCORE categories. EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR, high-risk group; LR: low-risk group; MUST: Malnutrition Universal Screening Tool.

To examine the contribution of the MUST to prediction of complex hospitalization, two logistic regression models were constructed (Table 5). The first model examined the contribution of continuous EuroSCORE values to predicting complex hospitalization, while the second model combined both the EuroSCORE and the MUST grouping. Table 5 describes the ROC curves and Hosmer–Lamishow goodness-of-fit *p* values attributed to these models. The second model resulted in a larger ROC of 0.77 (CI 0.71–0.82), for which the Hosmer–Lamishow goodness of fit was insignificant, suggesting a slightly less than perfect fit.

Figure 3 depicts postoperative complications among the high- and low-risk MUST groups, stratified by the EuroSCORE categories.

Discussion

The current study addressed two distinct topics, namely the MUST-based prevalence of malnutrition risk on admission and its association with adverse outcomes after cardiac surgery; and the addition of MUST-based assessment of DRU to the currently used EuroSCORE prediction tool for mortality in cardiac surgery. As current findings indicate high malnourishment rates in cardiac patients, it is paramount that their nutritional profile be accurately assessed preoperatively and that individual diets be optimized accordingly as part of the perioperative treatment management. An advantage of incorporating the MUST in the preoperative evaluation of cardiac surgery patients lies in the

Table 3. Postoperative complications among the low- and high-risk MUST groups

% of patients with:	Total ($N = 403$)	LR group ($N = 331$)	HR group ($N = 72$)	p	OR	95% CI
Complex hospitalization	28.0	23.9	47.2	<0.001	2.9	1.7–4.8
LOS > 21 days	13.9	11.2	26.4	0.002	2.9	1.5–5.3
BSI	6.0	4.5	12.5	0.020	3.0	1.3–7.2
Antibiotic treatment > 21 days	8.7	7.3	15.3	0.037	2.3	1.1–4.7
Vasopressor treatment > 11 days	7.9	6.3	15.3	0.016	2.7	1.2–5.8
New onset of renal failure	9.2	8.8	11.1	0.532	1.3	0.6–3
In-hospital mortality	3.7	2.7	8.3	0.03	3.3	1.1–9.4

BSI: blood stream infection; CI: confidence interval; HR: high risk; LOS: length of stay; LR: low risk; MUST: Malnutrition Universal Screening Tool; OR: odds ratio.

Table 4. Univariate associations of risk factors and development of postoperative complications

Parameter	Category	%	p	OR	OR 95% CI
Gender	Male	26.9 (78)	–	Ref.	–
	Female	31.0 (35)	0.413	1.2	0.8–2.0
Age	<60	16.8 (22)	–	Ref.	–
	60–64	29.9 (20)	0.036	2.1	1.1–4.3
	65–69	20.0 (10)	0.614	1.2	0.5–2.8
	70–74	32.4 (23)	0.012	2.4	1.3–4.7
	75–79	45.7 (21)	<0.001	4.2	2.0–8.7
	≥85	44.7 (17)	0.001	4.0	1.8–8.8
	–	–	0.001	p_{Trend}	–
EuroSCORE: continuous values	–	–	<0.001	1.078	1.051–1.1069
EuroSCORE: groups of predicted mortality	0–1.9%	10.5 (12)	–	Ref.	–
	2–4.9%	18.8 (25)	0.073	2.0	0.9–4.1
	5–5.9%	31.3 (15)	0.002	3.9	1.6–9.1
	6–12.9%	48.9 (23)	<0.001	8.2	3.6–18.6
	≥13%	62.3 (38)	<0.001	14.0	6.3–31.0
	–	–	<0.001	p_{Trend}	–
MUST group	LR group	23.9 (79)	–	Ref.	–
	HR group	47.2 (34)	<0.001	2.9	1.7–4.8

CI: confidence interval; EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR: high risk; LR: low risk; MUST: Malnutrition Universal Screening Tool; OR: odds ratio; Ref.: reference odds ratio of 1.

fact that MUST-based stratification yields distinct groups of low-risk and high-risk patients, with the latter demonstrating greater rates of in-hospital mortality, longer antibiotic and vasopressor treatments, and longer LOS durations. These observations highlight the importance of nutritional status evaluation on admission and its valuable impact on determining patient risk for postoperative complications and mortality.

In the clinical setting, malnutrition may be present on admission; during hospitalization it may worsen or develop de novo. As malnutrition can negatively affect all body systems, including the immune system, ability to heal, thermo-regulation, and muscular function, it is considered a significant risk factor associated with adverse effects on patients undergoing surgery,[19,20] as corroborated in our current study. Malnutrition appears at different rates among various patient groups: 20–50% among patients in care homes, 18–30% among ambulatory patients, and 14% among older patients.[4,5] In cardiac surgery wards, malnutrition prevalence is approximately 10–25%.[10,20,21] Studies from Europe and the United States present an overall malnutrition prevalence of 30–60%, with vast underdiagnosis.[22] Seventy to eighty percent of patients are

Table 5. Risk factors associated with the development of a complex hospitalization, as derived from multivariate analyses

