BMC Pulmonary Medicine

RESEARCH

Open Access

Low thoracic skeletal muscle is a risk factor for 6-month mortality of severe community-acquired pneumonia in older men in intensive care unit

Mengqin Zhang[1], Cuicui Dong[1], Yongpo Jiang[1], Fangjun Guo[1], Ke Cui[1], Sheng Zhang[1], Yinghe Xu[1*] and Yang Yang[2*]

Abstract

Background Patients with severe community-acquired pneumonia (sCAP) admitted to the intensive care unit (ICU) often exhibit muscle catabolism, muscle weakness, and/or atrophy, all related to an increased morbidity and mortality. However, the relationship between thoracic skeletal muscle mass and sCAP-related mortality has not been well-studied. Early recognition of sarcopenia in ICU patients with sCAP would benefit their prognosis.

Methods A retrospective study was conducted in Taizhou Hospital of Zhejiang Province, involving 101 patients with sCAP admitted in the ICU between December 2022 and February 2023. We measured the cross-sectional aera of the pectoralis, intercostal, paraspinal, serratus, and latissimus muscles at the T4 vertebral level ($T4_{CSA}$) using chest computed tomography. Discriminatory thresholds were established by performing receiver operating characteristic curve analysis, with a designated cutoff value of 96.75 cm^2 for male patients. This cohort was classified into mortality and survival groups based on a 6-month post-admission outcome. Univariate and multifactorial logistic regression analyses were performed to validate the correlation between low thoracic skeletal muscle area and prognostic outcomes.

Results The mean age of the patients was 75.39 ± 12.09 years, with an overall 6-month mortality of 73.27%. $T4_{CSA}$ of the 6-month survival group was significantly larger than that in the mortality group for overall cohort. The $T4_{CSA}$ in the survival group was significantly larger than that in the mortality group (104.29 ± 23.98cm^2 vs. 87.44 ± 23.0cm^2, $p = 0.008$). $T4_{CSA}$ predicted the 6-month mortality from sCAP in males with an AUC of 0.722 (95% confidence interval (CI), 0.582–0.861). The specificity and sensitivity were 71.4% and 71.1%, respectively, ($p < 0.05$). No significant difference was observed between the two groups in terms of $T4_{CSA}$.

Conclusions This study revealed that low thoracic skeletal muscle mass increased the risk of all-cause 6-month mortality in ICU patients with sCAP, particularly among male patients.

*Correspondence:
Yinghe Xu
xuyh@enzemed.com
Yang Yang
yanglaoss@163.com

Full list of author information is available at the end of the article

Keywords Sarcopenia, Severe community-acquired pneumonia, Mortality, Thoracic skeletal muscle area, Intensive care unit

Background

The global population of older individuals is rising, with projections indicating that the proportion of those aged over 65 years old will increase by at least 10% in the future. Sarcopenia, characterized by the decline in skeletal muscle function, strength, and mass, which occurs with age reportedly affects 30% of individuals over 60 years old [1]. Sarcopenia can not only cause physical disability but also increase the risk of mortality [2, 3]. An epidemiological study in China involving individuals over the age of 60 years found that two out of five older adults suffer from sarcopenia, with the prevalence of potential sarcopenia in this population exceeding 45.0% [4].

Severe community-acquired pneumonia (sCAP) is the leading cause of hospitalization and mortality among older adults [5], with hospital mortality rates exceeding 50% [6]. However, the mortality rate among older patients with sCAP in the intensive care unit (ICU) is high, and many of these patients have difficultly being weaned off the ventilator, often attributed to respiratory muscle atrophy. Respiratory sarcopenia refers to the gradual weakening and atrophy of the respiratory muscles over time; [7–9] moreover, it can lead to reduced respiratory function [10]. The diagnosis of sarcopenia includes at least two of the following three items: skeletal muscle mass, muscle strength, and measures of physical performance. Loss of skeletal muscle mass is associated with high risk of loss in mobility and increased mortality in older individuals [11, 12]. Meanwhile, the association between low thoracic skeletal muscle and mortality due to sCAP remains inconclusive. Several techniques have been used to assess skeletal muscle mass, including computed tomography(CT), magnetic resonance imaging, dual-energy X-ray absorptiometry, and bioimpedance analysis [3]. Grip strength and the chair stand test (five sets of sit-to-stand) are used to assess muscle strength [3]. The physical performance can be assessed using the timed up-and-go test, gait speed test, short physical performance battery, 400-meter timed walk, and cardiorespiratory fitness (CRF) test [13, 14]. CRF is used to assess the capacity of cardiorespiratory system to supply blood and oxygen to the skeletal muscles during moderate to strenuous physical activity, and has been associated with increased risk of mortality [15]. However, patients with sCAP especially in ICU often cannot be tested for sarcopenia using the criteria of muscle strength test and physical performance. Respiratory sarcopenia refers to the loss of muscle mass and strength in both respiratory and body skeletal muscles with aging. However, there is no consistent definition of respiratory sarcopenia, and the diagnosis criteria vary in clinical practice [16]. CT provides a simple and reliable method to assess both respiratory and body skeletal muscle mass in critically-ill patients [17]. The cross-sectional area (CSA) of thoracic skeletal muscles, as measured via CT, correlates closely with thoracic muscle volume [18]. This CSA assessment is a valuable tool in evaluating sarcopenia [19–21]. For critically-ill ICU patients, especially those on ventilator support, when sarcopenia cannot be assessed by conventional methods, chest CT scans can be used to measure the skeletal muscle mass. This approach is undoubtedly convenient, cost-effective, easy to interpret, and feasible for such patients, particularly those with sarcopenic respiratory disability. Moon et al. used the CSA at the 4th thoracic vertebral level ($T4_{CSA}$) on CT for sarcopenia assessment and found that cutoff values can be quantified according to sex when measuring thoracic muscle mass [19].

Risk factors for mortality from sCAP include age, comorbidities, vital signs, pathogen specificity, and illness severity [6]. However, the correlation between the thoracic skeletal muscle mass and sCAP-related mortality has not been well-studied. Therefore, the aim of this study was to investigate whether low thoracic skeletal muscle mass is associated with 6-month mortality following diagnosis of sCAP in patients in the ICU.

