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Rectus abdominis and rectus femoris muscle thickness in determining nutritional risk in critically ill patients: a prospective cohort study in Turkey

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ABSTRACT

Objectives Malnutrition is a clinical condition that is frequently seen in critically ill patients in the intensive care unit (ICU). Although there are many scoring systems and tools used to determine nutritional risk, those that can be used in critically ill patients in the ICU are very few. The scoring systems used are insufficient to identify ICU patients with malnutrition or at risk.
Malnutrition is generally presented with a decrease in skeletal muscle mass and muscle strength. Therefore, in many recent studies, attention has been drawn to the relationship between nutritional status and loss of muscle mass.

Design A cohort study.

Setting Forty-five patients hospitalised in an anaesthesia ICU in Turkey were included in the study.

Participants Patients aged 18 years and older.

Interventions Demographic data of patients included in the study, and Nutritional Risk Screening 2002 (NRS-2002) and Modified Nutrition Risk in Critically ill (mNUTRIC) scores in the first 24 hours of ICU admission were noted. Rectus abdominis muscle (RAM) and rectus femoris muscle (RFM) thicknesses were measured by the same person (intensive care specialist) with ultrasonography (USG).

Outcome measures Finding a quantitative and practical evaluation method by determining the correlation of measurement of RAM and RFM thickness with USG with NRS-2002 and mNUTRIC score, which are scoring systems used to assess nutritional risk.

Results The performance of RAM and RFM thickness in determining nutritional status was evaluated by receiver operating characteristic (ROC) analysis. Area under the ROC curves were calculated as >0.7 for RFM and RAM measurements ($p<0.05$). Specificity and sensitivity percentages of RAM were found to be higher than RFM in determining nutritional status.

Conclusion This study showed that RAM and RFM thickness measured by USG can be a reliable and easily applicable quantitative method that can be used to determine nutritional risk in the ICU.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study uses rectus abdominis muscle and rectus femoris muscle in nutritional risk assessment in the intensive care unit (ICU).
- ⇒ The limitation is that the study was conducted in a single centre and in a single ICU.
- ⇒ Since a specific ICU was not selected, patients' ICU admission diagnoses vary.

INTRODUCTION

Malnutrition is a clinical condition that is frequently seen in critically ill patients in the intensive care unit (ICU), characterised by prolonged mechanical ventilation and ICU stay, increased morbidity and mortality.[1]

Although there are many scoring systems and tools used to determine nutritional risk, the number of those that can be used in critically ill patients in the ICU is very few.[2] Although it is recommended evaluating critically ill patients with Modified Nutrition Risk in Critically ill (mNUTRIC) and Nutritional Risk Screening 2002 (NRS-2002) scoring systems according to the American Society for Parenteral and Enteral Nutrition/Society for Critical Care Medicine guidelines, there are some opinions that both scoring systems are not suitable for critically ill patients.[3] The European Society for Clinical Nutrition and Metabolism emphasises that these scoring systems are not the gold standard for identifying malnourished or at-risk ICU patients.[4] Due to these differences of opinion, nutritional risk assessment tools and methods that provide quantitative results specific to critically ill patients are still being researched in the ICU.

Malnutrition generally presents with a decrease in skeletal muscle mass and muscle strength.[5] In many recent studies, attention has been drawn to the relationship between nutritional status and loss of muscle mass, especially in the elderly population.[6 7] Based on this information, we come across studies