Model	Variables	Category	Coefficient	*p*	Adjusted OR	OR 95% CI	ROC area	ROC area 95% CI	Hosmer–Lameshow
Model I: EuroSCORE	EuroSCORE	0–1.9%	–	–	Ref.	–	0.74	0.68–0.79	1
		2–4.9%	0.677	0.073	2.0	1.0–4.1			
		5–6.9%	1.352	0.002	3.9	1.6–9.1			
		7–12.9%	2.098	<0.001	8.1	3.6–18.6			
		≤13%	2.642	<0.001	14.0	6.4–31.0			
	Constant	–	−2.140	<0.001	0.1	–			
Model II: EuroSCORE and MUST	EuroSCORE	0–1.9%	–	–	Ref.	–	0.77	0.71–0.82	0.63
		2–4.9%	0.702	0.065	2.0	1.0–4.3			
		5–6.9%	1.272	0.004	3.6	1.5–8.8			
		7–12.9%	2.135	<0.001	8.5	3.7–19.5			
		≤13%	2.542	<0.001	12.7	5.7–28.3			
		–	–	<0.001	p_{Trend}	–			
	MUST group	HR	0.883	0.003	2.4	1.3–4.3			
	Constant	–	−3.837	<0.0001	0.02	–			

CI: confidence interval; EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR: high risk; MUST: Malnutrition Universal Screening Tool; OR: odds ratio; Ref.: reference odds ratio of 1; ROC: receiver operating characteristic.

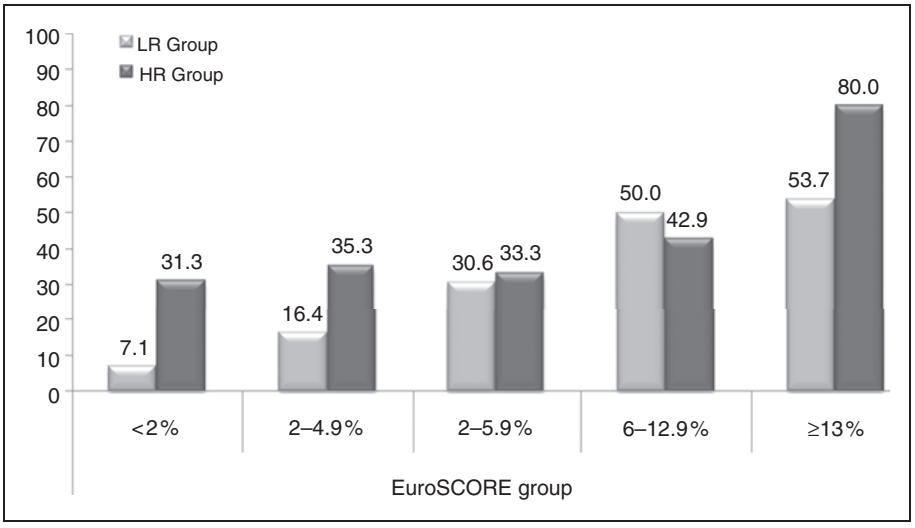

Figure 3. Postoperative complications by the risk for malnutrition stratified by the EuroSCORE. EuroSCORE: European System for Cardiac Operative Risk Evaluation; HR, high-risk group; LR, low-risk group.

released with no action being taken relative to nutrition evaluation and therapy.[23,24]

Accumulating evidence points to the relevance of nutrition-related factors to patient benefits from clinical treatments. Engelman et al. found that a BMI lower than 20 and hypoalbuminemia were related to post-operative mortality.[10] In keeping with this, Reeves et al. examined more than 4000 patients and found that a BMI lower than 20 was linked with mortality, extended ventilation, infections, blood loss, and extended hospitalization.[25] Potapov et al. examined over 22,000 patients and found that mortality, infections, extended hospitalization in the intensive care unit, and recurring surgery due to haemorrhaging were more common among patients with a BMI below 20.[26] In addition, Van Venrooij et al. found that increased UWL was associated with prolonged LOS after EuroSCORE stratification.[8] Our findings align with these studies as they suggest that MUST scores, which are composed of individual BMI and UWL values, contribute to postoperative prediction of both mortality and morbidity.

In terms of prediction of 30-day mortality, current findings suggest that the contribution of the MUST was chiefly evident for EuroSCORE values greater than 5%, since lower scores were associated with extremely minor mortality rates. As mortality is predominantly associated with higher EuroSCORE values, this result stresses the ability of the MUST to categorise cardiac patients at risk with greater clarity. In terms of prediction of postoperative complications, the contribution of the MUST was primarily evident for EuroSCORE values lower than 5%. These findings stress the relevance of incorporating the MUST-based evaluation of DRU with the currently used EuroSCORE tool in the prediction of 30-day mortality and postoperative complications in patients undergoing cardiac surgery.

The primary limitation of our study relates to its design as a descriptive, retrospective study, which limits its ability to demonstrate malnutrition as a causal factor in adverse hospitalization outcomes. Prospective, randomized controlled interventional studies are required to further elucidate the importance of malnutrition in cardiac surgery patients. Second, since DRU is associated with relatively high EuroSCORE values, screening tools to identify patients benefiting from a nutritional intervention are not necessarily better recognized using a model that best predicts complications or mortality. Third, the association found between the nutritional status and risk from cardiac surgery is vulnerable for confounding, as comparable conditions that increase surgical risk, such as age and advanced heart failure, may impact the factors comprising MUST scoring.

In conclusion, malnutrition was found to be prevalent in the studied group of patients undergoing cardiac surgery. Compared with well nourished patients, this group suffered from greater rates of postoperative complications and mortality. The MUST emerged in our study as a straightforward, easy-to-implement, and valid tool for identifying prospective cardiac surgery patients at risk for malnutrition and, therefore, one that enables early recognition and promotes well timed treatment of cardiac surgery patients.

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Conflict of interest

None declared.

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