Methods

Ethics statement

This retrospective study complied with the principles of the Declaration of Helsinki.

The Institutional Ethics Committee of Taizhou Hospital, Zhejiang Province, China approved this study (NO: KL20231204) and waived the requirement for written informed consent owing to the retrospective observational design.

Study design and population

We performed a single-center retrospective cohort study on patients with sCAP who were admitted to the ICU of Taizhou Hospital between December 2022 and February 2023. The inclusion criteria were as follows: (i) patients undergoing endotracheal intubation and mechanical ventilation, (ii) patients who had a chest CT scan before admission, (iii) admission to ICU for non-traumatic reasons, (iv) age > 18 years, and (v) diagnosis consistent with the 2007 Infectious Disease

Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults [22]. The exclusion criteria were as follows: (i) patients who had not been endotracheal intubation or mechanically ventilated ($n=15$), (ii) death or discharge within 24 h of admission, (iii) patients without chest CT scan before admission ($n=57$), (iv) pregnant or breastfeeding woman, and (v) patients aged < 18 years.

This study enrolled a total of 101 patients. All patients were selected for $T4_{CSA}$ measurement based on previous studies [19]. This cohort was divided into the mortality and survival groups based on the 6-month post-admission outcomes. As the threshold for sarcopenia is different in males and females [19, 23], the cohort in this study were subsequently divided into male and female groups based on sex. All enrolled patients were Chinese (Fig. 1).

Measurement of cross-sectional skeletal muscle area

The CSA of the pectoralis, intercostal, paraspinal, serratus, and latissimus muscles at the $T4_{CSA}$ was quantified using the semiautomatic sliceOmatic 5.0 (TomoVision, Canada) (Fig. 2). The T4 level, encompassing the aortic arch and serving as a standard reference section, was included in our analysis [19]. The authors identified images by visual evaluation. The $T4_{CSA}$ was automatically computed by summing the pixel attenuation within the range of -30 to +150 Hounsfield units, indicative of skeletal muscle tissue.

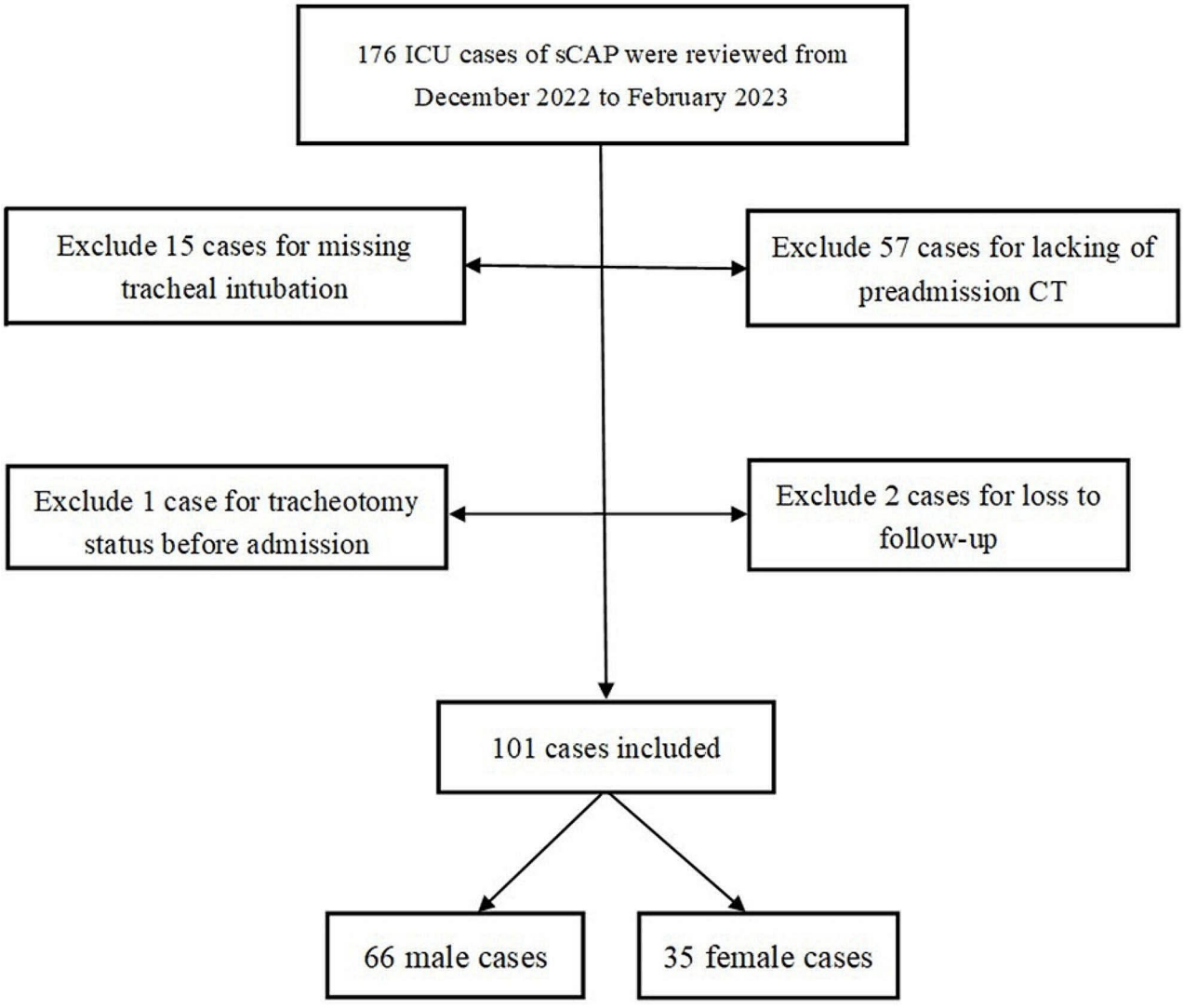

Fig. 1 Flowchart showing study cohort selection. ICU, Intensive care unit; sCAP, severe community-acquired pneumonia.

