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Acute muscle wasting rate assessment and long-term mortality in critically ill trauma

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Running title: Acute muscle wasting rate in trauma

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ABSTRACT

Background and Objectives: To evaluate the relationship between acute muscle wasting rate and long-term mortality in critically ill trauma. Methods and Study Design: A single-center, retrospective study was conducted in critically ill trauma. Patients with Computed Tomography scans including the L3 vertebra within 24 hours and 1 week after trauma were recruited. Acute muscle wasting rate was defined as the mean percent variation per day of skeletal muscle index in the first week after trauma. Multivariate logistic regression analysis and receiver operating characteristic curve analysis were performed to determine whether acute muscle wasting rate could help predict hospital malnutrition and 1-year mortality. **Results:** Skeletal muscle index was 49.3 ± 10.7 cm²/m² at baseline and decreased to 45.1 ± 9.6 cm^2/m^2 (p<0.001) at 1 week and 39.8±10.8cm²/m² (p<0.001) at 1 month after trauma. A sustained decrease of skeletal muscle index was observed from baseline up to 6 months $(33.7\pm8.4 \text{ cm}^2/\text{m}^2, p<0.001)$ post trauma, and lasted for 1 year $(37.7\pm5.6 \text{ cm}^2/\text{m}^2, p=0.004)$. Logistic regression analysis showed that acute muscle wasting rate was an independent risk factor for hospital malnutrition and 1-year mortality. Every 1% absolute increase of acute muscle wasting rate was associated with 1.82-fold higher odds of 1-year mortality in critically ill trauma. The area under curve of acute muscle wasting rate was 0.813 for hospital malnutrition prediction and 0.715 for 1-year mortality prediction. Conclusions: Acute muscle wasting rate was independently associated with higher 1-year mortality and hospital malnutrition in critically ill trauma.

Key Words: skeletal muscle, nutrition, mortality, trauma, critically ill

INTRODUCTION

Low skeletal muscle mass at admission was significantly associated with prolonged mechanical ventilation, increased ICU length of stay (LOS) and mortality in critically ill.^{1,2} Previously published studies reported that approximately 36-86% of critically ill patients suffered skeletal muscle atrophy.^{3,4,5} In trauma, the prevalence of skeletal muscle atrophy was about 30-50%.^{6,7} Decreased skeletal muscle index (SMI) assessed at the level of the 3rd lumbar (L3) vertebra derived from computed tomography (CT) scans was an independent risk factor for prolonged hospitalization and increased short-term mortality in trauma patients.^{8,9} However, skeletal muscle mass at baseline is an indicator of physiological reserve, but cannot reflect the severity of catabolism caused by diseases.

Intense catabolism occurring with critically ill patients result in acute skeletal muscle wasting,¹⁰ which is one of the typical symptoms and diagnostic criteria for malnutrition.¹¹ The longitudinal changes of acute muscle mass loss in critical illness have been demonstrated in several studies, which revealed that the cross-sectional area of the upper and lower limb muscles decreased significantly by 12.5-18.5% in the first week.^{12,13,14} A recent meta-analysis which included 3251 patients concluded that critically ill patients lost approximately 2% of muscle mass per day during the first week of ICU admission, by different assessment methods such as ultrasound or CT.¹⁵ However, there was less evidence for acute muscle wasting to predict mortality in critically ill. In mechanically ventilated patients, every 1% loss of quadriceps muscle layer thickness over the first week was associated with 5% higher odds of 60-day mortality.¹⁶ A threshold of 1.84% decline per day of psoas muscle was identified for survival prediction in critically ill COVID-19 patients recently.¹⁷ Interestingly, our previous work suggested that the acute change rates of SMI were not associated with 90-day mortality in abdominal trauma patients, while the change rate of SMI over 3 weeks was a significant predictor of 90-day mortality.¹⁸

However, no study has considered the relationship between acute skeletal muscle wasting and long term mortality in the critically ill. In addition, the cutoff value of acute skeletal muscle wasting for the diagnosis of malnutrition is still unclear. The present study explored whether acute muscle wasting rate is associated with new onset hospital malnutrition and long-term mortality in critically ill trauma.

MATERIALS AND METHODS

Study design

A single-center, retrospective, longitudinal observational study was conducted with critically ill trauma patients admitted to Intensive Care Unit (ICU) of Nanjing Drum Tower Hospital from January 1, 2018, to December 31, 2021. This cohort study was approved by the Hospital Ethics Review Board (Internal registration number: 2022-476-01).

