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Based on CT scans at the 12th thoracic spine level, assessing the impact of skeletal muscle and adipose tissue index on one-year postoperative mortality in elderly hip fracture patients: a propensity score-matched multicenter retrospective study

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Abstract

Background Research has demonstrated that individuals with sarcopenia or sarcopenic obesity who experience fractures or undergo major surgical interventions exhibit a poorer prognosis compared to the general population. However, few studies have investigated the relationship between the skeletal muscle and adipose tissue indices, as measured at the 12th thoracic spine level, and adverse outcomes following orthopedic surgery. Therefore, this study aimed to prove whether skeletal muscle and adipose tissue index measured by computed tomography (CT) images based on a single layer are associated with one-year postoperative mortality in elderly hip fracture patients.

Methods A total of 334 participants from two institutions were enrolled in this study to obtain skeletal muscle index (SMI), subcutaneous fat index (SFI), visceral fat index (VFI), and the visceral-to-subcutaneous ratio of the fat area (VSR) at T12 levels and divide them into death and survival groups based on the results of follow-up after 1 year. Propensity score matching (PSM) was employed to evaluate one-year postoperative mortality.

Results Institution 1's results identified that a lower SMI significantly heightened the risk of one-year postoperative mortality (OR = 0.799,95%CI 0.677–0.943, $P = 0.008$), making SMI an independent predictor. Institution 2's results

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identified that age (OR = 1.081, 95%CI 1.005–1.163, $P = 0.036$), SMI (OR = 0.881, 95%CI 0.784–0.991, $P = 0.035$) as independent predictors of one-year postoperative mortality in elderly hip fracture. Receiver operator characteristics analysis revealed area under the curve (AUC) values for institution 1: SMI (0.738 (95%CI 0.626–0.851), significant), VFI (0.605 (95%CI 0.476–0.734)), VSR (0.583 (95%CI 0.451–0.715)); and for institution 2: SMI (0.742 (95%CI 0.612–0.872), significant) and Age (0.775 (95%CI 0.677–0.874), significant). Collectively, these results underscore that SMI serves as an independent predictor of one-year postoperative mortality in elderly hip fracture patients.

Conclusion This study demonstrated that the T12-based SMI was independently associated with one-year mortality following hip fracture in geriatric patients, with lower preoperative SMI correlating with higher mortality rates post-surgery.

Keywords Hip fracture, Skeletal muscle index, Sarcopenia, Computed tomography, Mortality

Introduction

With the world's population aging, hip fractures have become a significant cause of death in the elderly [1]. Hip fractures can be classified into two main anatomical types: intertrochanteric fractures (extracapsular) and femoral neck fractures (intracapsular). These two types differ significantly in incidence, surgical trauma, and postoperative prognosis [2–5]. Hip fracture is considered the most devastating among the fragility fractures. Studies have shown that the type of hip fracture is an independent predictor of 1-year postoperative mortality [4]. The elderly are at a higher risk of dying after hip fracture surgery due to multiple comorbidities such as cognitive impairment, dementia, etc [6, 7]. The mortality rate of elderly patients with hip fractures is as high as 30% one year postoperatively [8]. 87–96% of hip fracture patients are 65 years of age or older [9].

Sarcopenia is a syndrome caused by the continued loss of skeletal muscle mass, strength, and function [10]. Adults over 40 lose about 1% of their skeletal muscle mass each year [11].The condition of sarcopenia is often accompanied by an increase in fat mass (FM) and may be worsened by obesity, known as sarcopenic obesity (SO) [12]. Research has demonstrated that individuals with sarcopenia or sarcopenic obesity who experience fractures or undergo major surgical interventions exhibit a poorer prognosis compared to the general population(e.g. increased mortality and poorer quality of life) [12–14].

