Title: The relationship between Malnutrition Universal Screening Tool (MUST), CT-derived body composition, systemic inflammation and clinical outcomes in patients undergoing surgery for colorectal cancer

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List of abbreviations:

ASA: American Society of Anesthesiologists

BMI: body mass index

mGPS: modified Glasgow Prognostic Score

MUST: malnutrition universal screening tool

NLR: Neutrophil-to-lymphocyte Ratio

SIR: Systemic Inflammatory Response.

SMD: skeletal muscle radiodensity.

SMI: skeletal muscle index

TNM stage: Tumour, Node, Metastasis

Abstract

Background: Nutritional status is an important factor affecting a patient's clinical outcomes. Early identification of patients who are at risk of malnutrition is important to improve clinical outcomes and reduce health cost. Malnutrition universal screening tool (MUST) has been recommended as part of the routine nursing assessment for all patients at hospital admission.

Objective: The aim of this study was to examine the association between nutritional status (MUST), systemic inflammatory response (SIR), body composition, and clinical outcomes in patients undergoing surgery for colorectal cancer.

Methods: The malnutrition risk was examined using MUST in patients admitted for surgery for colorectal cancer between March 2013 and June 2016. Pre-operative CT scans were used to define the body composition. The presence of SIR was evidenced by the modified Glasgow prognostic score (mGPS) and neutrophil to lymphocyte ratio (NLR). Post-operative complications, severity of complication, length of hospital stay and mortality were considered as outcome measures.

Result: The study included 363 patients (199 males, 164 females), 21% of the patients presented with a medium or high nutritional risk. There were significant associations between MUST and subcutaneous adiposity ($p<0.001$), visceral obesity ($p<0.001$) and low SMI ($p<0.001$). No statistically significant association was identified between MUST score and presence of any complication or severity of complication. On multivariate analysis, MUST remained independently associated with the length of hospital stay [OR=2.17 (95% CI 1.45,3.26) $p<0.001$]. Kaplan–Meier survival curves showed an increased number of deaths for patients at medium or high risk of malnutrition ($p<0.001$). This association was found to be independent of other confounding factors [HR=1.45 (95% CI 1.06,1.99) p=0.020].

Conclusion: MUST score is an independent marker of risk in those undergoing surgery for colorectal cancer surgery and should remain a key part of preoperative assessment.

Keywords: MUST, nutrition status, body composition, systemic inflammatory response, colorectal cancer

Introduction

Colorectal cancer is the third most common cancer and the fourth leading cause of cancer-related deaths worldwide, and its burden is expected to increase by 60% to more than 2.2 million new cases and 1.1 million cancer deaths by 2030 (1). In the United Kingdom in 2016, more than 41,000 patients are diagnosed and almost 16,500 patients die from colorectal cancer (2). Postoperative complications occur in up to one-third of patients undergoing colorectal procedures (3). Patients with complications have been shown to be at higher risk for mortality (4).

Nutritional status is an important factor affecting patient's clinical outcomes. Malnutrition has been shown to be associated with adverse postoperative outcomes of morbidity and mortality in patients with gastrointestinal cancer (5,6). Indeed, the presence of malnutrition can alter immune responses and impair wound healing in surgical patients (7).

Early identification of patients who are malnourished or at risk of becoming malnourished, and those who would benefit from specific nutritional support, is vital to reduce the risk of surgical complications, improve clinical outcomes and reduce health cost. According to the British Association for Parenteral and Enteral Nutrition (BAPEN) recommendation, the screening method should be: simple and understandable, rapid to implement, and validated for hospital use (8). Several nutritional screening tools have been developed for this purpose, including the Malnutrition Universal Screening Tool (MUST). MUST identifies patients who are malnourished or at risk of developing malnutrition based on assessment of body mass index (BMI), unintentional weight loss in the preceding three to six months, and the presence of an acute disease resulting in absence of dietary intake for more than five days (9) Subsequent management guidelines have followed, based on the overall malnutrition risk (MUST) score.

Published studies have been conducted to assess nutritional status in oncologic patients using different nutritional screening tools such as subjective global assessment (SGA), malnutrition screening tool (MST) and nutritional risk screening (NRS 2002) (10). MUST is now used in most of the UK as part of the routine nursing assessment for all patients admitted to hospital (11), However, to our knowledge no studies have examined the relationship between MUST, body composition, and systemic inflammatory responses. The aim of the present study was to examine these associations, and to relate MUST score to clinical outcomes after surgery for colorectal cancer.