Study population

Trauma patients who were admitted to ICU between January 2018 and December 2021 were recruited for this retrospective observational study. Critically ill trauma was defined according to the new Berlin criteria of polytrauma.¹⁹ Eligibility criteria were: 1) 18 years old or over; 2) Injury Severity Score (ISS) was 16 points or greater; 3) Length of hospital stay was more than 7 days; 4) CT scans including the L3 vertebra were performed within 24 hours and 1 week (6-8 days) after trauma, respectively. Exclusion criteria were: 1) Cachexia before trauma; 2)

Missing clinical data; 3) Unclear differentiation between muscle and surrounding tissue in CT image.

Data collection

Patient demographics and baseline clinical data were collected. Clinical outcomes involved new onset malnutrition in hospital, sepsis in hospital, requirement for mechanical ventilation, vasopressor, continuous renal replacement therapy, hospital LOS, ICU LOS, and 30-day, 60-day, 90-day, 1-year mortality. Hospital malnutrition was defined according to the Global Leadership Initiative on Malnutrition (GLIM) criteria,¹¹ excluding skeletal muscle measures. The Sepsis-3 definition was used to diagnose sepsis.²⁰

Muscle mass measurement

Skeletal muscle area (SMA) was assessed at the cross section of L3 vertebra derived from CT scans, including the psoas major, erector spinae, quadratus lumborum, transversus abdominis, external oblique and internal oblique muscles. Regions of Interest were demarcated using thresholds -29 to + 150 Hounsfield units (HU) for muscle tissue, and the boundaries were corrected manually if necessary. The average SMA measured from three physicians was used as the result. SMI (cm²/m²) was equal to SMA in cm² divided by the square of height in metres. Acute muscle wasting rate (Δ SMI%) reflects the mean percent variation per day of SMI in the first week after trauma, and the formula is as follows:

 Δ SMI% = (Baseline SMI - SMI at 1 week)/(Baseline SMI × days between 2 CT scans) × 100%

Statistical analyses

Statistical analyses were performed using SPSS version 26 software (IBM, Inc., Armonk, NY, USA). *p*-values below 0.05 and 95% confidence intervals (CI) not containing 1 were considered statistically significant. Descriptive statistics for all numeric variables were presented as median and interquartile range (IQR) or mean and standard deviation (mean±SD). Data were compared using the t-test or Mann-Whitney U test, as appropriate. Proportions were compared using Chi square tests. Paired two-sample t tests were performed to compare SMI on baseline, 1 week, 1 month, 6 months and 1 year after trauma, respectively. Multivariate logistic regression models were created to evaluate the effects of independent variables on hospital malnutrition and 1-year mortality in critically ill trauma patients. The

receiver operating characteristic (ROC) analysis was conducted to explore the sensitivity and specificity of Δ SMI% for hospital malnutrition and 1-year mortality prediction. Youden index was calculated to determine a potential cut-off value for Δ SMI%.

RESULTS

Patient baseline data

From January 2018 to December 2021, a total of 742 patients with critically ill trauma were retrospectively enrolled, of whom 598 patients were excluded and 144 met the selection criteria for analysis (Figure 1). Overall, the median age was 51 (36, 58) years with 84.0% (n=121) male. The median scores of Acute Physiology and Chronic Health Evaluation II (APACHE II), Sequential Organ Failure Assessment (SOFA), Nutrition Risk in Critically Ill (NUTRIC), Injury Severity Score (ISS) were 14, 5, 4, and 30.5, respectively. The most frequently injured sites were the abdomen (87.5%), followed by the chest (61.8%), head and neck (31.9%). Causes of trauma were traffic accident (65.3%), fall (19.4%), industrial machine (9.7%), sports (4.2%) and assault (1.4%). More than half of the patients had surgery within 24 hours of trauma (Table 1).

Outcomes

During hospitalization, 63.2% of the patients suffered from hospital malnutrition, 79.9% were diagnosed with sepsis, and 70.8% underwent surgery under general anesthesia. The median duration of mechanical ventilation (56.9%), vasopressor (33.3%), CRRT (16.0%), hospital and ICU length of stay were 9 (4, 14), 3 (2,6), 7 (4, 17), 31 (18, 46) and 17.5 (7, 30) days, respectively. The mortality rates at 30 days, 60 days, 90 days and 1 year after trauma were 4.2%, 10.4%, 18.1% and 22.9%, respectively (Table 2).

