Original Article

Sarcopenia associated with 90-day readmission and overall survival after abdominal trauma

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Background and Objectives: It is widely recognized that sarcopenia increases postoperative complications in trauma patients. However, the effects on prognosis remain unclear. This study aimed to evaluate the impact of sarcopenia on 90-day readmission and overall survival (OS) in abdominal trauma patients. **Methods and Study Design:** 485 consecutive patients who underwent abdominal surgery after trauma in our institution were enrolled. Sarcopenia was diagnosed with low muscle mass and low muscle strength-handgrip. Multivariate logistic regression analysis was performed to identify factors that contributed to 90-day readmission and OS. Cox logistic regression analysis was used to assess the relationship between sarcopenia and OS. **Results:** Sarcopenia was present in 120 of 485 patients (24.7%) with abdominal trauma within one week after admission based on the diagnostic cut-off values (40.9 cm^2/m^2 for men and 36.8 cm^2/m^2 for women). 90-day readmission was significantly higher in the sarcopenia group (p=0.019), and OS lower in the sarcopenia group (p=0.025). Sarcopenia was an independent predictor of 90-day readmission [odds ratio (OR): 5.34, 95% confidence interval (CI): 2.52-11.3]. **Conclusions:** Sarcopenia was associated with high 90-day readmission and low OS in abdominal trauma patients, and it was an independent risk factor for 90-day readmission.

Key Words: sarcopenia, skeletal muscle index, readmissions, trauma

INTRODUCTION

Trauma is one of the leading causes of death in the world. Every year, more than 5.8 million people die from trauma worldwide. Abdominal trauma accounts for nearly 6% of all injuries, and the overall case fatality rate is 8-25%.[1-3]

Severe trauma is often accompanied by visceral injury and multiple injuries, and recurrent hospitalization treatment such as pulmonary infection, abdominal abscess, hematoma, deep venous thrombosis or embolism, surgical site infection, or delayed hemorrhage may affect the patient's clinical prognosis.[4,5] Some researchers had identified age, Glasgow coma score, injury severity score, polytransfusion as predictive factors of mortality after trauma.[6,7] Sarcopenia has recently received clinical attention.[8] Because sarcopenia is associated with increased complications and mortality in critically ill, elderly trauma, surgery, and cancer patients, it is further considered an independent risk factor for these diseases.[9-13]

The readmission of trauma patients is common. Almost 19.6% of patients discharged from a hospital were readmissions within 30 days, and 34.0% were readmitted within 90 days. The most common reasons for readmission are heart failure, pneumonia, gastrointestinal bleeding, anastomotic disruption, postoperative infection.[14] Sarcopenia is considered as an independent risk factor for overall complications, pneumonia, catheter-associated urinary tract infections, and wound infections in trauma patients.[15-17] Although some literature had identified independent risk factors for readmissions in trauma patients,[18] little is known about sarcopenia's effect on readmission rates and overall survival (OS) in patients with abdominal trauma.

Therefore, this study aimed to investigate the relationship between sarcopenia and readmission and OS in a cohort of abdominal trauma patients and identify the risk factors for readmission of abdominal trauma patients.

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METHODS

Study design and participants

This is a retrospective cohort study of patients with abdominal trauma admitted to affiliated Jinling Hospital, Medical School of Nanjing University, between January 2010 to August 2019. We enrolled patients due to abdominal trauma who underwent abdominal Computed tomography (CT) scans within one week after admission and whose follow-up data was complete. Exclusion criteria: 1) Died in the hospital prior to discharge, 2) Inability to obtain abdominal CT data, 3) Failure to obtain follow-up data. This study was conducted at the Research Institute of General Surgery, Affiliated Jinling Hospital, Medical School of Nanjing University, and approval from the institutional review board of the Hospital was obtained.

Data collection

We collected demographic information along with data about the body mass index (BMI), type of abdominal trauma, physical activity, nutrition status at discharge (Handgrip strength, gait speed, nutrition risk screening), serum albumin, serum prealbumin, serum transferrin, skeletal muscle area (SMA), skeletal muscle mass index (SMI), comorbidities and primary diagnoses of 90-day readmissions. Clinical outcomes data included length of hospital stay, 30-day readmission rate, 90-day readmission rate, and OS rate.