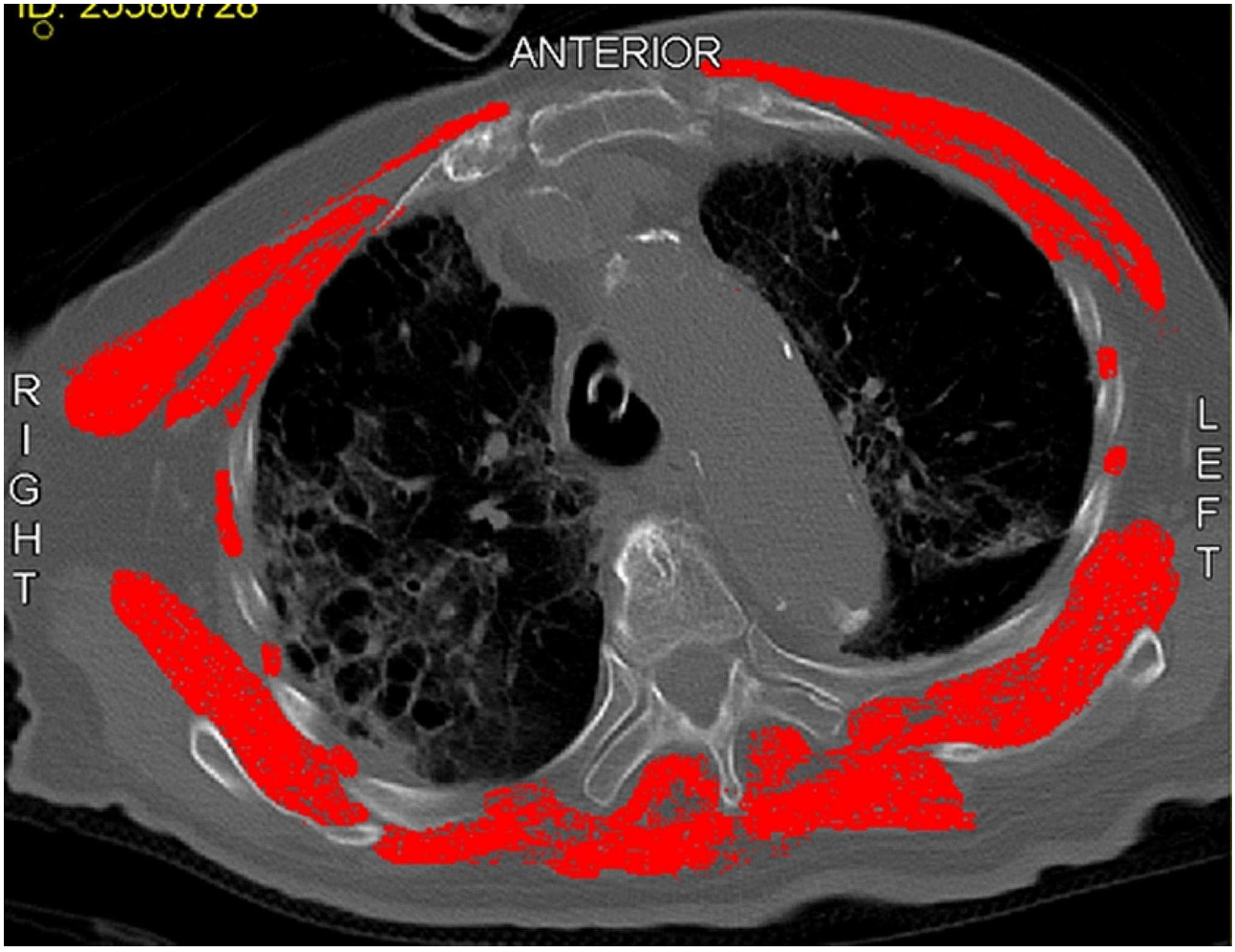

Fig. 2 Measurement of the cross-sectional area at the 4th vertebral level

Data collection

Baseline data, including presence of hypertension, diabetes, and coronary atherosclerotic heart disease, were recorded. White blood cell count, hemoglobin (HGB), platelet count, albumin, glutamic-pyruvic transaminase (ALT), creatinine, blood urea nitrogen (BUN) within the first 24 h of ICU admission were abstracted for further analysis, along with acute physiology and chronic health II (APACHE II) and the highest sequential organ failure assessment (SOFA) scores. All of these tests were performed within the first 24 h of ICU admission.

Outcomes

The primary outcome was death from any cause within 6 months. The second outcome was time to mechanical ventilation; tracheal reintubation after extubation failure; and whether tracheotomy was performed during hospitalization. We assessed the patients' ability to transition from ventilator support to spontaneous breathing using methods such as T-tube trials, continuous positive airway pressure, and minimal pressure support ventilation. Successful weaning is defined as achieving independent breathing without any ventilator support and maintaining freedom from non-invasive or invasive respiratory support for at least 48 h after extubation.

Statistical analyses

Continuous variables are reported as means with standard deviations or medians, or numbers along with proportions. The classified variables are expressed as counts and percentages. Chi-square and Fisher's exact tests were used to compare classified variables, while *t*-tests were used to compare continuous variables between groups. The Mann–Whitney U test was used to compare groups and assess a non-positive distribution. Univariate and multivariate logistic regression analyses were performed for data showing significant differences between the survival and mortality groups. The predictive power of $T4_{CSA} \leq 96.75\ cm^2$ was assessed using AUC. We used SPSS version 26.0 (IBM,

Armonk, NY, USA) for data analysis, with the significance threshold set at $p<0.05$.

Results

A total of 176 patients with sCAP admitted to the ICU of Taizhou Hospital between December 2022 and February 2023 were included in this study. Overall, 57 patients were excluded due to a lack of pre-admission CT, 15 patients were excluded due to missing tracheal intubation, 1 patient was excluded due to tracheotomy status before admission, and 2 patients were excluded due to loss to follow-up (Fig. 1). Finally, 101 patients with a mean age of 75.39±12.09 years were included in the analysis (Table 1). The baseline clinical characteristics are presented in Table 1. The overall 6-month mortality of this cohort was 73.27%.