Patients and Methods

Patients

Consecutive patients who underwent potentially curative resection for colorectal cancer between March 2013 and June 2016 were included. All procedures were performed at Glasgow Royal Infirmary. Those patients with a preoperative recorded MUST score, preoperative CT scan, and documentation reporting the presence or absence of post-operative complications were included. Data regarding the nature, severity and management of complications were retrospectively classified using the Clavien-Dindo grade, where 0 is no complication, 1 is any deviation from the normal post-operative course without the need for pharmacological treatment or surgical, endoscopic and radiological interventions, 2 is requiring pharmacological treatment with drugs other than such allowed for grade 1 complications, 3 is requiring surgical, endoscopic or radiological intervention, 4 is a life threatening complication (including CNS complications) requiring IC/ICU management, 5 is the death of a patient (12). Patient comorbidity was classified using the American Society of Anesthesiologists (ASA) grading system. ASA 1 a patient with normal health, ASA 2 a patient with mild systemic disease, ASA 3 a patient with severe systemic disease and ASA 4 a patient with severe systemic disease that is a constant threat to life.

All data were collected prospectively in a database, anonymised, and were subsequently analysed. Any uncertainties were addressed by review of electronic and/or physical case notes.

Malnutrition risk assessment

The MUST scores were recorded in patient notes, using a dedicated pro forma, by clinical nursing staff, within 24 h of admission. MUST incorporates three components to determine the overall risk for malnutrition (Figure1): current weight status using BMI, unintentional weight loss, and acute disease effect that has induced a phase of nil per mouth for > 5 days.

Each parameter can be rated as 0, 1, or 2. Overall risk for malnutrition is established as low (score = 0), medium (score = 1), or high (score ≥2).

Body composition

CT images were obtained at the level of the third lumbar vertebra. Patients whose scans were taken 3 months or more prior to their surgery were excluded from the study. The median and range for the interval between CT scanning and operation was 0.91 months (0.03-2.83) with 78% of scans carried out within 30 days of operation. Scans with significant movement artefact or missing region of interest were not considered for inclusion. Each image was analysed using a free-ware program [NIH Image J version 1.47 (24)]. Region of interest (ROI) measurements were made of visceral adipose tissue, subcutaneous adipose tissue and skeletal muscle areas (cm^2) using standard Hounsfield Unit (HU) ranges (adipose tissue -190 to -30, and skeletal muscle -29 to +150). These were then normalised for $height^2$ to create indices; total adipose tissue index (cm^2/m^2), subcutaneous adipose tissue index (cm^2/m^2), visceral adipose tissue index (cm^2/m^2), and skeletal muscle index (SMI, cm^2/m^2). Skeletal muscle radiodensity (SMD, HU) was measured from the same ROI used to calculate SMI, as its mean HU. Visceral obesity was defined as VFA >160cm^2 for male patients and >80cm^2 for female patient (13). High subcutaneous adipose tissue index was defined as ≥50.0 cm^2/m^2 in males and ≥42.0 cm^2/m^2 in females (14). Sarcopenia was described by Caan and colleagues as an SMI<52.3 cm^2/m^2 if BMI<30kg/m^2 and SMI<54.3 cm^2/m^2 if BMI≥30kg/m^2 in male patients and an SMI<38.6 cm^2/m^2 if BMI<30kg/m^2 and an SMI<46.6 cm^2/m^2 if BMI≥30kg/m^2 in female patients (15). Low SMD was defined by SMD <41HU in patients with BMI <25kg/m^2 and <33HU in patients with BMI >25kg/m^2 (25).

Inflammatory markers

Serum CRP (mg/L) and albumin (g/L) concentrations were measured by routine laboratory procedures with an automated analyzer (Architect; Abbott Diagnostics, Maidenhead, UK).

The limit of detection for CRP was 0.1 mg/L. Intraassay imprecision was <4%. The laboratory participated in external quality assurance/ proficiency testing programs, the A, B and C scores were within the EQA (NEQAS) targets throughout the time period of the study. Performance was acceptable throughout, which indicated that methodologic changes did not result in any bias. The presence of preoperative systemic inflammatory response was evidenced by an mGPS and NLR. The mGPS was derived as the following; patients with a normal C-reactive protein (<10mg/L) were allocated a score of 0, those with an elevated C-reactive protein (>10 mg/L) allocated a score 1, and those with an elevated C-reactive protein (>10 mg/L) and hypoalbuminaemia (<35 g/L) were allocated a score of 2 (16). The neutrophil lymphocyte ratio (NLR) was calculated for each patient for whom preoperative neutrophil and lymphocyte counts were available. Values < than 3 considered normal, 3-5 moderate and >5 were considered raised (26).