Definition and groups

In this study, sarcopenia was based on CT assessment. CT scans of the abdomen were routinely performed within one week after admission. The total cross-sectional SMA at the third lumbar vertebra (L3) with semi-automated threshold-based segmentation was measured from the admission CT by trained research staff.[19-21] The SMA was calculated with Image J2 software (The National Institutes of Health, Washington, MD, USA). We used attenuation thresholds at -29 and +150 Hounsfield units (HU) for skeletal muscle at L3.[22] The skeletal muscle mass at the L3 level was normalized to the patient's height to calculate the SMI (cm^2/m^2).[17,23]

Sarcopenia was defined as low muscle mass plus low muscle strength and/or low physical performance according to the Asian consensus definition.[24] Low muscle mass was defined as SMI below the lowest sex-specific quartile [15,25] (<40.9 cm^2/m^2 for males and <36.8 cm^2/m^2 for females). Low muscle strength was defined as a grip strength of <26 kg for males and <16 kg for females.[26,27] Low physical performance was defined as a gait speed of < 0.8 m/s.[28]

Readmission was defined as planned or unplanned based on a review of the patient's treatment plan and medical record.[29] In this study, readmission was defined as an admission to an acute-care hospital that occurred within 30 or 90 days of hospital discharge.[30]

Patient OS was calculated as the time from day one postoperatively until death (from any cause) or the date last known alive.

Comorbidities were assessed using the Charlson comorbidity index.[31] Comorbidities included hypertension, heart disease, respiratory disease, acute infection, liver disease, chronic kidney disease (CKD), central nervous system (CNS) disease, anemia, tumour of any type, falls in the previous 12 months, gastrointestinal (GI) disease, diabetes, hypothyroidism, hyperthyroidism, osteoarthritis, arthrolithiasis, depression, cognitive impairment, polypharmacy, and alcohol use, smoking status was also identified.

Statistical analysis

Statistical analyses were conducted by SPSS 22.0 software (IBM, Inc., Chicago, Illinois). Data were presented as mean and standard deviation (SD) for continuous variables or percentages for categorical variables. These characteristics were analyzed using independent-samples t-test or Manne Whitney and χ^2 or Fisher's exact tests when appropriate. To identify potential risk factors of 90-day readmission and OS. Univariate analyses were performed first, and multivariate analysis was further conducted. Multivariate logistic regression analysis was performed to evaluate the relationship between sarcopenia and readmission and OS. OS was estimated using the Kaplan–Meier method, and survival estimates were compared using the log-rank test. A Cox proportional hazards model was used to assess the impact of sarcopenia on OS. A p value of <0.05 was considered statistically significant.

RESULTS

Patient characteristics

A flow chart of study participants is shown in Figure 1. A total of 1112 patients presented as an abdominal trauma from January 2010 to April 2020 at affiliated Jinling Hospital, Medical School of Nanjing University. A total of 485 patients who had abdominal CT scans and the follow-up met the inclusion in this study cohort. Among 627 patients who were excluded, 19 patients died in the hospital before discharge, 214 patients missing CT scan data, 327 patients were unable to be contacted, 67 patients were refused to follow up and did not cooperate with the follow-up. The lowest sex-specific quartile of SMI at L3 in these patients was 40.91 cm^2/m^2 for men and 36.75 cm^2/m^2 for women.

Baseline characteristics of the 485 participants were shown in Table 1. Overall, 120 patients (24.7%) were sarcopenia and 365 patients (75.3%) were non-sarcopenia. The sarcopenic group was comparable to nonsarcopenic group with regard to patient age, sex, type of abdominal trauma, physical activity, NRS, serum albumin, serum prealbumin, serum transferrin (p>0.05). However, sarcopenia was significantly associated with weight (61.3±9.2 vs 64.5±12.1 kg, p=0.008), BMI (21.2±2.8 vs 22.5±3.6 kg/m^2, p<0.001), handgrip strength (23.6±10.6 vs 27.1±10.8 kg, p<0.001), gait speed (0.72±0.22 vs 0.82±0.23 m/s, p<0.001), Serum transferrin (164±61.1 vs 189±72.5, mg/dL, p<0.001), SMA (99.0±15.7 vs 135±22.9 cm^2, p<0.001), SMI (34.5±5.0 vs 47.3±7.5 cm^2/m^2, p<0.001), hospital stay (26.1±12.6 vs 21.4±14.9 days, p<0.001).