Risk factors in 6-month all-cause mortality for the overall cohort

No statistically significant differences were observed in presence of hypertension, diabetes, coronary heart disease, sex, APACHE II score, SOFA score, white blood cell count, HGB, platelet count, albumin, ALT, creatinine, BUN, duration of mechanical ventilation, tracheal reintubation after extubation failure, or whether tracheotomy was performed during hospitalization between two groups (all $p>0.05$) (Tables 1 and 2).

The patients in the 6-month mortality group were significantly older than those in the survival group. Additionally, $T4_{CSA}$ of the 6-month survival group was significantly larger than that of the mortality group (Table 1). The number of tracheotomies conducted during hospitalization were significantly higher in the 6-month survival group than that in the mortality group (all $p<0.05$) (Table 2).

Risk factors for all-cause death at 6 months in the male group

Based on previous studies [19], all patients were classified according to sex for the subgroup analysis. Six months after admission, males were categorized based on their survival prognosis. The two groups did not significantly differ in terms of presence of hypertension, diabetes, coronary heart disease, APACHE II score, SOFA score, HGB, white blood cell count, platelet count, albumin, ALT, creatinine, BUN, duration of mechanical ventilation, reintubation after extubation failure, or whether tracheotomy was performed during hospitalization (all $p>0.05$) (Table 1). The 6-month mortality group was significantly older ($p<0.05$) and exhibit a smaller $T4_{CSA}$ than did the survival group (87.44±23.00 cm^2 vs.104.29±23.98 cm^2, $p=0.008$) (Table 1). The overall 6-month mortality in the male patients was 68.18%.

$T4_{CSA}$ predicted the 6-month mortality from sCAP in males with an AUC of 0.722 (95% confidence interval (CI), 0.582–0.861). The specificity and sensitivity were 71.4% and 71.1%, respectively ($p<0.05$) (Fig. 3). The cut-off value for $T4_{CSA}$ was 96.75 cm^2. Univariate logistics regression analysis revealed that age and $T4_{CSA}\leq 96.75$ cm^2 were risk factors for 6-month mortality in male patients with sCAP ($p<0.05$) (Table 3). Multivariate logistics regression analysis showed that $T4_{CSA}\leq 96.75$ cm^2 was an independent risk factor for 6-month mortality in male patients with sCAP (odds ratio, 3.99; 95%CI, 1.08–14.73) ($p<0.05$) (Table 3).

Risk factors for all-cause death at 6 months in the female group

No significant difference was observed between the females in the two groups in terms of presence of hypertension, diabetes, coronary heart disease, APACHE II score, SOFA score, age, $T4_{CSA}$, HGB, platelet count, albumin, ALT, creatinine, BUN, duration of mechanical ventilation, reintubation following failed extubation, or whether tracheotomy was performed during hospitalization (all $p>0.05$) (Tables 1 and 2). The white blood cell count was significantly higher in the 6-month mortality than in the survival group ($p<0.05$) (Table 1). No significant difference was observed between the two groups in terms of $T4_{CSA}$. The overall 6-month mortality in the female group was 82.86%.

Discussion

Epidemiological investigation of community-acquired pneumonia in China shows that the proportion of sCAP is higher in males and older adults over 60 years old [24]. Similarly, a multicenter prospective study by Qu et al. showed that most patients with sCAP were older men over 65 years old [25], which is consistent with other studies on sCAP conducted in other countries [26, 27]. The mortality rate in older patients with sCAP remains high despite advances in diagnosis, management, and antimicrobial therapy. Aging leads to the confluence of multiple diseases in the older individuals, including sarcopenia, characterized by age-related loss of muscle mass [28]. Muscle mass and strength peak at the age of 40 years, with men having a higher peak than women; however, both parameters gradually decline after the age of 50 years [13]. There is growing evidence of a robust interrelationship between sarcopenia and adverse clinical outcomes [29, 30]. Patients with sarcopenia experience elevated rates of hospitalization and mortality [2]. Moreover, sarcopenia is as an independent risk factor for mortality