During the acute phase of a hip fracture, patients often can't complete sarcopenia mobility tests, and many hospitals don't have dual energy x-ray absorptiometry (DXA) to measure muscle mass [15]. Clinical guidelines recommend using either computed tomography (CT) or magnetic resonance imaging (MRI) for measuring muscle and fat mass [16, 17], In clinical practice, chest CT scans are more frequently utilized than abdominal and thigh CT scans. Elderly patients with multiple comorbidities often undergo chest CT scans to opportunistically diagnose other conditions prior to surgery. Opportunistic chest CT images would be an overlooked resource [18]. Meanwhile, It is more practical to select an optimal level of axial CT images to represent the whole-body muscle and nutritional status [19]. Few studies have examined whether the 12th thoracic spine level skeletal muscle and adipose tissue indexes (the area of muscle or adipose tissue at the T12 level divided by the square of height) are associated with adverse outcomes following orthopaedical surgery [20].

This study aimed to evaluate whether muscle and adipose tissue indexes derived from chest CT scans were independently associated with one-year postoperative mortality in elderly patients with hip fractures, thereby aiding clinicians in identifying high-risk individuals and tailoring treatment plans(nutritional supplementation、resistance training and vibration therapy) [13, 21, 22].

Methods

Study design

After approval by the institutional review boards of the Second Affiliated Hospital of Wenzhou Medical University (Institution 1) and Affiliated Yueqing Hospital of Wenzhou Medical University (Institution 2), we conducted a multicenter retrospective study to collect patients older than 60 who underwent thoracic CT, from January 2023, and April 2023. Method of subject allocation: patients were divided into 2 groups, the control group (surviving patients) and the experimental group (deceased patients), based on the results of follow-up after 1 year. Mortality was identified by interviewing a member of the family of the patient involved. The inclusion criteria were: (1) age≥60 years; (2) hip fracture clearly diagnosed by X-ray or CT, etc. (3) complete follow-up and clinical data; The exclusion criteria were: (1) chest CT examination was not performed; (2) refusal of surgery; (3) artifacts on CT images. Figure 1 shows the flow chart of this research method.

Skeletal muscle and adipose index measurements

Unenhanced chest CT image data were collected using the Philips Brilliance 16 CT scanner (Philips Medical Systems, Eindhoven, the Netherlands), operated at 120 kV