Survival

The cause and date of death were confirmed with the Registrar General (Scotland) until 30 June 2018, which served as the censor date. Informed consent was obtained from patients prior to surgery. Ethical approval was granted by the West of Scotland Research Ethics Committee, Glasgow.

Statistical analysis:

In the present study no formal power calculation was carried out since low SMI has been shown to be associated with overall survival (primary endpoint) in smaller and similar sized cohorts of patients undergoing surgery for colorectal cancer (19, 27). Secondary outcome measures were length of hospital stay and post-operative complications

Categorical variables were analysed using Chi-square test for linear-by-linear association. Where there was a significant association on Chi-square analysis, pairwise comparisons were carried out to detect where the differences in proportions were. Missing data were excluded from analysis on a variable by variable basis. Due to the number of statistical comparisons carried out (~40) a P value ≤ 0.001 was considered statistically significant. Mortality within 30 days of the index procedure or during the index admission were excluded from subsequent survival analysis. The time between the date of surgery and the date of death of any cause was used to define overall survival (OS). The Cox regression hazard model was applied to assess the ability of the MUST to predict survival. Those variables associated to a degree of $p<0.1$ at univariate analysis were entered into a backward conditional multivariate model. Length of hospital stay was classified as binary variable (<7 vs >7 days) and then analysed using univariate and multivariate binary logistic regression.

Statistical analysis was performed using SPSS software (Version 21.0. SPSS Inc., Chicago, IL, USA).

Results:

In total 483 patients were identified as having undergone potentially curative surgery for colorectal cancer. Of these, 120 were excluded due to missing MUST score, or clinical and pathological data. A total of 363 patients were included in the final analysis. There were 199 males and 164 females. The mean (±SD) age was 66 ± 12 y and BMI 27.6 ± 6.4. The majority of patients had ASA grade 1 and 2 comorbidity (69%), colon cancer (62%) and had TNM stage 0-2 disease (64%). The majority of patients had subcutaneous (63%) and visceral (72%) adiposity, low SMI (50%) and low SMD (61%). The majority of patients had a mGPS (76%) and NLR (51%) in the normal range. The majority of patients had no complication type (63%) and severity measured by Clavien-Dindo grade (66%), had a hospital stay more than 7 days (54%) and were alive at 3 years (79%).

MUST and patients' characteristics

A total of 288 patients had a MUST 0 (79%, Low risk), 31 had MUST 1 (9%, medium risk), and 44 had a MUST ≥ 2 (12%, high risk).

The associations of nutritional status classified by MUST with patients' characteristics, body composition, systemic inflammatory response and colorectal cancer outcomes are presented in **Table 1**. Since TNM stage 4 disease is commonly associated with malnutrition risk the analysis was repeated after excluding the patients (n=13). The results of the analysis did not change materially. There were significant associations between MUST, age and BMI. Around 39% of patients with MUST score 2 were older than 74y ($p<0.001$), and BMI: All underweight patients had MUST score ≥1 and only 7% of patients with MUST score 2 were obese.

There were no association with sex, ASA, tumour site and stage.

MUST and body composition

There were significant associations between MUST and subcutaneous adiposity (p<0.001), visceral obesity (p<0.001) and low SMI (p<0.001). Specifically, 42% of patients with a MUST score 2 had subcutaneous adiposity compared with 86% of patients with a MUST score of 0 (p<0.001). Also, 38% of patients with MUST score 2 had visceral obesity compared with 80% of patients with a MUST score 0 (p<0.001). Finally, 76% of patients with MUST score 2 had low SMI compared with 45% of patients with a MUST score 0 (p=0.001).

MUST and systemic inflammatory response

There were significant associations between MUST and mGPS (p<0.001). Specifically, 36% of patients with a MUST score 2 had a mGPS of 2 compared with 8% of patients with a MUST score of 0 (p<0.001).