There were no significant differences in the patient comorbidities (hypertension, heart disease, respiratory disease, acute infection, liver disease, CKD, CNS disease, anemia, tumour of any type, falls in the previous 12 months, GI disease, diabetes, hypothyroidism, hyperthyroidism, osteoarthritis, arthrolithiasis, depression, cogni-

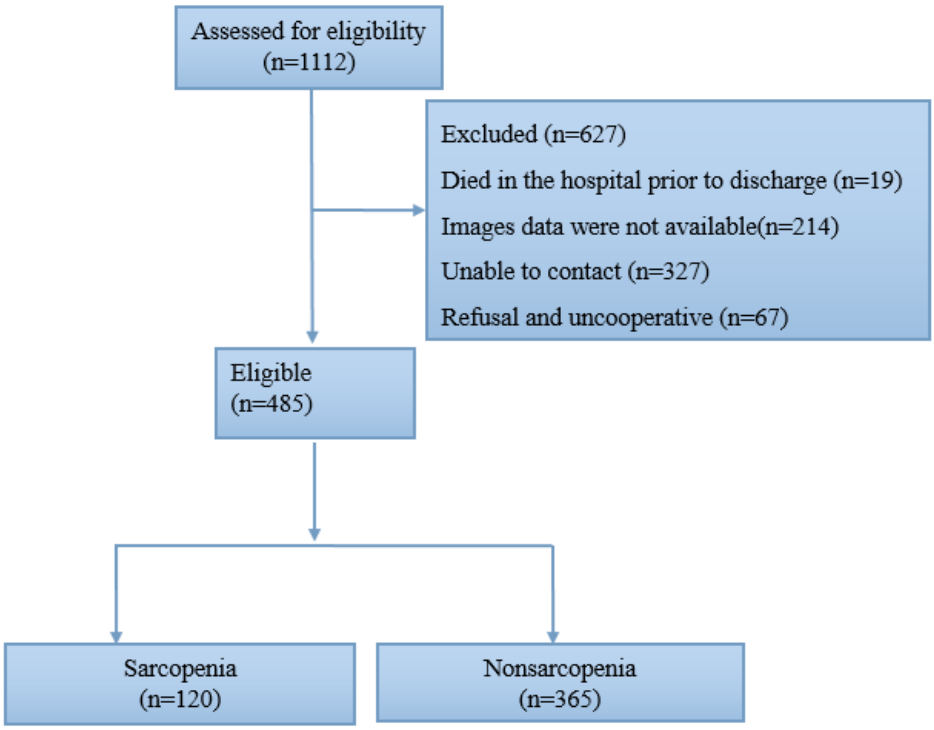

Figure 1. Flow chart of study participants.

Table 1. Baseline demographic and clinical characteristics

	Sarcopenia (n=120)	Non-sarcopenia (n=365)	*p* value
Age (years)†	48.0±14.7	47.3±14.2	0.548
Sex (%)‡			0.560
Male	99 (82.5)	298 (81.6)	
Female	21 (17.5)	67 (18.4)	
Weight (kg)†	61.3±9.2	64.5±12.1	0.008**
BMI (kg/m^2)†	21.2±2.8	22.5±3.6	<0.001**
Type of abdominal trauma (%)‡			0.593
Liver	2 (1.67)	25 (6.85)	
Biliary tract	0 (0.00)	1 (0.27)	
Pancreas	8 (6.67)	19 (5.21)	
Spleen	3 (2.50)	24 (6.57)	
Gastric	1 (0.83)	5 (1.37)	
Duodenal	4 (3.33)	15 (4.11)	
Small intestine	26 (21.7)	56 (15.3)	
Colon	5 (4.17)	18 (4.93)	
Rectum	0 (0.00)	3 (0.82)	
Abdominal Multiple Injuries	71 (59.2)	199 (54.5)	
Nutrition status at discharge			
Physical activity ≥30 min/day (%)‡	17 (14.2)	62 (16.9)	0.348
Handgrip strength (kg)†	23.6±10.6	27.1±10.8	<0.001**
Gait speed (m/s)†	0.72±0.22	0.82±0.23	<0.001**
NRS†	2.76±1.04	2.71±1.21	0.726
Serum albumin (g/L)†	32.2±6.1	31.8±7.0	0.594
Serum prealbumin (mg/dL)†	14.8±9.6	14.6±8.7	0.838
Serum transferrin (mg/dL)†	164±61.1	189±72.5	<0.001**
SMA (cm^2)†	99.0±15.7	135±22.9	<0.001**
SMI (cm^2 /m^2)†	34.5±5.0	47.3±7.5	<0.001**
Hospital stay (days)†	26.1±12.6	21.4±14.9	<0.001**