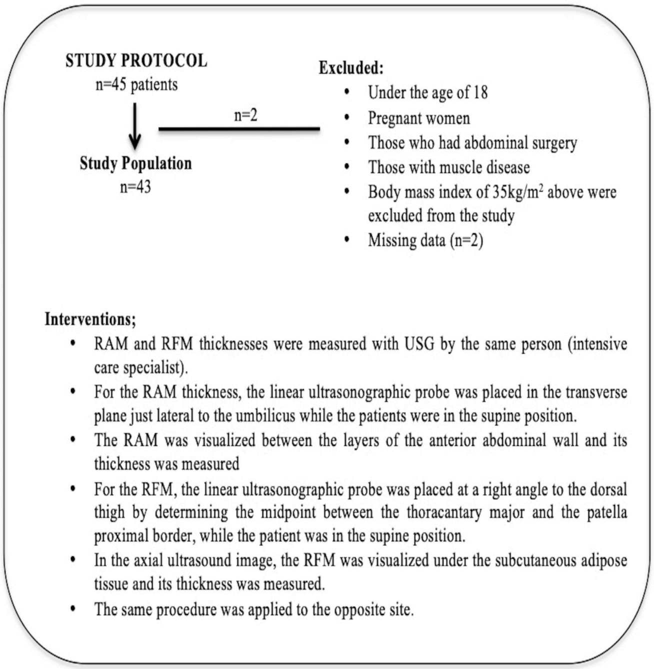

Figure 1 Flow chart displaying selective and exclusive process of patients in the current study. RAM, rectus abdominis muscle; RFM, rectus femoris muscle; USG, ultrasonography.

examining the changes in the amount of muscle and fat in the follow-up of the nutritional therapy of critically ill patients in the ICU. Considering that the most important step in the treatment of malnutrition is to recognise the malnutrition or to determine the risk, it will play a critical role in the treatment to seek an ideal test that can identify malnutrition both sensitively and specifically.

The aim of this study is to find a quantitative and practical evaluation method by determining the correlation of ultrasonographic measurement of rectus abdominis muscle (RAM) and rectus femoris muscle (RFM) thickness in critically ill patients in the ICU with the NRS-2002 and mNUTRIC score, which are scoring systems used to assess nutritional risk.

MATERIAL AND METHODS

Study design

After the approval of the Clinical Research Ethics Committee, patients aged 18 years and older who were hospitalised in Muğla Training and Research Hospital Anesthesia Intensive Care Units were included in the study. Those under the age of 18 years, pregnant women, those who had abdominal surgery, and those with muscle disease and body mass index of 35 kg/m^2 and above were excluded from the study (figure 1).

Age, gender, comorbidity, diagnosis of admission to the ICU, duration of ICU hospitalisation, presence and duration of mechanical ventilation and discharge status of all patients were recorded. Acute physiology and chronic health evaluation scoring system II (APACHE II), NRS-2002 and mNUTRIC scores were noted in the first 24 hours of ICU admissions. RAM and RFM thicknesses were measured with ultrasonography (USG) by the same person (intensive care specialist).

For the RAM thickness, the linear ultrasonographic probe was placed in the transverse plane just lateral to the umbilicus while the patients were in the supine position. The RAM was visualised between the layers of the anterior abdominal wall and its thickness was measured. The same procedure was applied to the opposite site.

For the RFM, the linear ultrasonographic probe was placed at a right angle to the dorsal thigh by determining the midpoint between the thoracantary major and the patella proximal border while the patient was in the supine position. In the axial ultrasound image, the RFM was visualised under the subcutaneous adipose tissue and its thickness was measured. The same procedure was applied to the opposite site.

All the patients grouped with a score of 3 and above for NRS-2002 were considered nutritionally risky, mNUTRIC scores between 5 and 9 were considered high risk, and those with 0–4 were considered low risk.

The measurement results obtained for RAM and RFM were recorded.

Statistical analysis

The sample size was calculated using the G*Power program to determine the minimum number of participants needed for the correlation analysis. Significance level α=0.05, power of the statistical test (Power 1−β=0.95) and medium effect size (0.5) were taken in the calculation. According to the power analysis, 45 patients were planned to be included in the study since the sample size should consist of at least 42 participants.

The data of the patients were analysed with the SPSS V.23.00 statistical package program. Descriptive statistics of the data were calculated as number, percentage distribution, mean and SD. The performance of RAM and RFM thickness in predicting nutritional risk was examined by receiver operating characteristic (ROC) curve analysis. In the presence of significant limit values, the sensitivity and specificity values of these limits were calculated. The findings were evaluated at the 95% CI and at the 5% significance level.