Changes of SMI in patients with critically ill trauma

Trauma patients exhibited acute and persistent muscle wasting. SMI at baseline was $49.3\pm10.7 \text{ cm}^2/\text{m}^2$ and decreased to $45.1\pm9.6 \text{ cm}^2/\text{m}^2$ at 1 week after trauma (p<0.001), the acute muscle wasting rate (Δ SMI%) was 1.16 ± 1.41 %. In 101 patients with CT scans at 1 month after trauma, SMI was $39.8\pm10.8\text{cm}^2/\text{m}^2$ and decreased from baseline by 18.7% (p<0.001) (Figure 2). CT scans were performed at 6 months and 1 year after trauma in few patients. With limited data, we observed a sustained decrease in SMI from baseline up to 6 months ($42.9\pm4.6 \text{ cm}^2/\text{m}^2$ vs. $33.7\pm8.4 \text{ cm}^2/\text{m}^2$, p=0.004) (Figure 2).

Acute muscle wasting rate(Δ SMI%) and hospital malnutrition

Compared to well-nourished patients, critically ill trauma patients who developed malnutrition in hospital were characterized by higher BMI (23.5±3.0 vs. 22.4±2.7, p=0.027), APAHCE II scores (16.1±7.7 vs. 13.0±8.7, p=0.030), lymphocyte counts (1.1±1.0 vs. 0.8±0.5, p=0.028) and Δ SMI% (1.67±1.32 vs. 0.28±1.12, p=0.000), prolonged hospital stays (45.0±29.5 vs. 25.1±21.7, p=0.000) and ICU stays (26.6±22.8 vs. 14.8±16.8, p=0.001), increased 90-day (23.1% vs. 9.4%, p=0.040) and 1-year (31.9% vs. 13.2%, p=0.034) mortality (Table 3).

Binomial Logistic regression analysis showed that male (OR=5.111, 95% CI 1.468-17.800, p=0.010) and Δ SMI% (OR=2.892, 95%CI 1.895-4.416, p<0.001) were independent risk factors for hospital malnutrition (Table 4).From ROC curve analysis, the area under curve (AUC) of Δ SMI% for hospital malnutrition prediction was 0.813 (95%CI 0.740-0.887, p<0.001), and the optimal cut-off value was 0.687 with a sensitivity of 83.5% and a specificity of 71.7% (Table 5, Figure 3).

Acute muscle wasting rate ($\Delta SMI\%$) and mortality

ROC curve analysis showed that Δ SMI% was a good predictor for 1-year mortality with AUC 0.715 (95% CI 0.581-0.849, *p*=0.001), and the optimal cut-off point derived from the ROC curve for Δ SMI% was 1.968 with a sensitivity of 62.5% and specificity of 83.3% (Figure 3). However, ROC curve analysis did not verify the predictive value of Δ SMI% for 30-day, 60-day, 90-day mortality (Table 5).

Compared with patients who were alive at 1 year after trauma, those who died within 1 year had higher baseline SOFA scores (7.4±4.0 vs. 5.1 ± 3.6 , p=0.006) and Δ SMI% (2.11±1.86 vs. 0.97±1.22, p=0.007) (Table 6). In multiple logistic regression, after adjustment for selected predictors of 1-year mortality, baseline SOFA score (OR=1.163, 95%CI 1.023-1.310, p=0.013) and Δ SMI% (OR=1.817, 95%CI 1.279-2.581, p=0.001) were independent risk factors. However, the baseline SMI was not significantly associated with 1-year mortality (Table 7).

DISCUSSION

The novel finding of this retrospective study is that acute skeletal muscle wasting quantified as Δ SMI%, was useful for prediction of 1-year mortality in critically ill trauma. Every 1% absolute increase of Δ SMI% was associated with 1.82-fold higher odds of 1-year mortality.

To our knowledge, this is the first study to investigate the relation between CT-derived markers for acute muscle wasting and long-term mortality in the critically ill.