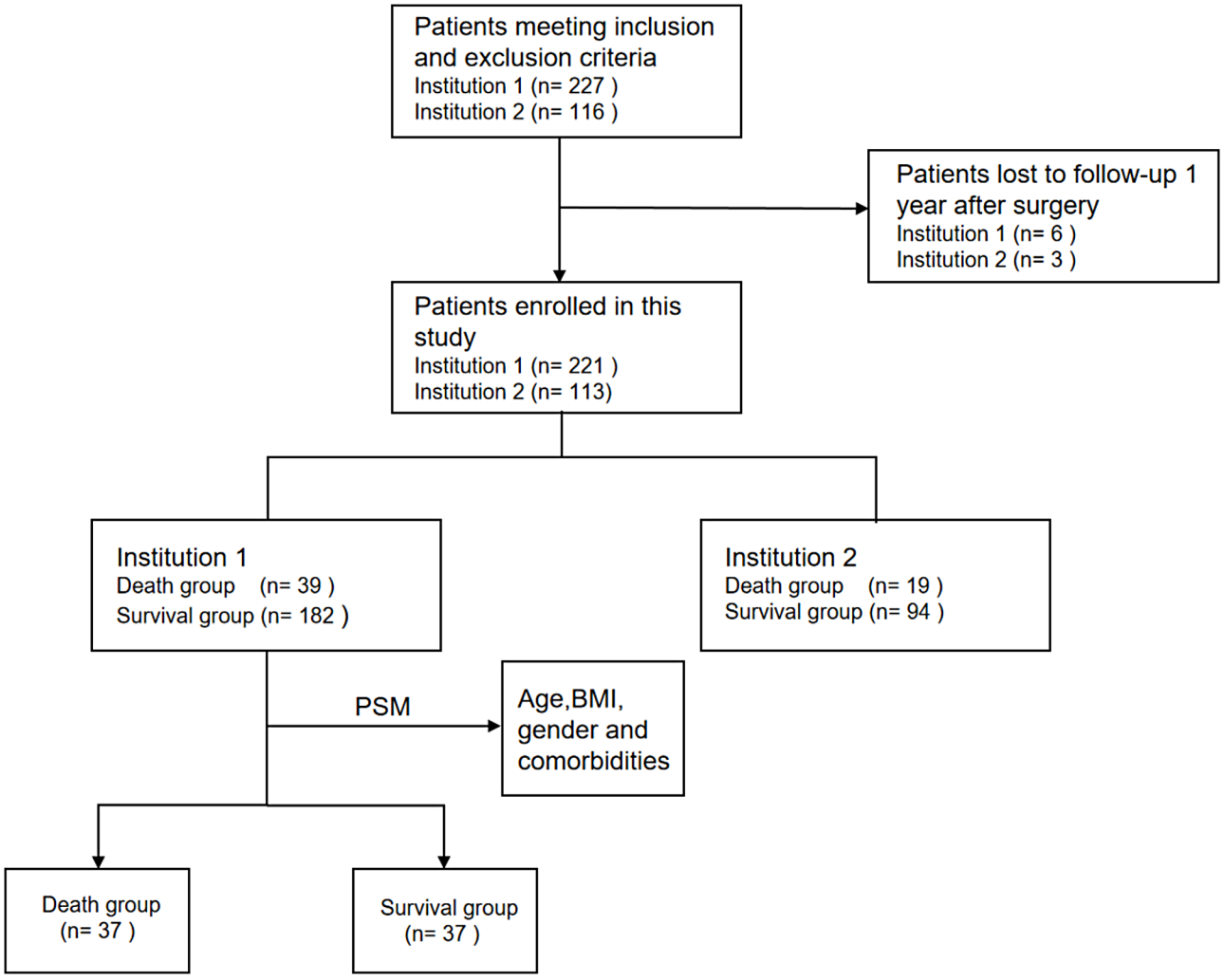

Fig. 1 The flow chart of this study

and 250 mA with a 5 mm slice thickness, and archived via its picture archiving and communication system. Image J (NIH Image J v1.52c) software was used to measure the cross-sectional areas of skeletal muscle, subcutaneous fat, and visceral fat at the horizontal plane of the T12 vertebral body's midsection (Fig. 2). Based on previous studies [23], the thresholds for skeletal muscle and adipose tissue were −29HU to 150HU and −150HU to -50HU, respectively. The areas measured were then divided by the square of the patient's height (m^2) to calculate the skeletal muscle index (SMI) and subcutaneous fat index (SFI), and visceral fat index (VFI). The visceral-to-sub. cutaneous ratio of the fat area (VSR) was also calculated. Two experts, each with over 5 years of clinical experience and proficiency in Image J software, collaborated: one outlined skeletal muscle, subcutaneous fat, and visceral fat on CT images, while the other checked the results of the contours.

Statistical analysis

The Shapiro-Wilk test was employed to assess the normality of data distribution. Baseline characteristics of the patients were described using median and interquartile range (IQR), mean ± standard deviation (SD), and counts with percentages (n, %). Continuous variables were analyzed using either the Mann-Whitney U test or the t-test, contingent upon the data distribution. Categorical variables were examined using the Pearson Chi-square test or Fisher's exact test. Binary logistic regression was utilized to investigate the associations between SMI, SFI, VFI, VSR, and mortality, with p-values less than 0.05 considered statistically significant. The predictive efficacy of each metric for mortality was evaluated utilizing the Receiver Operating Characteristic (ROC) curve. All statistical analyses were conducted using SPSS software (version 27.0; IBM Corp., Armonk, NY, USA).