BMI: body mass index; NRS: nutrition risk screening; SMA: skeletal muscle area; SMI: skeletal muscle index.
†Student's t-test was used to calculate the *p* value.
‡The chi-square test or Fisher's exact test was used to calculate the *p* value.
*p<0.05, **p<0.01.

tive impairment, polypharmacy, and alcohol use, smoking status) when the sarcopenia group was compared with non-sarcopenia group (p>0.05) (Table 2).

Clinical outcomes

There was no significant difference in the readmission rate within 30 days of discharge between the sarcopenia group (20%) and the non-sarcopenia group (19.7%) (p>0.05); however, the readmission rate within 90 days after discharge was significantly higher in the sarcopenia group (35.8%) than in the non-sarcopenia group (20.8%) (p=0.019) (Figure 2). Kaplan-Meier curve (log-rank test), sarcopenia was associated with OS (p=0.025) (Figure 3). Among 485 patients who completed a 1-year follow-up, the 1-year survival rate was 78.33% and 68.38% in the sarcopenia and non-sarcopenia groups, respectively.

Univariate and multivariate analyses

Univariate and multivariate analyses of risk factors associated with 90-day readmission in abdominal trauma patients. In univariate analysis BMI <18.5 OR: 2.09, 95% confidence interval (CI): 1.15-3.78), smoking (OR: 2.38, 95% CI: 1.49-3.83), GI disease (OR: 5.23, 95% CI: 2.80-9.78), handgrip strength (OR: 1.96, 95% CI: 1.24-3.07), gait speed (OR: 1.91, 95% CI: 1.25-2.93), discharge NRS (OR: 1.79, 95% CI: 1.13-2.85), hospital stay (OR: 2.71, 95% CI: 1.78-4.11), and sarcopenia (OR: 2.09, 95% CI: 1.34-3.27) were identified as significant predictors of 90-day readmission. In the multivariate logistic regression analysis, BMI <18.5 kg/m^2 (OR: 2.92, 95% CI: 1.35-6.31), smoking (OR: 3.06, 95% CI: 1.63-5.76), GI disease (OR: 5.96, 95% CI: 2.86-12.4), hospital stay (OR: 1.99, 95% CI: 1.17-3.36), and sarcopenia (OR: 5.34, 95% CI: 2.52-11.3) were independent risk factors for 90-day

Table 2. Admission and patient comorbidities

Comorbidities, n%	Sarcopenia (n=120)	Non-sarcopenia (n=365)	p value
Hypertension	10 (8.33)	18 (4.93)	0.284
Heart disease	0 (0.00)	2 (0.54)	0.316
Respiratory disease	2 (1.67)	3(0.82)	0.561
Acute infection	1 (0.83)	4 (1.09)	1.000
Liver disease	2 (1.67)	7 (1.91)	1.000
CKD	1 (0.83)	1 (0.27)	0.316
CNS disease	0 (0.00)	7 (1.91)	0.155
Anemia	0 (0.00)	1 (0.27)	1.000
Tumour of any type	0 (0.00)	1 (0.27)	1.000
Falls in the previous 12months	1 (0.83)	4 (1.09)	1.000
GI disease	19 (15.8)	44 (12.1)	0.415
Diabetes	0 (0.00)	8 (2.19)	0.155
Hypothyroidism	0 (0.00)	2 (0.54)	0.316
Hyperthyroidism	1 (0.83)	0 (0.00)	0.316
Osteoarthritis	1 (0.83)	4 (1.09)	1.000
Arthrolithiasis	0 (0.00)	1 (0.27)	1.000
Depression	5 (4.16)	26 (7.12)	0.352
Cognitive impairment	4 (3.33)	5 (1.37)	0.312
Polypharmacy	3 (2.50)	10 (2.74)	0.990
Current smokers	29 (24.2)	68 (18.6)	0.246
Current alcohol drinkers	12 (10.0)	63 (17.2)	0.107