Patient and public involvement

Patients or the public have not been involved in the design, or conduct, or reporting of this trial.

RESULTS

Two of the 45 patients included in the study were excluded due to deficiencies in muscle measurements, and the results were evaluated on 43 patients. The mean age was 67.5±18.86 years, the mean number of ICU stays was 8.67±7.63 and the mean APACHE II score was 16.6±8.19. The reasons for admission to the ICU were 53.5% pneumonia, 14% head trauma, 9.3% sepsis and 23.3% other

Table 1 Patient demographic characteristics and results

Variables	Mean/frequency
Gender, n (%)	
Female	12 (27.9)
Male	31 (72.1)
Age, mean (SD)	67.51 (18.86)
APACHE II	
Mean (SD)	16.60 (18.86)
Minimum	4
Maximum	40
NRS-2002 score	
Mean (SD)	3.58 (1.05)
Minimum	1
Maximum	7
mNUTRIC	
Mean (SD)	4.18 (2.06)
Minimum	1
Maximum	8
ICU length of stay (day), mean (SD)	8.67 (7.63)
MV, n (%)	
No	14 (32.6)
IMV	22 (51.2)
NIMV	7 (16.3)
MV days, mean (SD)	7.51 (6.20)
Mortality, n (%)	16 (37.2)
Right RAM	
Mean (SD)	8.86 (2.87)
Minimum	4.30
Maximum	17.50
Left RAM	
Mean (SD)	9.03 (2.95)
Minimum	4.40
Maximum	19.30
Right RFM	
Mean (SD)	12.20 (3.37)
Minimum	6.20
Maximum	20.30
Left RFM	
Mean (SD)	11.60 (3.11)
Minimum	5.90
Maximum	19.70

APACHE II, acute physiology and chronic health evaluation scoring system II; ICU, intensive care unit; IMV, invasive mechanical ventilation; mNUTRIC, Modified Nutrition Risk in Critically ill; MV, mechanical ventilation; NIMV, non-invasive mechanical ventilation; NRS-2002, Nutritional Risk Screening 2002; RAM, rectus abdominis muscle; RFM, rectus femoris muscle.

reasons. While 32.6% (n=14) of the patients did not need mechanical ventilation support, 51.2% (n=22) were followed up with invasive mechanical ventilation support and 16.3% non-invasive mechanical ventilation support. The overall mortality was 37.2% (16 of 43). Other demographic data and parameters are given in table 1.

The mean score of NRS-2002 used in nutritional risk assessment was calculated as 3.53±1.05, and the mean score of mNUTRIC score was calculated as 4.18±2.06. When the patients were grouped according to their nutritional risks, it was determined that 95.3% (n=41) of patients were at risk in terms of nutrition in the evaluation made with NRS-2002. According to the mNUTRIC score, while 46.5% (n=20) of the patients were at high risk in terms of nutrition, 53.5% (n=23) were considered as low risk.

The performance of RAM and RFM thickness in determining nutritional status was evaluated by ROC analysis. Area under the ROC curve (AUROC), as assessed with mNUTRIC score, was 0.747 with 0.080 SE for right RAM, 0.736 with 0.078 SE for left RAM, 0.715 with 0.083 SE for right RFM and 0.712 with 0.087 SE for left RFM (figure 2 and table 2). Similar AUROCs were calculated for RAM and RFM thickness. When evaluated with NRS-2002, similar AUROCs were calculated for RFM and RAM values, but none of them were found to be statistically significant ($p>0.05$) (figure 3 and table 3).

In the nutritional risk comparison determined by mNUTRIC score, results for right RAM thickness were cut-off point of 8.15 cm, sensitivity of 78.3% and specificity of 70%. Results for left RAM thickness were cut-off point of 8.2 cm, sensitivity of 73.2% and specificity of 70.6%. Results for right RFM thickness were cut-off point of 11.5 cm, sensitivity of 51.2% and specificity of 48.8%; and results for left RFM thickness were cut-off point of 11.5 cm, sensitivity of 51.2% and specificity of 46.3%. Specificity and sensitivity percentages of RAM were found to be higher than RFM in determining nutritional status (table 4).