Table 1 Baseline characteristics of patients with sCAP in ICU

	All patients (*n* = 101)	6-month survival group (*n* = 27)	6-month mortality group (*n* = 74)	*p*-value	Male (*n* = 66))	6-month survival group (*n* = 21)	6-month mortality group (*n* = 45)	*p*-value	Female (*n* = 35)	6-month survival group (*n* = 6)	6-month mortality group (*n* = 29)	*p*-value
Gender(male/female)	66/35	21/6	45/29	0.113[a]	66				35			
Age(year); mean ± SD	75.39 ± 12.09	68.96 ± 13.84	77.73 ± 10.55	0.005	74.46 ± 12.16	68.10 ± 12.04	77.42 ± 11.14	0.003	77.14 ± 11.94	72 ± 20.04	78.21 ± 9.72	0.489
$T4_{CSA}$ (cm^2); mean ± SD	82.76 ± 26.29	96.58 ± 26.76	77.72 ± 24.41	0.001	92.8 ± 24.44	104.29 ± 23.98	87.44 ± 23.0	0.008	63.83 ± 18.06	69.59 ± 17.29	62.63 ± 18.28	0.399
Apache II score; mean ± SD	21.25 ± 8.10	20.30 ± 7.41	21.60 ± 8.36	0.478	21.18 ± 8.53	20.29 ± 7.34	21.60 ± 9.08	0.564	21.37 ± 7.33	20.33 ± 8.33	21.59 ± 7.24	0.709
SOFA score; mean ± SD	7.51 ± 2.99	7.56 ± 3.12	7.49 ± 2.97	0.919	7.29 ± 3.05	7.91 ± 3.33	7 ± 2.91	0.265	7.91 ± 2.87	6.33 ± 1.97	8.24 ± 2.95	0.141
Hypertension; n= (%)	58(57.43)	15(55.56)	43(58.11)	0.818[a]	35(53.03)	11(52.38)	24(53.33)	0.942[a]	23(65.71)	4(66.67)	19(65.52)	0.999[b]
Coronary heart disease; n= (%)	14(13.86)	3(11.11)	11(14.86)	0.875[c]	10(15.15)	3(14.29)	7(15.56)	0.999[c]	4(11.43)	0(0)	4(13.79)	0.999[b]
Diabetes mellitus; n= (%)	29(28.71)	6(22.22)	23(31.08)	0.384[a]	16(24.24)	5(23.81)	11(24.44)	0.955[a]	13(37.14)	1(16.67)	12(41.38)	0.377[b]
White blood cell, 10^9/L; median (IQR)	9.4(6.3, 12.55)	8.7(6.3, 13.6)	9.45(6.6, 12.125)	0.747[d]	9.3(6.3, 12.675)	11.3(6.35, 14.95)	9(6.3, 11.55)	0.302[d]	9.5(6.3, 12.5)	6.3(5.08, 7.73)	10.3(7.65, 15.55)	0.031[d]
Hemoglobin, g/L; mean ± SD	112 ± 26	117 ± 29	110 ± 25	0.288	116 ± 26	119 ± 28	115 ± 25	0.491	104 ± 24	106 ± 30	104 ± 23	0.801
Platelet, 109/L; median (IQR)	162(124, 209)	145(125, 209)	166(111, 211)	0.924[d]	158(124, 202)	142(124, 195)	163(119, 204)	0.659[d]	173(109, 272)	170(137, 279)	173(93, 268)	0.623[d]
Albumin, g/L; mean ± SD	27.92 ± 4.26	27.40 ± 4.57	28.12 ± 4.16	0.455	27.65 ± 4.23	26.82 ± 4.66	28.04 ± 4.01	0.279	28.43 ± 4.32	29.42 ± 3.91	28.23 ± 4.44	0.549
Glutamic-pyruvic transaminase ; median (IQR)	24(14.5, 43)	24(12,50)	23.5(14.75, 43)	0.773[d]	25.5(14.75, 46.5)	31(15.5, 50.5)	24(14.5, 44.5)	0.741[d]	23(12, 39)	21.5(10, 102.5)	23(13.5, 41)	0.782[d]
Creatinine, umol/L; median (IQR)	106(70, 199)	92(66, 241)	113(70, 187)	0.809[d]	110(72, 231)	84(63, 235)	121(81, 237)	0.148[d]	97(63, 134)	132.5(82.5, 682.75)	89(61, 126)	0.122[d]
Blood urea nitrogen, mmol/L; median (IQR)	12.1(8.13, 21.35)	10.66(8.25, 20.1)	12.4(8, 21.57)	0.860[d]	13.14(9.07, 22.28)	10.64(6.71, 19.48)	13.9(9.71, 23.21)	0.346[d]	11.6(8.06, 19.43)	15.04(8.98, 26.62)	11.6(7.38, 17.50)	0.312[d]

a, Pearson's chi-square test; b, Fisher's exact test; c, continuity correction chi-square test; d, Mann–Whitney test. $T4_{CSA}$, the cross-sectional area at the 4th vertebral level; APACHE II, acute physiology and chronic health II; SOFA, sequential organ failure assessment; IQR, interquartile range. SD, standard deviation

Table 2 Comparison of clinical outcomes

	All patients (*n* = 101)	6-month survival group (*n* = 27)	6-month mortality group (*n* = 74)	*p*-value	Male (*n* = 66))	6-month survival group (*n* = 21)	6-month mortality group (*n* = 45)	*p*-value	Female (*n* = 35)	6-month survival group (*n* = 6)	6-month mortality group (*n* = 29)	*p*-value
Mechanical ventilation duration, days; mean ± SD	15.14 ± 10.04	15.22 ± 9.80	15.11 ± 10.19	0.96	16.02 ± 10.42	16.33 ± 10.36	15.87 ± 10.57	0.867	13.49 ± 9.18	11.33 ± 6.86	13.93 ± 9.63	0.536
Extubation fail; n= (%)	5(4.95)	0(0)	5(6.76)	0.403[c]	3(4.55)	0(0)	3(6.67)	0.547[a]	2(5.71)	0(0)	2(6.9)	0.999[a]
Tracheostomy n= (%)	3(2.97)	3(1.11)	0(0)	0.018[b]	3(4.55)	3(14.29)	0(0)	0.029[a]	0	0	0	—

a, Fisher's exact test; SD, standard deviation

[31]. Several studies have shown that the mortality risk among sarcopenic Japanese patients is 2-fold greater than that in nonsarcopenic counterparts [32, 33].

Ongoing studies have confirmed that sarcopenia can lead to fractures in older adults [34], need for invasive mechanical ventilation, weaning difficulty, and increased mortality in critically-ill patients [23, 35, 36], as well as predict 90-day mortality from aspiration pneumonia [37]. However, there is a paucity of studies investigating the association between sarcopenia and long-term prognosis of patients with sCAP admitted in ICU. In this study, we found that low thoracic skeletal muscle mass was associated with 6-month mortality in older men with sCAP. Sarcopenia can be age-related or secondary to systemic disease, physical inactivity, and inadequate intake of energy or protein [13], and has been associated with obesity and frailty. Patients with sCAP, especially the older individuals, often have multiple aetiologies for sarcopenia, which may explain why sarcopenia is a risk factor for mortality in older men with sCAP. Concomitantly, sarcopenia, especially respiratory muscle sarcopenia exacerbates low activity, undernutrition, and inflammation. These underlying causes of sarcopenia further compound respiratory sarcopenia, leading to pulmonary functional disability [16]. In a prospective study conducted on a large sample size, mechanical ventilation was the most predominant driver for mortality [38]. In patients with mechanical ventilation, the challenge of weaning from a ventilator may arise due to a vicious cycle perpetuated by respiratory sarcopenia. Notably, no statistical difference was found in the duration of mechanical ventilation between the mortality and survival groups in this study. However, in clinical practice, patients treated with ventilators can be hospitalized for longer duration in the ICU owing to weakness or sarcopenia, and cannot be weaned off from the ventilator for a long time, or eventually die from secondary infections. Sabatino et al. measured the skeletal muscle area at the level of the thoracic 12 vertebral body and found that myosteatosis, as assessed by CT, played a relevant role as a prognostic marker in critically-ill patients with severe pneumonia [39]. Although the chest CT level