CKD: chronic kidney disease; CNS disease: central nervous system disease; GI disease: gastrointestinal disease.
The chi-square test or Fisher's exact test was used to calculate the p value.
$^*p$<0.05, $^{**}p$<0.01.

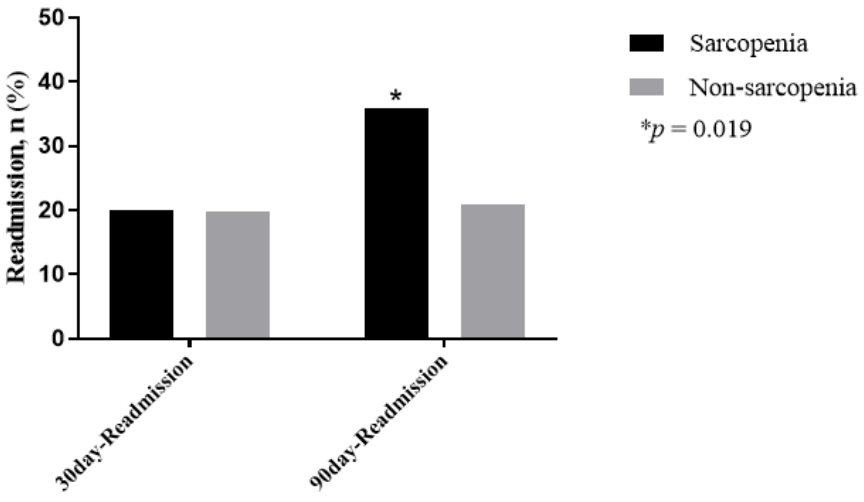

Figure 2. The 30-day and 90-day readmissions.

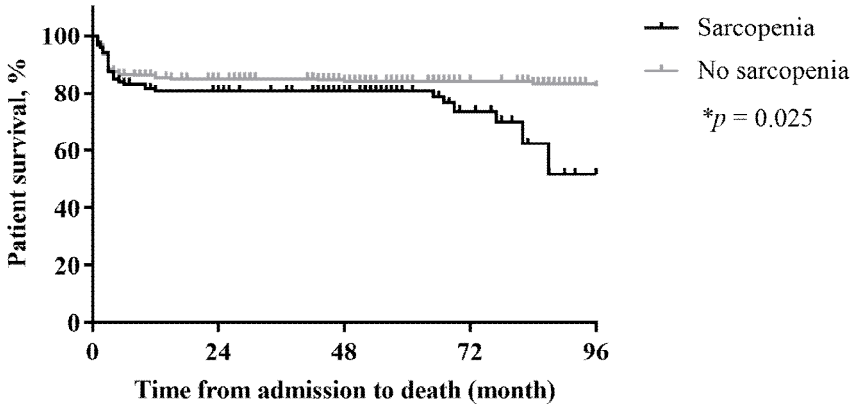

Figure 3. Kaplan–Meier survival curve for patients with and without sarcopenia. Sarcopenia was associated with OS in the log-rank test ($p = 0.025$)

readmission (Table 3).

Cox regression analysis of OS in abdominal trauma patients. Univariate analysis revealed that both BMI >25 kg/m^2 (OR: 1.65, 95% CI: 1.02-2.68) and serum prealbumin (OR: 2.53, 95% CI: 1.40-4.57) were significantly associated with OS. In the multivariate cox logistic regression analysis, prealbumin (OR: 2.71, 95% CI: 1.35-5.45) was significantly associated with OS. In both univariate and multivariate analysis, sarcopenia was not an independent risk factor for OS (p>0.05) (Table 4).