MUST and clinical outcome

There were significant associations between MUST and length of hospital stay (p<0.001) and 3 year survival (p=0.002). Specifically, 78% of patients with a MUST score 2 had a length of stay >7 days compared with 49% of patients with a MUST score of 0 (p=0.002). Also, 33% of patients with MUST score 2 were dead at 3 years compared with 17% of patients with a MUST score 0 (p=0.001).

Length of hospital stay

The variables associated with the length of hospital stay are presented in **Table 2**. On univariate logistic regression, age (p=0.019), ASA (p=0.026), BMI (p=0.045), MUST (p=0.001),visceral obesity (p=0.094), mGPS (p =0.043), NLR(p=0.002), and complication (p<0.001) were significantly associated with length of hospital stay >7 days. Multivariate analysis showed that MUST [OR=2.17 (95% CI 1.45, 3.26) p<0.001] and complication [OR=11.04 (95% CI 5.96,20.44) p<0.001] were independently associated with length of hospital stay >7 days.

Complications

There was no significant association between MUST score and either the presence of complications or their severity.

Survival

A total of 239 patients were alive at the censor date. Death due to any cause occurred in 82 patients with 51 being cancer specific. The median survival was 38 months (range 1-122 months). After exclusion of thirty-day postoperative mortality (1%), there was a significant association between MUST score and overall survival ($p<0.001$). Kaplan–Meier curves **(Figure 2)** showed an increased number of deaths for patients at medium or high risk of malnutrition (log rank test, $p<0.001$).

On univariate cox regression survival analysis **(Table 3)**, age ($p<0.001$), sex ($p=0.048$), ASA ($p<0.001$), TNM stage ($p<0.001$), BMI ($p=0.005$), MUST ($p<0.001$), subcutaneous adiposity ($p=0.033$), low SMD ($p=0.015$), mGPS ($p=0.005$), and NLR ($p=0.026$) were significantly associated with overall survival. Multivariate analysis showed that age [HR=1.45 (95% CI 1.05,2.01) p=0.023], TNM stage [HR=2.19(95% CI 1.56,3.08) p<0.001], MUST [HR=1.45 (95% CI 1.06,1.99) p=0.020], and NLR [HR=1.39(95% CI 1.01,1.90) p=0.037] were independently associated with overall survival.

Discussion

The results of the present study show for the first time that there was a significant association between pre-operative nutritional status (MUST), subcutaneous adiposity, visceral obesity low SMI, systemic inflammatory response and clinical outcomes after surgery of colorectal cancer. Specifically, the majority of patients with a MUST score of 2 were underweight (54%) but only 19% in those with a score of 1. Similarly, there was low adiposity in 58% and 40% respectively, low SMI in 76% and 60% respectively and a mGPS 2 in 36% and 31% respectively. Also, MUST was independently associated with length of hospital stay and overall survival. Therefore, routine MUST assessment usefully characterises important phenotypes associated with malnutrition including loss of skeletal muscle mass and the presence of a systemic inflammatory response in patients with primary operable colorectal cancer.

The present results are consistent with previous studies that have shown a relationship between the presence of a systemic inflammatory response and the loss of skeletal muscle (sarcopenia) (17,18,19&20) in primary operable colorectal cancer. Indeed, the presence of a systemic inflammatory response is now recognised as a key hallmark of progressive nutritional decline in patients with cancer (21). It is now clear that nutritional assessment tools such as MUST may also reflect the systemic inflammatory status in patients with cancer. To date, although other studies have reported that nutritional screening tools are associated with poor post-operative outcomes in patients with gastrointestinal cancer (5,6), few studies have clearly delineated the prognostic value of nutritional screening tools independent of potential confounding factors. The results of the present study show that MUST was independently associated with length of hospital stay and long term survival. In contrast, MUST was not associated with the development and severity of post-operative complications.

It may be that poor nutritional status per se is a relatively weak determinant of post-operative complications in these patients. While this might appear to be counterintuitive, in terms of the present study cohort MUST clearly identifies the underweight (BMI<18.5kg/m^2). However, post-operative complications have been consistently associated with obesity (BMI>30kg/m^2) (22) and it may be that in the present cohort where approximately 10% were underweight and approximately 30% were obese that obesity was the main driver of post-operative complications. Indeed, visceral obesity has been reported to be independently associated with post-operative complications (23).

In contrast, MUST was independently associated with length of hospital stay and overall survival. The basis of these associations may be more obvious. Patients identified at nutritional risk (ie underweight) are more likely to receive dietetic input and have delayed discharge. Patients with cancer and underweight are likely to be cachectic and this has long been recognised to compromise long term outcomes (21).