Skeletal muscle mass is considered an important physiologic reserve in the critically ill.²¹ Sarcopenia at baseline, as well as low muscle mass, was closely associated with poor prognosis and high disease related burden. Different cutoff levels for CT-derived SMI at the level of L3 vertebra were set according to age, gender and regions to define sarcopenia.^{22,23,24,25} Therefore, SMI less than the reference values means that there are insufficient energy and protein reserves to negotiate critical illness, with resultant prolonged hospital stay and increased mortality. However, SMI at baseline cannot reflect the severity of catabolism caused by diseases and adequately capture individual risk.²² It is well documented that muscle wasting occurs rapidly due to excessive catabolism in the critically ill, and is exacerbated thereafter during the ICU stay. Daily muscle wasting rate in the first week after trauma, abbreviated as Δ SMI%, is a good indicator of body composition change in response to metabolic stress, and reflects the severity of skeletal muscle atrophy in the acute phase. Our study showed that Δ SMI% was a good predictor for 1-year mortality with AUC 0.715 (95%) CI 0.581-0.849), and that 1-year mortality increased by 1.82 times for every 1% absolute loss of SMI per day over the first week. However, the baseline SMI was not significantly associated with 1-year mortality.

The overall fatality rate of patients with severe trauma during hospitalization was 6.4%-27.2%.^{26,27} Malnutrition increased mortality chances 1.96 times in critically ill trauma patients.²⁸ In this study, the 90-day and 1-year mortality rate was significantly higher in severe trauma patients with hospital malnutrition than those without malnutrition. It was suggested that hospital malnutrition was strongly associated with long-term mortality in trauma. Additionally, our study showed that Δ SMI% was a good predictor for evaluating newly onset malnutrition during hospitalization, with an optimal cut-off value of 0.7%. It provided a novel insight into early recognition of potential malnutrition in acute and critical illness. Therefore, we propose that Δ SMI% can be used as an assessment tool for evaluating the nutritional status in the critically ill.

Our study also demonstrated the longitudinal changes of SMI over a year. In the first week after trauma, CT-derived SMI decreased by 8.5% compared with baseline. However, it has previously been reported that skeletal muscle area measured by ultrasound significantly reduced by up to 18.5% in critically ill patients during the first week of hospitalization.¹⁴ As is known, CT is a gold standard technique for assessment of skeletal muscle mass,²⁹ and that there is a good correlation between ultrasound and CT in assessing skeletal muscle mass and

its rate of change, whereas the change rates for muscle mass measured by CT seem lower than those from ultrasound in general.^{13,15} Further research is needed to explore these differences and identify the reasons.

The decline of skeletal muscle mass in the critically ill occurs quickly and lasts for a long period of time.¹⁷ The short-term changes of muscle mass measured with CT or ultrasound have been described in several studies.¹⁵ However, the follow-up data for long-term changes of skeletal muscle mass among ICU survivors are rare. Sepsis patients exhibited persistent muscle wasting with an 8.4% decrease at 3 months and a 2.9% decrease at 1 year in SMI from baseline.³⁰ Critically ill trauma patients were worse off in the present study, with an 18.7% decrease in SMI at 1 month, 21.8% decrease at 6 months and a 11.7% decrease at 1 year from baseline. The trough of muscle mass was between 1 month and 6 months after trauma. Although the sample size was relatively small, these findings may provide insights into long-term skeletal muscle wasting in critical illness.

Limitations

Our study had several limitations. First, the single-center retrospective observational study design introduced the risk of bias and residual confounding. Second, the number of CT scans was limited due to the retrospective nature. Cases were deleted because they could not meet the eligibility criteria that 2 CT scans with an interval of more than 5 days in the first week were performed. The long-term variation in SMI is not convincing on account of data limitation. Third, nutrition intake and physical exercise during hospital stay and post-discharge were not considered in this study. Finally, although CT is considered a gold standard technique for assessment of skeletal muscle mass, ultrasound of skeletal muscle avoids the hazards of transportation and extra radiation exposure. It is not clear whether our findings would be supportable using ultrasound.