Propensity score matching (PSM), a method frequently employed in observational studies to balance potential

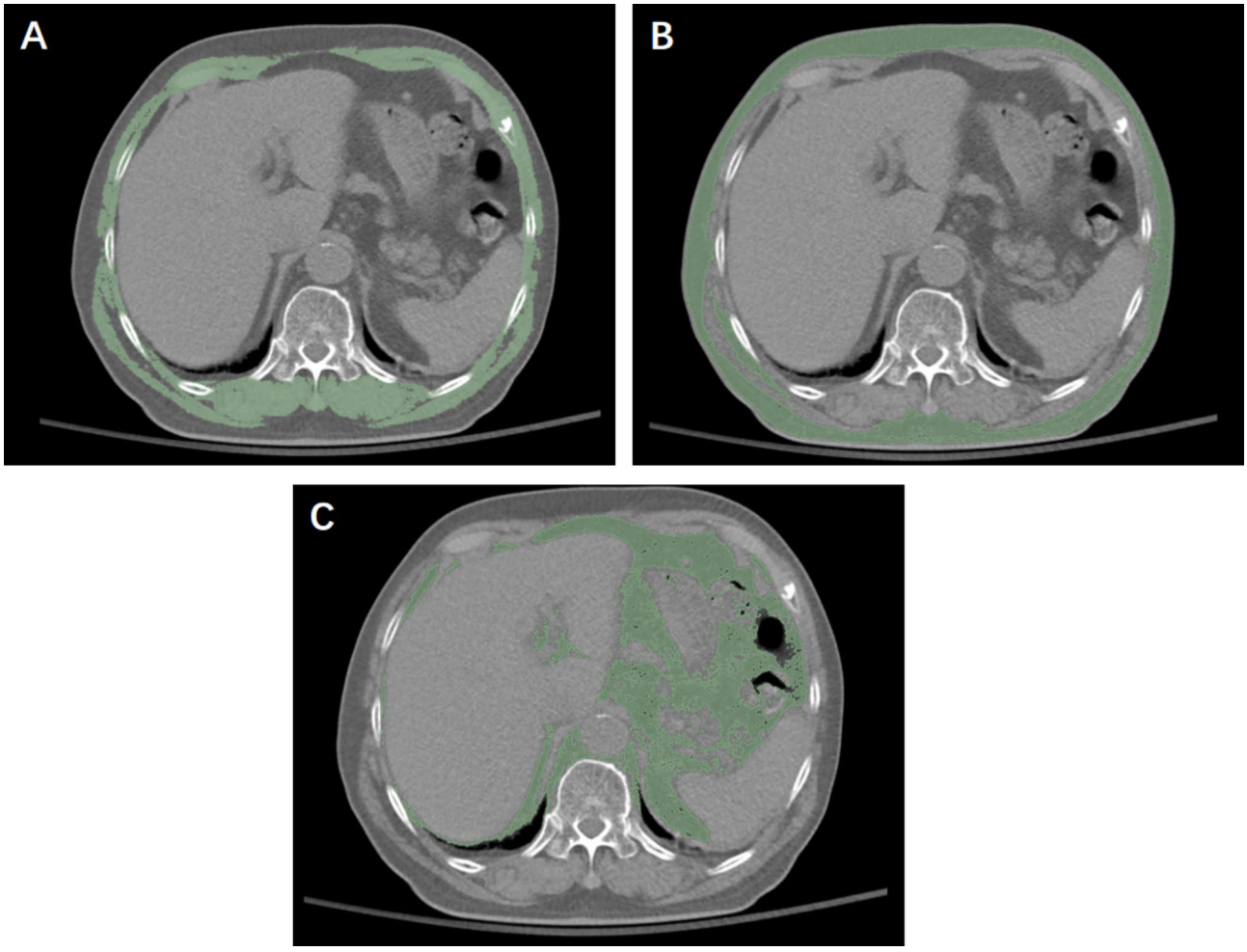

Fig. 2 Measurement of the skeletal muscle index (**A**), subcutaneous fat index (**B**) and visceral fat index (**C**) using computed tomography at the T12 level