The implications of the present observations are important. MUST uses three criteria to assess the overall risk for malnutrition and it appears that each of the criteria can independently predict clinical outcome (9). Furthermore, it appears to compare well with other nutritional screening tools such as NRI, MST and SGA for defining nutritional status and it has been concluded that MUST and SGA are effective in the outpatient setting (10). However, the interpretation of nutritional screening tools such as MUST is of major importance since if such patients are identified to be at nutritional risk there may be an assumption that they are likely to benefit from a nutritional intervention. If, in patients with cancer, MUST reflects, in part, the cachectic process including the systemic inflammatory response then it may be that down regulation of the systemic inflammatory response would be of more benefit (28). There is also the possibility to treat the malnutrition and down regulate the systemic inflammatory response. Indeed, recently updated nutritional strategies for cancer patients now suggest considering nutrition with anti-catabolic and inflammation-suppressing ingredients such as arginine, omega-3-polyunsaturated fatty acids, and glutamine (21). A growing number of studies have evaluated the use of such immunonutrients in patients with cancer undergoing surgery. For example, a systematic review and meta-analysis of 20 studies with a total of 2005 gastrointestinal cancer patients reported that, compared with a standard feed, an immune enhancing feed was associated with lower infective complication rates and length of hospital stay (29&30) More clinical trials in the context of the systemic inflammatory response are required.

The main limitation of the present study is that it was a retrospective study of patients in a single institution and only patients with an available MUST score were included in the analysis. However, this study, is to our knowledge, the first to examine the association between a preoperative nutritional assessment tool (MUST), body composition and systemic inflammation in large number of patients undergoing surgery for primary operable cancer.

In summary, there was a significant association between pre-operative nutritional status (MUST), body composition, systemic inflammatory response and clinical outcomes after surgery of colorectal cancer. These observations warrant confirmation in other clinical scenarios where nutritional assessment tools are routinely used.

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Author contribution is as follows: AA, DM and CE designed research; AA, RD, SM collect the data; AA and DM analyzed data and interpretation; AA wrote the paper; DM and CE manuscript editing; AA, CE and DM had responsibility for final content. All authors read and approved the final manuscript.

Conflict of interest

All authors confirm no conflict of interest

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Tables:

Table 1. The relationship between MUST and clinical and pathological characteristics, SIR and clinical outcomes [1]

Characteristic		All n(%)	Nutrition risk MUST Low risk n=288(79)	Medium risk n=31(9)	High risk n=44(12)	P value
Age	<65	141(39)	124 (43)	6(19)	11(25)	**<0.001**
	65 – 74	136(37)	108(38)	12(39)	16(36)	
	>74	86(24)	56(19)	13(42)	17(39)	
Sex	Male	199(55)	163(57)	13(42)	23(52)	0.334
	Female	164(45)	125(43)	18(58)	21(48)	
BMI (kg/m2)	Underweight (<20)	30(8)	0(0)	6(19)	24(54)	**<0.001**
	Normal 20-24.9	98(27)	75(26)	14(45)	9(20)	
	Overweight 25-29.9	124(34)	109(38)	7(23)	8(18)	
	Obese (≥30)	111(31)	104(36)	4(13)	3(7)	
ASA grade	1	89(25)	72(26)	6(21)	11(25)	**0.036**
	2	155(44)	128(46)	14(48)	13(30)	
	3	96(27)	74(26)	7(24)	15(34)	
	4	13(4)	6(2)	2(7)	5(11)	
Tumor site	Colon	225(62)	173(60)	23(74)	29(66)	0.264
	Rectum	137(38)	114(34)	8(26)	15(34)	