Conclusions

Skeletal muscle wasting occurred in the acute phase of trauma, and baseline muscle mass might not be fully restored a year after trauma. Acute skeletal muscle wasting rate, as assessed by Δ SMI%, was independently associated with a higher 1-year mortality and hospital malnutrition in critically ill trauma. Every 1% absolute increase of Δ SMI% was associated with 1.82-fold higher odds ratio for 1-year mortality in critically ill trauma. The area under the curve of Δ SMI% was 0.813 for the hospital malnutrition prediction and 0.715 for the 1-year mortality prediction. Future research should explore the relationship between

acute muscle wasting rate and mortality in prospective studies with a larger sample size, in other populations, and with different methods for assessment of skeletal muscle mass. Furthermore, interventions to reduce acute skeletal muscle wasting, so reducing mortality in critically ill, await study.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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Characteristics	Value
n	144
Age, years [median (IQR)]	51 (36, 58)
Gender, n (%)	
Male	121 (84.0)
Female	23 (16.0)
BMI, kg/m ²	23.1±2.9
APACHE II, [median (IQR)]	14 (9, 19.75)
SOFA, [median (IQR)]	5 (3, 8)
NUTRIC, [median (IQR)]	4 (3, 5)
ISS, [median (IQR)]	30.5 (22, 40.25)
Operation within 24 hours, n (%)	82 (56.9)
Injured sites , n (%)	
Head and neck	46 (31.9)
Chest	89 (61.8)
Abdomen	126 (87.5)
Spine	40 (27.8)
Pelvis	30 (20.8)
Limbs	28 (19.4)
Cause, n (%)	
Traffic accident	94 (65.3)
Fall	28 (19.4)
Industrial machine	14 (9.7)
Sports	6 (4.2)
Assault	2 (1.4)
Laboratory results at admission	12.8 . 6 4
WBC, $\times 10^{9}$ /L	13.8 ± 0.4
Lymphocyte, $\times 10^{9}/L$	1.0 ± 0.8
Hemoglobin, g/L	109.0 ± 24.7
Platelet, $\times 10^{9}/L$	155.4 ± 91.3
Total Bilirubin, µ mol/L	30.5 ± 42.4
Albumin, g/L	31.7 ± 5.5
Creatinine, µ mol/L	84.0 ± 44.9
Fibrinogen, g/L	3.6 ± 8.9
CRP, mg/L	98.3 ± 80.3
PCT, ng/mL	5.8 ± 14.2

Table 1. Baseline clinical and demographic characteristics of the critically ill trauma patients

BMI, body mass index; APACHE II, Acute Physiology and Chronic Health Evaluation II; SOFA, Sequential Organ Failure Assessment; NUTRIC, Nutrition Risk in Critically III; ISS, Injury Severity Score; WBC, white blood cell; CRP, C-reactive protein; PCT, procalcitonin

Table 2. Outcomes of the critically ill trauma patients

Outcomes	Value	
MV, n (%)	82 (56.9)	
MV days, median (IQR)	9 (4, 14)	
VA, n (%)	48 (33.3)	
VA days, median (IQR)	3 (2, 6)	
CRRT, n (%)	23 (16.0)	
CRRT days, median (IQR)	7 (4, 17)	
Sepsis, n (%)	115 (79.9)	
Surgical operation, n (%)	102 (70.8)	
Malnutrition, n (%)	91 (63.2)	
Hospital LOS, median (IQR)	31 (18, 46)	
ICU LOS, median (IQR)	17.5 (7, 30)	
30-day mortality, n (%)	6 (4.2)	
60-day mortality, n (%)	15 (10.4)	
90-day mortality, n (%)	26 (18.1)	
1-year mortality, n (%)	33 (22.9)	

MV, Mechanical ventilation; VA, Vasopressor; CRRT, Continuous Renal Replacement Therapy; LOS, Length of Stay.