Table 3 Univariate and multivariate logistics regression analysis of 6-month mortality in male patients with sCAP in ICU

	Univariate analysis		Multivariate analysis		
	OR	*p*-value	OR	95%CI	*p*-value
Age	1.07	0.005	1.042	0.984~1.104	0.162
APPACH II score	1.019	0.558	1.008	0.937~1.084	0.827
$T4_{CSA} \leq 96.75cm^2$	6.154	0.002	3.994	1.083~14.725	0.038

ICU, intensive care unit; sCAP, severe community-acquired pneumonia; OR, odds ratio; CI, confidence interval; APPACH II, acute physiology and chronic health II; $T4_{CSA}$, the cross-sectional area at the 4th vertebral level

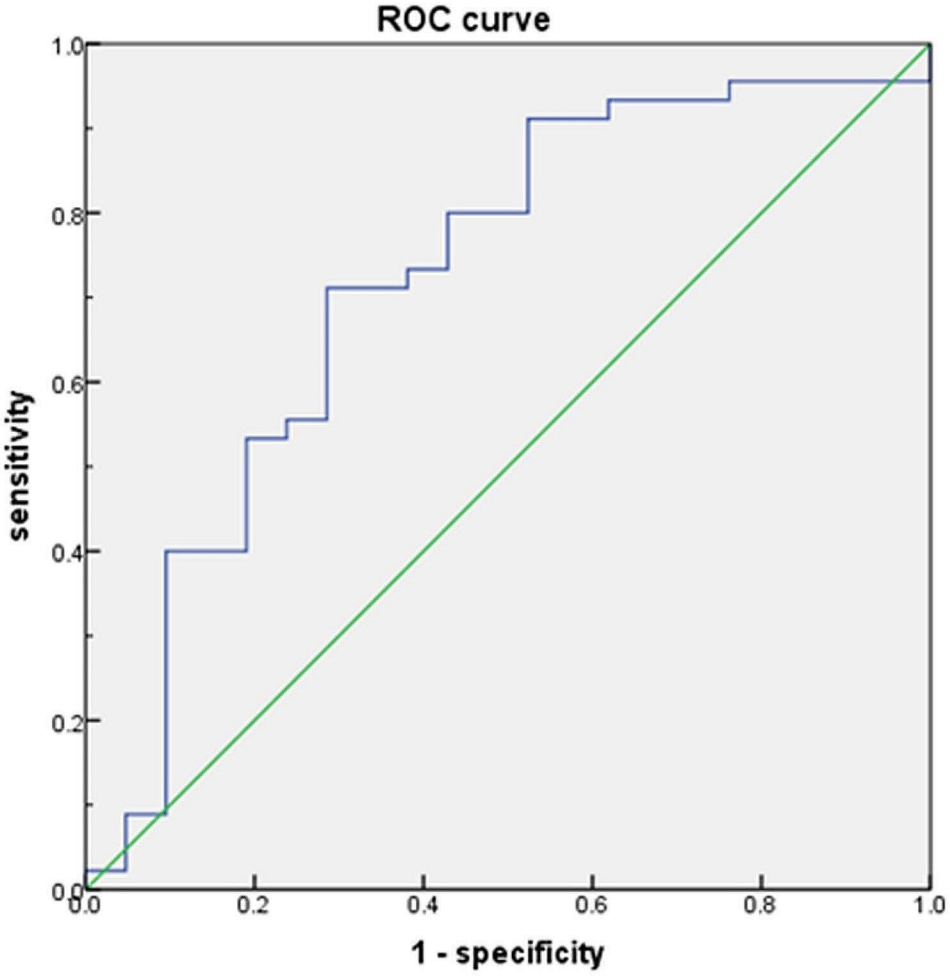

Fig. 3 Receiver operating characteristic curve analysis of $T4_{CSA} \leq 96.75 cm^2$ on 6-month mortality of male patients with severe pneumonia hospitalized in intensive care unit

evaluated in their study is different from that in our study, the conclusion is consistent: low thoracic skeletal muscle mass is a risk factor for poor prognosis of sCAP. Moon et al. found that the $T4_{CSA}$ cut-off value of male sarcopenia was 100.06 cm^2 [19]. This cut-off value was different from that used in our study, which may be related to the different patient groups between studies; the average age was 62.4±9.4 years in their study, while it was 75.39±12.09 years in our study. Furthermore, our study focused on sCAP patients in the ICU, whereas their study investigated healthy individuals undergoing physical examinations. In this study, we found that $T4_{CSA}$ was not associated with 6-month mortality in female patients with sCAP. This could be attributed to a higher prevalence of sarcopenia observed in Chinese community-dwelling older males than in females [40, 41]. It may also be caused by the small sample size in the study. Therefore, future prospective studies with larger samples are warranted.

This study had several limitations. First, although the total sample size of 101 patients was sufficient to investigate the association between $T4_{CSA}$ and 6-month mortality for the overall cohort, the sample size for the female cohort may have been inadequate to draw definitive conclusions. Second, this study was conducted at a single-center and included only Chinese patients, which may limit the generalizability of the findings to other populations and healthcare settings. Third, a formal diagnosis of sarcopenia using standardized criteria was not included because the cohort comprised critically-ill patients, which limited the study's validity and the ability to compare with other studies. Last, potential confounding factors such as nutritional status, physical activity level, and frailty were not included, which could influence both $T4_{CSA}$ and mortality. Given the association noted between low $T4_{CSA}$ and mortality in sCAP, future research studies should explore interventional strategies to improve muscle mass and function in this patient population.

Conclusion

This study revealed that low thoracic skeletal muscle mass increased the risk of all-cause 6-month mortality in ICU patients with sCAP, particularly among male patients. This finding highlights the significance of assessing sarcopenia in ICU patients with sCAP and implementing a tailored treatment strategy that includes personalized mechanical ventilation management and nutritional support.