TNM stage	0	11(3)	9(3)	0(0)	2(5)	0.459
	1	75(21)	66(24)	6(19)	3(7)	
	2	140(40)	103(37)	16(52)	21(49)	
	3	115(32)	89(32)	9(29)	17(40)	
	4	13(5)	13(5)	0(0)	0(0)	
Body composition						
Subcutaneous adiposity	No	112(37)	38(14)	12(40)	22(58)	**<0.001**
	Yes	188(63)	242(86)	18(60)	16(42)	
Visceral obesity	No	100(28)	58(20)	16(52)	26(62)	**<0.001**
	Yes	258(72)	227(80)	15(48)	16(38)	
Low SMI	No	175(50)	154(55)	12(40)	9(24)	**<0.001**
	Yes	173(50)	126(45)	18(60)	29(76)	
Low SMD	No	138(39)	116(41)	12(39)	10(24)	0.047
	Yes	220(61)	169(59)	19(61)	32(76)	
Inflammatory response						
mGPS	0	266(76)	226(80)	17(59)	23(55)	**<0.001**
	1	39(11)	32(11)	3(10)	4(9)	
	2	47(13)	23(8)	9(31)	15(36)	
NLR	<3	184(51)	151(53)	13(42)	20(45)	0.038
	3-5	115(32)	92(32)	12(39)	11(25)	
	>5	60(17)	41(14)	6(19)	13(29)	

Post-operative outcome						
Any complication	No	227(63)	182(64)	18(58)	27(61)	0.682
	Yes	133(37)	103(36)	13(42)	17(39)	
Non infective complication	No	301(84)	243(85)	25(81)	33(75)	0.077
	Yes	59(16)	42(15)	6(19)	11(25)	
Infective complication	No	267(74)	214(75)	21(68)	32(73)	0.566
	Yes	93(26)	71(25)	10(32)	12(27)	
Clavien Dindo grade	0	236(66)	191(67)	18(58)	27(61)	0.285
	1-2	102(28)	78(27)	12(39)	12(27)	
	3-5	22(6)	16(6)	1(3)	5(11)	
Length of hospital stay	≤ 7 days	165(46)	145(51)	11(36)	9(22)	**0.001**
	> 7 days	192(54)	141(49)	20(64)	31(78)	
Survival for 3 years	Alive	288(79)	239(83)	24(77)	25(67)	**0.002**
	All causes death	75(21)	49(17)	7(23)	19(33)	

[1] N(%), Chi test for linear by linear association. Significant value p<0.001. mGPS: modified Glasgow Prognostic Score. NLR: Neutrophil-to-lymphocyte Ratio. SMD: skeletal muscle radiodensity. SMI: skeletal muscle index

Table 2. The relationship between MUST, clinical and pathological characteristics and **length of hospital stay (>7vs<7 days)** in patients undergoing surgery for colorectal cancer[1]

LOS	***Variable***	***Univariate OR (95% CI)***	***P value***	***Multivariate) OR (95% CI)***	***P value***
	Age	1.389(1.05,1.82)	**0.019**	1.28(0.79,1.71)	0.176
	Sex	1.23 (0.81,1.87)	0.328	-	-
	ASA	1.35(1.03,1.76)	**0.026**	1.22(0.87,1.72)	0.234
	TNM stage	1.01(0.80,1.28)	0.898	-	-
	BMI	0.79 (0.63,0.99)	**0.045**	0.99(0.67,1.47)	0.972
	MUST	1.88(1.31,2.69)	**0.001**	2.17(1.45,3.26)	**<0.001**
	Subcutaneous adiposity	0.69(0.40,1.18)	0.183	-	-
	Visceral obesity	0.66(0.41,1.07)	**0.094**	0.62(0.29,1.32)	0.217
	Low SMI	1.37(0.89,2.10)	0.142	-	-
	Low SMD	1.09(0.70,1.67)	0.696	-	-
	mGPS	1.38 (1.01,1.90)	**0.043**	0.99(0.67,1.47)	0.993
	NLR(<3/3-5/>5)	1.59(1.19,2.12)	**0.002**	1.26(0.88 ,1.80)	0.190
	Complication	9.10(5.26,15.75)	**<0.001**	11.04(5.96,20.44)	**<0.001**

[1] Binary logistic regression, OR: odd ratio, variables associated to a degree of p<0.1 at univariate analysis were entered into a backward conditional multivariate model. P<0.05 considered significant. mGPS: modified Glasgow Prognostic Score. NLR: Neutrophil-to-lymphocyte Ratio. SMD: skeletal muscle radiodensity. SMI: skeletal muscle index

Table 3. The relationship between MUST, clinical and pathological characteristics and overall survival in patients undergoing surgery for colorectal cancer[1].