DISCUSSION

The results of our study showed that RAM and RFM thickness could be a useful parameter when compared with the mNUTRIC score to determine nutritional risk in the ICU.

Malnutrition is one of the most important problems in ICUs. While there may be malnutrition during admission to the ICU in critically ill patients, malnutrition may develop due to the critical illness in the period after admission. Malnutrition, which causes complications such as infection, multiple organ failure and prolonged mechanical ventilation, prolongs the duration of stay in the ICU, and increases mortality and morbidity. Therefore, early determination of the nutritional status of critically ill patients in the ICU and initiation of appropriate nutritional therapy are very important. Tests with clinical evaluations such as mNUTRIC score and NRS-2002, anthropometric, chemical and immunological parameters can be used to determine nutritional status and identify malnutrition. However, there is still no consensus on which method is the gold standard.

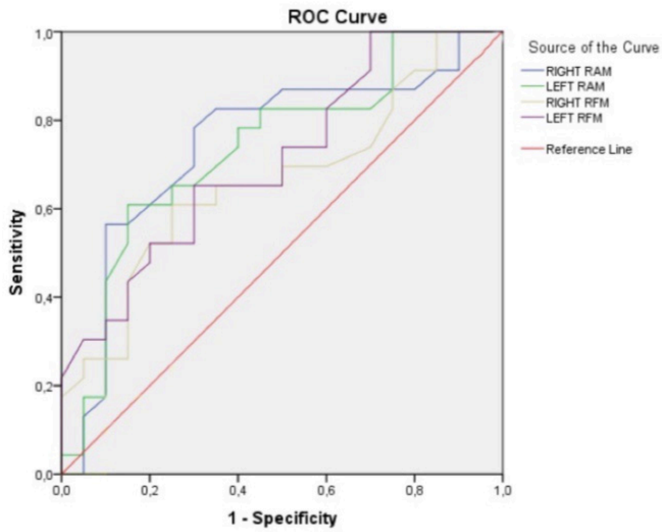

Figure 2 Receiver operating characteristic (ROC) curves displaying predictive value of RFM and RAM thickness with mNUTRIC score. mNUTRIC, Modified Nutrition Risk in Critically ill; RAM, rectus abdominis muscle; RFM, rectus femoris muscle.

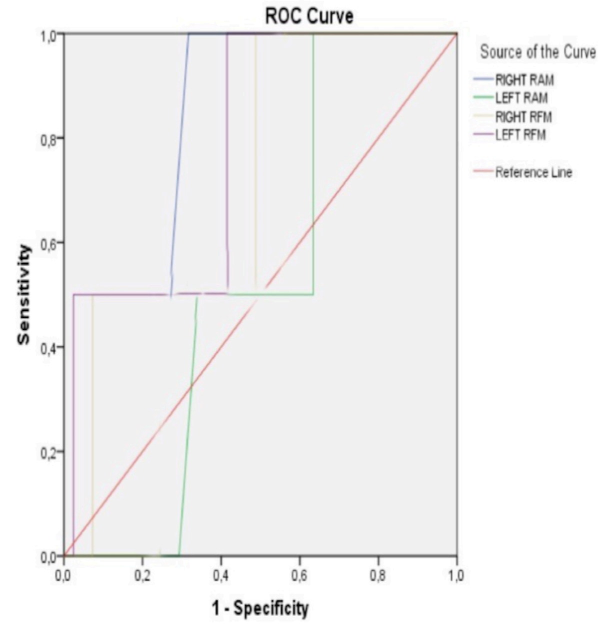

Figure 3 Receiver operating characteristic (ROC) curves displaying predictive value of RFM and RAM thickness with NRS-2002. NRS-2002, Nutritional Risk Screening 2002; RAM, rectus abdominis muscle; RFM, rectus femoris muscle.