DISCUSSION

This study found that sarcopenia in patients with abdominal trauma was associated with 90-day readmission and OS rate. Multivariate regression analysis showed that sarcopenia was an independent risk factor for 90-day readmission. To our knowledge, this is the first to investigate the relationship between sarcopenia and 90-day readmission and survival rate in the surgical population. This study suggests that assessment of sarcopenia may be part of risk stratification in patients with abdominal trauma.

Sarcopenia is considered as a progressive, systemic muscle-skeletal dysfunction involving accelerated loss of muscle mass and function. Numerous studies have recently shown that sarcopenia is associated with increased poor prognosis, including complications, functional outcomes, decreased quality of life, and mortality in older trauma patients.[15,20,21,28,32,33] However, another study reported that sarcopenia was not predictive of weakness in elderly patients with trauma. It is important to evaluate sarcopenia in patients with trauma. Therefore, we investigated whether sarcopenia impacts the clinical prognosis of patients with abdominal trauma and whether sarcopenia is associated with readmission and survival.

There are a number of methods for measuring skeletal muscle, including X-ray, CT, magnetic resonance imaging (MRI) and ultrasound,[34,35] of which the SMI of the third lumbar vertebrae (L3) area on CT scan is a widely accepted evaluation method.[15,25] Up to now，there is no

Table 3. Univariate and multivariate analyses of 90-day readmission

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
Male	1.45 (0.81-2.57)	0.206		
Age ≥65 (years)	1.05 (0.54-2.06)	0.878		
BMI (kg/m^2)				
<18.5	2.09 (1.15-3.78)	0.015*	2.92 (1.35-6.31)	0.001**
>25	1.03 (0.58-1.81)	0.931		
Smoking	2.38 (1.49-3.83)	<0.001**	3.06 (1.63-5.76)	0.001**
Alcohol drinking	0.90 (0.51-1.60)	0.903		
Hypertension	1.67 (0.75-3.71)	0.212		
Diabetes	1.96 (0.55-7.09)	0.301		
GI disease	5.23 (2.80-9.78)	<0.001**	5.96 (2.86-12.41)	<0.001**
Physical activity <30 (min/day)	1.57 (0.86-2.87)	0.142		
Handgrip strength (kg)	1.96 (1.24-3.07)	0.003**	1.39 (0.78-2.51)	0.262
Female <18 or male <26				
Gait speed <0.80 (m/s)	1.91 (1.25-2.93)	0.003**	1.53 (0.86-2.71)	0.147
Discharge NRS ≥3	1.79 (1.13-2.85)	0.014*	1.61 (0.88-2.91)	0.119
Albumin <35 (g/L)	1.04 (0.82-1.73)	0.847		
Prealbumin <18 (mg/dL)	1.68 (0.64-4.38)	0.283		
Transferrin <200 (mg/dL)	1.06 (0.69-1.63)	0.771		
Hospital stay ≥28 (days)	2.71 (1.78-4.11)	<0.001**	1.99 (1.17-3.36)	0.010*
Sarcopenia	2.09 (1.34-3.27)	0.001**	5.34 (2.52-11.27)	<0.001**

OR: odds ratio; CI: confidence interval; BMI: body mass index; NRS: nutrition risk screening; GI disease: gastrointestinal disease.
*p<0.05, **p<0.01.