OS	***Variable***	***Univariate HR (95% CI)***	***P value***	***Multivariate HR (95% CI)***	***P value***
	Age	1.78 (1.32,2.42)	**<0.001**	1.45(1.05,2.01)	**0.023**
	Sex	1.63(1.00,2.64)	**0.048**	1.61(0.91,2.85)	0.109
	ASA	1.64(1.24,2.17)	**<0.001**	1.27(0.90,1.77)	0.271
	TNM stage	1.88(1.40,2.53)	**<0.001**	2.19(1.56,3.08)	**<0.001**
	BMI	0.71(0.56,0.90)	**0.005**	0.91(0.62,1.32)	0.749
	MUST	1.69(1.30,2.21)	**<0.001**	1.45(1.06,1.99)	**0.020**
	Subcutaneous adiposity	0.56(0.33,0.96)	**0.033**	0.87(0.42,1.82)	0.360
	Visceral obesity	0.81(0.49,1.33)	0.411	-	-
	Low SMI	1.43(0.87,2.34)	0.155	-	-
	Low SMD	1.88(1.13,3.14)	**0.015**	1.08(0.56,2.08)	0.848
	mGPS	1.52(1.13,2.06)	**0.005**	1.25(0.90,1.73)	0.303
	NLR(<3/3-5/>5)	1.38(1.03,1.85)	**0.026**	1.39(1.01,1.90)	**0.037**

[1]Binary logistic regression, OR: odd ratio, variables associated to a degree of p<0.1 at univariate analysis were entered into a backward conditional multivariate model. P<0.05 considered significant. mGPS: modified Glasgow Prognostic Score. NLR: Neutrophil-to-lymphocyte Ratio. SMD: skeletal muscle radiodensity. SMI: skeletal muscle index

Legends for figures :

Figure 1: MUST score (Elia., 2003) (9)

Figure 1.

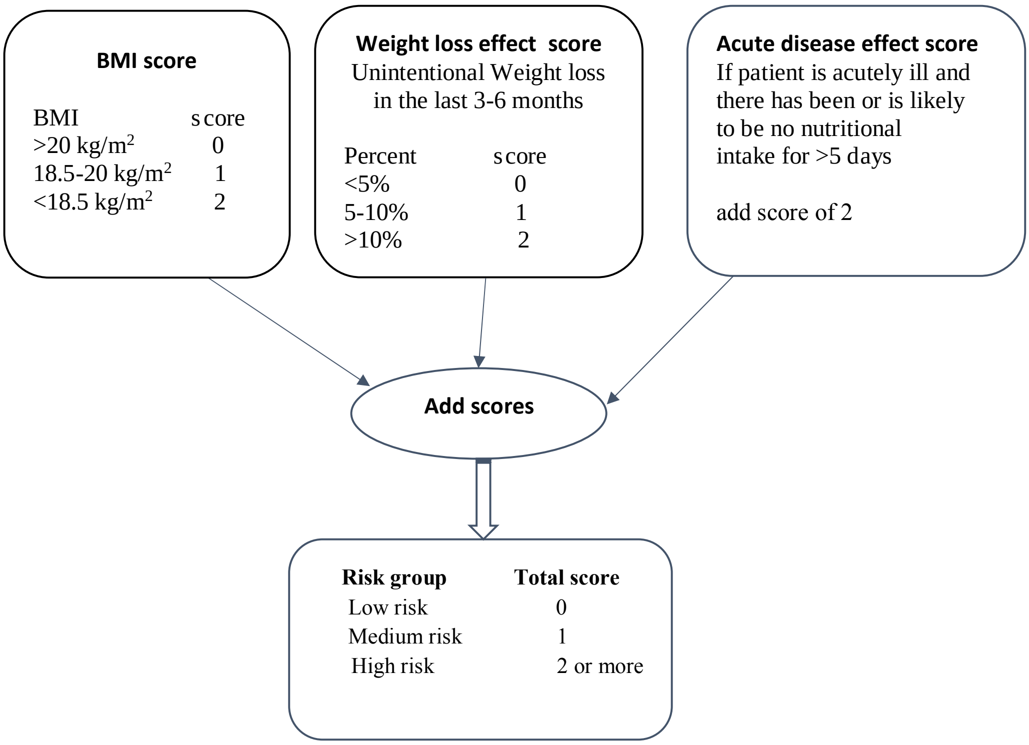

Figure 2: Kaplan–Meier curves showing the relationship between MUST score and overall survival in patients with colorectal cancer (Median follow-up: 38 month. MUST score 0 *n* = 288, MUST score 1 *n* = 31, MUST score ≥2 *n* = 44.)

Figure 2