Characteristics	Malnourished	Well-nourished	р	
	(n=91)	(n=53)		
Age, years [median (IQR)]	51 (38, 58)	50 (36, 58)	0.720	
Gender			0.076	
Male, n (%)	72 (79.1)	48 (90.6)		
Female, (%)	19 (20.9)	5 (9.4)		
BMI, kg/m ²	23.5 ± 3.0	22.4 ± 2.7	0.027	
APACHE II, [median (IQR)]	15 (10, 21)	10 (6, 18)	0.011	
SOFA, [median (IQR)]	5 (3,8)	4 (2, 7)	0.118	
NUTRIC, [median (IQR)]	4 (3, 5)	4 (2, 5)	0.283	
ISS, [median (IQR)]	33 (24, 41)	27 (17, 34)	0.058	
Laboratory tests at admission				
WBC, $\times 10^{9}/L$	14.0 ± 6.6	13.4 ± 6.0	0.640	
Lymphocyte,×10 ⁹ /L	1.1 ± 1.0	0.8 ± 0.5	0.028	
Hemoglobin, g/L	107.1 ± 25.5	112.2 ± 23.2	0.234	
Platelet, $\times 10^{9}$ /L	152.8 ± 99.8	159.7 ± 75.1	0.666	
Total bilirubin,µmol/L	32.5 ± 49.6	27.0 ± 25.9	0.454	
Albumin, g/L	32.0 ± 5.6	31.1 ± 5.4	0.363	
Creatinine,µmol/L	84.9 ± 42.4	82.6 ± 49.3	0.773	
Fibrinogen, g/L	2.8 ± 1.7	4.9 ± 14.5	0.191	
CRP, mg/L	107.4 ± 85.0	82.8 ± 69.5	0.076	
PCT, ng/mL	6.6 ± 14.2	4.5 ± 14.2	0.407	
Skeletal muscle index (cm ² /m ²)				
Baseline	50.1 ± 11.3	47.8 ± 9.4	0.198	
1 Week	44.1 ± 10.2	46.8 ± 8.2	0.095	
ΔSMI (%)	1.67 ± 1.32	0.28 ± 1.12	< 0.001	
Outcomes	<i>w</i> •			
MV, n (%)	57 (62.6)	25 (47.2)	0.071	
VA, n (%)	33 (36.3)	15 (28.3)	0.328	
CRRT, n (%)	17 (18.7)	6 (11.3)	0.245	
Hospital LOS, [median (IQR)]	36 (23, 52)	19 (13, 32)	< 0.001	
ICU LOS, [median (IQR)]	23 (9, 32)	10 (5.5, 20)	0.003	
Mortality				
30-day, n (%)	3 (3.3)	3 (5.7)	0.801	
60-day, n (%)	11 (12.1)	4 (7.5)	0.564	
90-day, n (%)	21 (23.1)	5 (9.4)	0.040	
1-year, n (%)	26 (31.9)	7 (13.2)	0.034	

Table 3. Characteristics of the critically ill trauma patients malnourished and well-nourished

BMI, body mass index; APACHE II, acute physiology and chronic health evaluation II; SOFA, sequential organ failure assessment; NUTRIC, nutrition risk in critically ill; ISS, Injury Severity Score; WBC, white blood cell; CRP, C-reactive protein; PCT, procalcitonin; Δ SMI(%), acute muscle wasting rate per day in the first week; MV, Mechanical ventilation; VA, Vasopressor; CRRT, Continuous Renal Replacement Therapy; LOS, Length of Stay

Table 4. Logistic regression analysis on risk factors of hospital malnutrition in the critically ill trauma patients

	β	S.E.	Wald	OR	95%CI	р
Age						0.905
Male	1.631	0.637	6.566	5.111	1.468-17.800	0.010
BMI						0.063
APACHE II						0.330
ISS						0.389
Lymphocyte	0.716	0.370	3.748	2.046	0.991-4.225	0.053
CRP						0.292
SMI						
Baseline						0.403
$\Delta SMI(\%)$	1.062	0.216	24.206	2.892	1.895-4.416	< 0.001

BMI, body mass index; APACHE II, acute physiology and chronic health evaluation II; ISS, Injury Severity Score; CRP, C-reactive protein; SMI, Skeletal muscle index; ΔSMI (%), acute muscle wasting rate per day in the first week

Table 5. ROC analysis for Δ SMI (%) to predict hospital malnutrition and mortality

Predicted value	AUC	95%CI	р	Sensitivity	Specificity	Youden's	Cut-off	
						index		
Hospital	0.813	0.740-0.887	< 0.001	0.835	0.717	0.552	0.678	
malnutrition						4		
30-day mortality	0.495	0.186-0.805	0.967					
60-day mortality	0.606	0.396-0.816	0.225					
90-day mortality	0.623	0.462-0.785	0.091	0.500	0.794	0.294	1.968	
1-year mortality	0.715	0.581-0.849	0.001	0.625	0.833	0.458	1.968	
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ROC, receiver operating characteristic curve; AUC, area under curve; CI, confidence interval