Abbreviations

ICU	Intensive care unit
CT	Computed tomography
CSA	Cross-sectional area
$T4_{CSA}$	The cross-sectional area at the 4th vertebral level
sCAP	Severe community-acquired pneumonia
CI	Confidence interval
AUC	Area under the curve
APACHE II	Acute physiology and chronic health II
SOFA	Sequential organ failure assessment
HGB	Hemoglobin
ALT	Alanine aminotransferase
BUN	Creatinine, blood urea nitrogen
OR	Odds ratio

Acknowledgements

We would like to thank Editage (www.editage.cn) for English language editing.

Author contributions

MQZ, YY, and YHX conceived and designed the study; CCD measured the cross-sectional area at the 4th vertebral level; YPJ, KC collected the baseline data and clinical outcomes; FJG and SZ analyzed the data; MQZ, YY wrote and revised the manuscript; All authors read and approved the final manuscript.

Funding

This study was funded by the Taizhou City Science and Technology Program of Zhejiang (23ywb22), and the National Key Research and Development Program of Zhejiang Province (2023C03083).

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This retrospective study complied with the principles of the Declaration of Helsinki.

The study was approved by the Institutional Ethics Committee of Taizhou Hospital, Zhejiang Province, China (NO: KL20231204). The need for obtaining the written informed consent was waived off due to retrospective study design.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Critical Care Medicine, Taizhou Hospital of Zhejiang Province, Affiliated to Wenzhou Medical University, No.150, Ximen Street, Linhai City, China

[2]Department of Orthopedics, Taizhou Hospital of Zhejiang Province, Affiliated to Wenzhou Medical University, No.150, Ximen Street, Linhai City, China

Received: 19 April 2024 / Accepted: 5 August 2024

Published online: 11 August 2024

References

1. Petermann-Rocha F, Balntzi V, Gray SR, Lara J, Ho FK, Pell JP, Celis-Morales C. Global prevalence of Sarcopenia and severe Sarcopenia: a systematic review and meta-analysis. J Cachexia Sarcopenia Muscle. 2022;13(1):86–99.
2. Beaudart C, Zaaria M, Pasleau F, Reginster JY, Bruyère O. Health outcomes of Sarcopenia: a systematic review and Meta-analysis. PLoS ONE. 2017;12(1):e0169548.
3. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, Cooper C, Landi F, Rolland Y, Sayer AA, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(4):601.
4. Chen Z, Ho M, Chau PH. Prevalence, Incidence, and Associated Factors of Possible Sarcopenia in Community-Dwelling Chinese Older Adults: A Population-Based Longitudinal Study. Front Med (Lausanne). 2021; 8(769708.
5. Sun Y, Li H, Pei Z, Wang S, Feng J, Xu L, Gao P, Cao B, Zhan S. Incidence of community-acquired pneumonia in urban China: a national population-based study. Vaccine. 2020;38(52):8362–70.
6. Nair GB, Niederman MS. Updates on community acquired pneumonia management in the ICU. Pharmacol Ther. 2021; 217(107663.
7. Kera T, Kawai H, Hirano H, Kojima M, Watanabe Y, Motokawa K, Fujiwara Y, Ihara K, Kim H, Obuchi S. Definition of respiratory Sarcopenia with Peak Expiratory Flow Rate. J Am Med Dir Assoc. 2019;20(8):1021–25.
8. Vang P, Vasdev A, Zhan WZ, Gransee HM, Sieck GC, Mantilla CB. Diaphragm muscle sarcopenia into very old age in mice. Physiol Rep. 2020;8(1):e14305.
9. Greising SM, Mantilla CB, Gorman BA, Ermilov LG, Sieck GC. Diaphragm muscle sarcopenia in aging mice. Exp Gerontol. 2013;48(9):881–7.
10. Ohara DG, Pegorari MS, Oliveira Dos Santos NL, de Fátima Ribeiro Silva C, Monteiro RL, Matos AP, Jamami M. Respiratory muscle strength as a discriminator of Sarcopenia in Community-Dwelling Elderly: a cross-sectional study. J Nutr Health Aging. 2018;22(8):952–58.
11. de Santana FM, Premaor MO, Tanigava NY, Pereira RMR. Low muscle mass in older adults and mortality: A systematic review and meta-analysis. Exp Gerontol. 2021; 152(111461.
12. Sayer AA, Cruz-Jentoft A. Sarcopenia definition, diagnosis and treatment: consensus is growing. Age Ageing. 2022; 51(10).
13. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, Cooper C, Landi F, Rolland Y, Sayer AA, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16–31.
14. Cruz-Jentoft AJ, Sayer AA, Sarcopenia. Lancet. 2019;393(10191):2636–46.
15. Kokkinos P, Faselis C, Samuel IBH, Pittaras A, Doumas M, Murphy R, Heimall MS, Sui X, Zhang J, Myers J. Cardiorespiratory Fitness and Mortality Risk across the Spectra of Age, Race, and sex. J Am Coll Cardiol. 2022;80(6):598–609.
16. Nagano A, Wakabayashi H, Maeda K, Kokura Y, Miyazaki S, Mori T, Fujiwara D. Respiratory Sarcopenia and Sarcopenic Respiratory disability: concepts, diagnosis, and treatment. J Nutr Health Aging. 2021;25(4):507–15.
17. Ju S, Lee SJ, Park MJ, Cho YJ, Jeong YY, Jeon KN, Bae K, Lee JD, Kim HC. Clinical importance of cross-sectional area of intercostal muscles in patients with chronic obstructive pulmonary disease. Clin Respir J. 2018;12(3):939–47.
18. Rozenberg D, Mathur S, Herridge M, Goldstein R, Schmidt H, Chowdhury NA, Mendes P, Singer LG. Thoracic muscle cross-sectional area is associated with hospital length of stay post lung transplantation: a retrospective cohort study. Transpl Int. 2017;30(7):713–24.
19. Moon SW, Lee SH, Woo A, Leem AY, Lee SH, Chung KS, Kim EY, Jung JY, Kang YA, Park MS, et al. Reference values of skeletal muscle area for diagnosis of Sarcopenia using chest computed tomography in Asian general population. J Cachexia Sarcopenia Muscle. 2022;13(2):955–65.
20. Kottlors J, Zopfs D, Fervers P, Bremm J, Abdullayev N, Maintz D, Tritt S, Persigehl T. Body composition on low dose chest CT is a significant predictor of poor clinical outcome in COVID-19 disease - A multicenter feasibility study. Eur J Radiol. 2020; 132(109274.
21. Mishra A, Bigam KD, Extermann M, Faramand R, Thomas K, Pidala JA, Baracos VE. Sarcopenia and low muscle radiodensity associate with impaired FEV(1) in allogeneic haematopoietic stem cell transplant recipients. J Cachexia Sarcopenia Muscle. 2020;11(6):1570–79.
22. Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC, Dowell SF, File TM Jr., Musher DM, Niederman MS, et al. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. Clin Infect Dis. 2007;44(Suppl 2):S27–72.