Table 4. Cox regression analysis of OS

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Male	0.95 (0.50-1.80)	0.878		
Age ≥65 (years)	1.05 (0.63-1.73)	0.236		
BMI (kg/m^2)				
<18.5	1.31 (0.62-2.74)	0.480		
>25	1.65 (1.02-2.68)	0.040*	1.85 (0.98-3.48)	0.054
Smoking	1.27 (0.39-4.05)	0.685		
Alcohol drinking	1.04 (0.14-7.52)	0.969		
Hypertension	1.13 (0.35-3.58)	0.841		
Diabetes	1.07 (0.65-5.18)	0.465		
GI disease	1.27 (0.39-4.05)	0.685		
Physical activity <30 (min/day)	1.07 (0.39-2.95)	0.895		
Handgrip strength (kg)	0.71 (0.34-1.47)	0.707		
Female <18 or male <26				
Gait speed <0.80 (m/s)	1.64 (0.66-4.09)	0.289		
Discharge NRS ≥3	1.32 (0.74-2.37)	0.343		
Albumin <35 (g/L)	1.36 (0.32-5.79)	0.677		
Prealbumin <18 (mg/dL)	2.53 (1.40-4.57)	0.002**	2.71 (1.35-5.45)	0.005**
Transferrin <200 (mg/dL)	0.99 (0.53-1.84)	0.975		
Hospital stay ≥28 (days)	1.21 (0.74-1.98)	0.457		
Sarcopenia	1.01 (0.61-1.63)	0.991		

OR: odds ratio; CI: confidence interval; BMI: body mass index; NRS: nutrition risk screening; GI disease: gastrointestinal disease.
*p<0.05, **p<0.01.

uniform definition of sarcopenia. Most studies defined the SMI cut-offs as 52.4 cm^2/m^2 for men and 38.5 cm^2/m^2 for women.[17,36-38] Another study defined the cut-offs as SMI 43 cm^2/m^2 and BMI <25 kg/m^2 for men, with SMI <53 cm^2/m^2 and BMI ≥25 kg/m^2 for men, and 41 cm^2/m^2 for women.[39,40] Furthermore, a part of researchers defined sarcopenia threshold SMI as 55.4 cm^2/m^2 for men and 38.9 cm^2/m^2 for women.[20,41] It has been reported that the definition of SMI in Chinese population is 43.[13] cm^2/m^2 and 37.81 cm^2/m^2.[42] Because different studies use different methods, standards, and populations, it is difficult to compare them. In our study, we defined sarcopenia as 40.9 cm^2/m^2 in men and 36.8 cm^2/m^2 in women. 24.74% of patients with abdominal trauma had low SMI in combination with low handgrip strength and low gait speed before abdominal surgery. These patients were classified as sarcopenia. This study found that sarcopenia was associated with lower body weight, lower BMI, and longer hospital stay.

Our study further found a significant correlation between sarcopenia and 90-day readmission and OS. Multivariate regression analysis showed that sarcopenia was an independent risk factor for a 90-day readmission，which is consistent with previous studies.[39,43-46] In this study, the most common reason for unplanned readmission were new infections and gastrointestinal complication. A study showed that half of sepsis 90-day readmissions patients are related to new infections.[47] Another study showed that half of the readmitted patients after 90 days are due to procedural complications.[48] The other study found relevant patient comorbidities and surgical complications were associated with increased readmission within 90 days.[49] There were no significant differences in the patient comorbidities between the sarcopenia group and the non-sarcopenia group in this study. However, our previous studies have shown that sarcopenia is associated with patient complications.

In addition, malnutrition and sarcopenia may coexist in elderly or critically ill patients,[50] and malnutrition is a major risk factor for sarcopenia, which can also be defined as malnutrition.[44,51] Numerous studies have shown a correlation between malnutrition and readmission.[52-54] In our study, although BMI<18.5 kg/m^2 is an independent risk factor for 90-day readmission, and prealbumin is an independent risk factor for OS, it cannot really distinguish between malnutrition and sarcopenia on the impact of patients. Furthermore, the literature found no statistically significant relationships between sarcopenia and the 90-day readmission rate and OS rate.[55] Therefore, more prospective studies are needed to confirm this in different populations.

This study also has two limitations. First of all, it is a single-center retrospective study. Secondly, there were many kinds of traumatic mechanisms in the included patients, which may impact the results. More multicenter prospective studies are needed to confirm the current findings.

Conclusions

Sarcopenia in patients with abdominal trauma was associated with 90-day readmission and OS rate, and it was an independent risk factor for 90-day readmission. It is essential to evaluate sarcopenia in abdominal traumatic patients by preoperative CT. Assessment of sarcopenia could help identify high risk factors of poor prognosis after abdominal trauma.

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AUTHOR DISCLOSURES

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