The prevalence of malnutrition in ICUs varies between 20% and 50%.[8–10] Wang *et al* emphasised that they detected high incidences of malnutrition in surgical ICU patients in a large prospective observational study, and they found a high nutritional risk (mNUTRIC scores ≥5) in 28.2% of the patients in ICU admissions.[8] In another study, similar results were obtained in the postoperative ICU evaluation.[9] In our study, it was observed that 46.5%

Table 2 ROC curves for RFM and RAM compared with mNUTRIC score

Significance of right RAM ROC curve	
Area under the ROC curve (AUROC)	0.747
SD	0.080
95% CI	0.591 to 0.903
P value	0.006
Significance of left RAM ROC curve	
AUROC	0.736
SD	0.078
95% CI	0.583 to 0.889
P value	0.008
Significance of right RFM ROC curve	
AUROC	0.715
SD	0.083
95% CI	0.502 to 829
P value	0.044
Significance of left RFM ROC curve	
AUROC	0.712
SD	0.078
95% CI	0.559 to 865
P value	0.018

mNUTRIC, Modified Nutrition Risk in Critically ill; RAM, rectus abdominis muscle; RFM, rectus femoris muscle; ROC, receiver operating characteristic.

Table 3 ROC curves for RFM and RAM compared with NRS-2002

Significance of right RAM ROC curve	
Area under the ROC curve (AUROC)	0.732
SD	0.070
95% CI	0.594 to 0.870
P value	0.273
Significance of left RAM ROC curve	
AUROC	0.524
SD	0.132
95% CI	0.266 to 0.783
P value	0.908
Significance of right RFM ROC curve	
AUROC	0.720
SD	0.157
95% CI	0.412 to 1.00
P value	0.299
Significance of left RFM ROC curve	
AUROC	0.780
SD	0.147
95% CI	0.493 to 1.00
P value	0.185

NRS-2002, Nutritional Risk Screening 2002; RAM, rectus abdominis muscle; RFM, rectus femoris muscle; ROC, receiver operating characteristic.

Table 4 Diagnostic scanning tests for RAM and RFM

Diagnostic scanning tests for right RAM	
Cut-off	8.15
Sensitivity	78.3%
Specificity	70%
Diagnostic scanning tests for left RAM	
Cut-off	8.2
Sensitivity	73.2%
Specificity	70,6%
Diagnostic scanning tests for right RFM	
Cut-off	11.55
Sensitivity	51.2%
Specificity	48.8%
Diagnostic scanning tests for left RFM	
Cut-off	11.55
Sensitivity	51.2%
Specificity	46.3%

RAM, rectus abdominis muscle; RFM, rectus femoris muscle.

of the patients had a high nutritional risk according to the mNUTRIC score. This rate was found to be higher (95.3%) compared with NRS-2002 scores. Similar results are seen in many studies and nutritional risk is significantly higher in evaluations made with NRS-2002.[9 10] The fact that the results of the scoring systems frequently used in ICUs are so different can be considered as evidence of the inadequacy of evaluation methods in critically ill patients. Coltman *et al* showed that traditional screening and evaluation tools do not define patients who are undernourished or at risk in the ICU as a single type and therefore may not be suitable for use in ICU patients.[11] With the search for a reliable method, it was aimed to evaluate the performance of RAM and RFM thicknesses in determining nutritional risk.

It is known that malnutrition and inadequate protein intake cause serious problems in preserving muscle mass. During periods of starvation, the body's goal is to initially maintain lean muscle. While glycogen stores are used as the primary energy source, the increased time adapts to the breakdown of fat to ensure maximal protection of the muscles. In the case of increased stress with hunger, it causes negative nitrogen balance and rapid muscle loss.[12] Malnutrition, insufficient protein and energy intake, which are also involved in the pathophysiology of malnutrition and age-related sarcopenia, are held responsible for the loss of muscle mass.[13] In intensive care patients, this muscle loss begins in the early stages of critical illness (within hours after the onset of the disease) with the effect of hormones and mediators (catecholamines, cortisol, growth hormone, cytokines, etc).[12 14] Although muscle wasting is a part of the acute inflammatory process, immobilisation, age, drugs, comorbidities, pre-critical skeletal muscle function and condition are also related to the nutritional status of the pre-critical patient.[14] For this reason, information about the nutritional status of the patient can be obtained by evaluating the skeletal muscles in ICU hospitalisation of critically ill patients.