23. Weijs PJ, Looijaard WG, Dekker IM, Stapel SN, Girbes AR, Oudemans-van Straaten HM, Beishuizen A. Low skeletal muscle area is a risk factor for mortality in mechanically ventilated critically ill patients. Crit Care. 2014;18(2):R12.
24. Liu YN, Zhang YF, Xu Q, Qiu Y, Lu QB, Wang T, Zhang XA, Lin SH, Lv CL, Jiang BG, et al. Infection and co-infection patterns of community-acquired pneumonia in patients of different ages in China from 2009 to 2020: a national surveillance study. Lancet Microbe. 2023;4(5):e330–39.
25. Qu J, Zhang J, Chen Y, Huang Y, Xie Y, Zhou M, Li Y, Shi D, Xu J, Wang Q, et al. Aetiology of severe community acquired pneumonia in adults identified by combined detection methods: a multi-centre prospective study in China. Emerg Microbes Infect. 2022;11(1):556–66.
26. Jain S, Self WH, Wunderink RG, Fakhran S, Balk R, Bramley AM, Reed C, Grijalva CG, Anderson EJ, Courtney DM, et al. Community-Acquired Pneumonia requiring hospitalization among U.S. adults. N Engl J Med. 2015;373(5):415–27.
27. Lee JS, Primack BA, Mor MK, Stone RA, Obrosky DS, Yealy DM, Fine MJ. Processes of care and outcomes for community-acquired pneumonia. Am J Med. 2011;124(12):e11759–17.
28. Coletta G, Phillips SM. An elusive consensus definition of sarcopenia impedes research and clinical treatment: A narrative review. Ageing Res Rev. 2023; 86(101883.
29. Ustevic C, Rajovic N, Stanisavljevic D, Tiosavljevic D, Pavlovic A, Tasic R, Rajovic T, Grupkovic J, Pilipovic F, Pejin V et al. From Sarcopenia to depressive symptoms in Elderly: a path analysis. Int J Environ Res Public Health. 2023; 20(2).
30. Laskou F, Fuggle NR, Patel HP, Jameson K, Cooper C, Dennison E. Associations of osteoporosis and sarcopenia with frailty and multimorbidity among participants of the Hertfordshire Cohort Study. J Cachexia Sarcopenia Muscle. 2022;13(1):220–29.
31. Bianchi L, Maietti E, Abete P, Bellelli G, Bo M, Cherubini A, Corica F, Di Bari M, Maggio M, Martone AM, et al. Comparing EWGSOP2 and FNIH Sarcopenia definitions: Agreement and 3-Year Survival Prognostic Value in older hospitalized adults: the GLISTEN Study. J Gerontol Biol Sci Med Sci. 2020;75(7):1331–37.
32. Kitamura A, Seino S, Abe T, Nofuji Y, Yokoyama Y, Amano H, Nishi M, Taniguchi Y, Narita M, Fujiwara Y, et al. Sarcopenia: prevalence, associated factors, and the risk of mortality and disability in Japanese older adults. J Cachexia Sarcopenia Muscle. 2021;12(1):30–8.
33. Nakamura K, Yoshida D, Honda T, Hata J, Shibata M, Hirakawa Y, Furuta Y, Kishimoto H, Ohara T, Kitazono T, et al. Prevalence and mortality of Sarcopenia in a community-dwelling older Japanese Population: the Hisayama Study. J Epidemiol. 2021;31(5):320–27.
34. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010; 39(4):412 – 23.
35. Sabatino A, Cuppari L, Stenvinkel P, Lindholm B, Avesani CM. Sarcopenia in chronic kidney disease: what have we learned so far? J Nephrol. 2021;34(4):1347–72.
36. Bhurchandi S, Kumar S, Agrawal S, Acharya S, Jain S, Talwar D, Lomte S. Correlation of Sarcopenia with modified Frailty Index as a predictor of Outcome in critically Ill Elderly patients: a cross-sectional study. Cureus. 2021;13(10):e19065.
37. Maeda K, Akagi J. Muscle Mass loss is a potential predictor of 90-Day mortality in older adults with aspiration pneumonia. J Am Geriatr Soc. 2017;65(1):e18–22.
38. Ferrer M, Travierso C, Cilloniz C, Gabarrus A, Ranzani OT, Polverino E, Liapikou A, Blasi F, Torres A. Severe community-acquired pneumonia: characteristics and prognostic factors in ventilated and non-ventilated patients. PLoS ONE. 2018;13(1):e0191721.
39. Sabatino A, Pacchiarini MC, Regolisti G, Ciuni A, Sverzellati N, Lesignoli M, Picetti E, Fiaccadori E, Di Mario F. The impact of muscle mass and myosteatosis on mortality in critically ill patients with Sars-Cov2-related pneumonia. Clin Nutr ESPEN. 2023; 58(409 – 15.
40. Chen Z, Li WY, Ho M, Chau PH. The prevalence of Sarcopenia in Chinese older adults: Meta-Analysis and Meta-Regression. Nutrients. 2021; 13(5).
41. Liu X, Hou L, Xia X, Liu Y, Zuo Z, Zhang Y, Zhao W, Hao Q, Yue J, Dong B. Prevalence of Sarcopenia in multi ethnics adults and the association with cognitive impairment: findings from West-China health and aging trend study. BMC Geriatr. 2020;20(1):63.

Publisher's Note