Characteristics	Survived	Died	р
	(n=111)	(n=33)	-
Age, years	51 (36, 58.8)	49 (36.5, 57.8)	0.582
Gender			
Male, n (%)	101 (84.2)	20 (83.3)	0.919
Female, (%)	19 (15.8)	4 (16.7)	
BMI, kg/m ²	22.9 ± 2.7	24.1 ± 3.5	0.118
APACHE II	14.4 ± 8.2	17.7 ± 7.9	0.075
SOFA	5.1 ± 3.6	7.4 ± 4.0	0.006
NUTRIC	3.8 ± 1.7	4.5 ± 1.5	0.104
ISS	30.1 ± 11.4	31.3 ± 9.5	0.686
Laboratory tests at admission			
WBC, ×10 ⁹ /L	13.5 ± 6.3	15.1 ± 6.6	0.268
Lymphocyte, ×10 ⁹ /L	1.0 ± 0.8	1.0 ± 0.9	0.906
Hemoglobin, g/L	109.5 ± 25.8	106.5 ± 18.8	0.583
Platelet, $\times 10^9$ /L	156.7 ± 95.3	148.6 ± 68.5	0.693
Total Bilirubin, µmol/L	28.6 ± 41.5	40.0 ± 46.6	0.231
Albumin, g/L	31.6 ± 5.4	32.3 ± 6.3	0.578
Creatinine, µmol/L	82.2 ± 45.0	93.3 ± 44.5	0.271
Fibrinogen, g/L	3.6 ± 9.7	3.5 ± 1.7	0.967
CRP, mg/L	92.7 ± 77.1	126.5 ± 91.8	0.060
PCT, ng/mL	5.7 ± 14.2	6.6 ± 14.5	0.773
Skeletal muscle index (cm ² /m ²)			
Baseline	48.6 ± 10.7	52.6 ± 10.3	0.095
1 Week	45.2 ± 9.9	44.4 ± 7.7	0.678
$\Delta SMI(\%)$	0.97 ± 1.22	2.11 ± 1.86	0.007

Table 6. Characteristics of the critically ill trauma patients survived or died over 1 year after trauma

BMI, body mass index; APACHE II, acute physiology and chronic health evaluation II; SOFA, sequential organ failure assessment; NUTRIC, nutrition risk in critically ill; ISS, Injury Severity Score; WBC, white blood cell; CRP, C-reactive protein; PCT, procalcitonin; Δ SM I(%), acute muscle wasting rate per day in the first week

Table 7. Logistic regression analysis on risk factors of 1-year mortality in critically ill trauma

	β	S.E.	Wald	OR	95%CI	р
Age						0.368
Male						0.906
BMI						0.513
APACHE II						0.679
SOFA	0.151	0.061	6.178	1.163	1.023-1.310	0.013
NUTRIC						0.918
CRP						0.428
SMI (Baseline)						0.638
$\Delta SMI(\%)$	0.597	0.179	11.106	1.817	1.279-2.581	0.001

BMI, body mass index; APACHE II, acute physiology and chronic health evaluation II; SOFA, sequential organ failure assessment; NUTRIC, nutrition risk in critically ill; CRP, C-reactive protein; SMI, Skeletal muscle index; Δ SMI (%), acute muscle wasting rate per day in the first week





Figure 2. Short-term (A) and long-term (B) changes of SMI in the critically ill trauma patients. (A) SMI at baseline was 49.3 ± 10.7 cm²/m² and decreased to 45.1 ± 9.6 cm²/m² at 1 week after trauma (p<0.001). In 101 patients with CT scans at 1 month after trauma, SMI descended to 39.8 ± 10.8 cm²/m² comparing to baseline (p<0.001). (B) SMI decreased continuously from baseline up to 6 months (42.9 ± 4.6 cm²/m² vs. 33.7 ± 8.4 cm²/m², p<0.001) after trauma in 15 patients and lasted for at least 1 year (42.9 ± 5.3 cm²/m² vs. 37.7 ± 5.6 cm²/m², p=0.004) in 11 patients.



Figure 3. ROC analysis for Δ SMI (%) in predicting hospital malnutrition and 1-year mortality. (A) The area under curve of Δ SMI% for hospital malnutrition prediction was 0.813 (95% CI 0.740-0.887, *p*<0.001), and the optimal cut-off value was 0.687 with a sensitivity of 83.5% and a specificity of 71.7%. (B) The area under curve of Δ SMI% for 1-year mortality prediction was 0.715 (95% CI 0.581-0.849, *p*=0.001), and the optimal cut-off value was 1.968 with a sensitivity of 62.5% and a specificity of 83.3%.