While the muscle loss that occurs in sarcopenia is discussed in more detail, and muscle evaluation in critically ill patients in the ICU is examined in the follow-up of nutritional status, there is still a debate about which skeletal muscle can be used.[12] The lower extremity muscles are more prone to early atrophy because they carry weight compared with the upper extremity muscles, fat and muscle loss can be noticed even with palpation, as the upper trunk muscles are less affected by oedema.[12] It has been found that the upper body muscles reflect the general muscle mass in a better way.[15] Temporalis, pectoralis, trapezius, deltoideus, gastrocnemius, supraspinatus and infraspinatus muscles are used to evaluate muscle loss among the other muscles.[16] Large muscle groups such as the RFM, RAM or quadriceps muscles are more preferred in the follow-up due to fewer errors during measurement.[7] We preferred RFM and RAM, which are more prone to atrophy and have a clear relationship with nutrition in determining nutritional risk in our study. In addition, evaluation of RAM and RFM with USG can be done in the supine position without the need for any position. Their anatomical placement provides practical imaging of the muscles with USG.

Puthucheary *et al* examined muscle loss in the quadriceps region and correlated the loss with the catabolic state resulting from decreased protein synthesis and increased muscle breakdown.[17] According to Detsky *et al*, the evaluation of deltoid and quadriceps muscles is clinically significant to determine muscle loss.[18] Four muscle groups including rectus abdominis, biceps, rectus femoris and tibialis anterior muscles were examined in the first 24 hours of admission to the ICU by Bulinski *et al*. They emphasised that very early changes occur in all the evaluated muscles and that these changes can lead to difficulty in weaning patients.[19] In another study, muscle mass of ICU patients was followed by USG and it was found that muscle mass was negatively correlated with ICU stay. It was concluded that the first 2–3 weeks in the ICU is the period in which muscle loss is most common.[20] In the light of studies showing that loss of muscle mass is evident in the first weeks in the ICU, early and serial evaluation of these patients is very important.[11] Considering that the first step of malnutrition treatment is to determine the nutritional risk, the availability of a safe, practical, bedside and cost-effective method has a critical importance in the ICU.

In our study, the nutritional status determined by mNUTRIC score was compared with RAM and RFM thicknesses; AUROCs were found to be >0.7 and it was concluded that RAM and RFM muscle could be used to determine nutritional status in our study. When the sensitivity and specificity percentages are examined, it has been shown that RAM is more reliable than RFM. Because it is a practical and easily applicable method at the bedside, RFM and RAM thickness will provide ease of use in clinical practice.

This study has a few limitations. The first of these is that the study was conducted in a single centre and in a single ICU. Since a specific ICU was not selected, patients' ICU admission diagnoses vary. Due to the increasing muscle loss with age, the specificity of the study for different age groups may reveal the reason for the difference in specificity and sensitivity between RFM and RAM. We think that subgroup analyses should be done by increasing the number of patients participating in the study.

As a result, RFM and RAM measurement with USG is a practical and reliable method that can be applied at the bedside in the ICU. We thought that since traditional screening and evaluation tools are not reliable in ICU patients, adding the evaluation of muscle mass by USG to the currently used methods will enable clinicians to obtain more accurate and reliable results.

Contributors Guarantor—CG. Conceived the study—CG and AA. Formal analysis—CG, AA, EKÇ and EK. Writing (original draft preparation)—CG, HOY and TÇ. Writing (reviewing and editing)—CG, HOY and TÇ. All authors have read and agreed to the final version of the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval This study involves human participants and was approved by Muğla Sıtkı Koçman University Clinical Research Ethics Committee (number: 08/10/2022-16/VIII). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

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