confounders between groups, was applied in this study. Seventeen covariates were included in the analysis: age, gender, body mass index (BMI), smoking status, alcohol consumption, hypertension, diabetes mellitus, hyperlipidemia, cardiac disease, digestive system disorders, stroke, respiratory system disorders, rheumatic system disorders, renal disease, dementia, Parkinson's disease, and tumors. Based on these covariates, a logistic regression-based propensity score was utilized, and nearest neighbor matching was employed to generate pairs of subjects in the survivor and mortality groups, with a caliper value of 0.03. Propensity score matching (PSM) was conducted using IBM SPSS Statistics version 27.0.

Results

Institution 1

After thorough screening, 221 patients were enrolled at institution 1. They were divided into two groups based on whether they died one year after surgery: 39 died and 182 survived. The only significant difference between the two groups was age (88 versus 78 $p<0.001$). To minimize confounders and bias, we included age, gender, BMI, and comorbidities in the PSM analysis, matching them 1:1 with a caliper of 0.03. This resulted in a well-matched cohort of 37 cases, with no significant differences in age, gender, BMI, smoking, drinking, or comorbidities after matching (Table 1).

Using Image J software, we compare skeletal muscle, fat indices between two groups (Table 2). Before matching, the death group had lower SMI, VFI, and VSR values and a higher ASA score than the survival group (25.54 versus 30.61 $p<0.001$; 35.63 versus 54.51 $p=0.005$; 1.81 versus 2.16 $p=0.024$), while SFI, LOS, surgery duration, intraoperative blood loss, intraoperative blood transfusion, anesthesia, fracture type and surgical procedure showed no significant differences. After matching, only the SMI value remained lower in the death group (25.54 versus 30.16 $p<0.001$), with no significant differences in other indicators.

Conditional logistic regression models were created using SMI, VFI, and VSR (Table 3). Results showed that lower SMI significantly increased the risk of one-year

Table 1 Clinical baseline characteristics of the raw cohort samples and propensity matched participants at institutions 1

	Institution 1			Propensity-matched institution 1		
variable	**Death group($n=39$)**	**Survival group($n=182$)**	**P value**	**Death group($n=37$)**	**Survival group($n=37$)**	**P value**
Age, (years)	88(82–91)	78(70–85)	< 0.001	88(82-90.5)	86(81.5–89.5)	0.974
BMI, (kg/m^2)	20.51(18.67–23.44)	21.85(19.61–24.45)	0.220	20(18.52–23.44)	20.23(18.52–24.48)	0.766
Gender, n(%)			0.149			1
Female	24(61.5)	133(73.1)		24(64.9)	24(64.9)	
Male	15(38.5)	49(26.9)		13(35.1)	13(35.1)	
Current smoking, n(%)	2(5.1)	8(4.4)	0.842	2(5.4)	1(2.7)	0.556
Current drinking, n(%)	2(5.1)	7(3.8)	0.713	2(5.4)	2(5.4)	1
Hypertension, n(%)	22(56.4)	101(55.5)	0.917	20(54.1)	21(56.8)	0.815
Diabetes, n(%)	7(17.9)	46(25.3)	0.331	7(18.9)	3(8.1)	0.174
Hyperlipidemia, n(%)	1(2.6)	4(2.2)	0.889	1(2.7)	0(0)	0.314
Cardiac diseases, n(%)	7(17.9)	21(11.5)	0.275	6(16.2)	6(16.2)	1
Stroke, n(%)	3(7.7)	19(10.4)	0.603	3(8.1)	3(8.1)	1
Peptic diseases, n(%)	2(5.1)	13(7.1)	0.650	2(5.4)	2(5.4)	1
Respiratory diseases, n(%)	4(10.3)	15(8.2)	0.684	4(10.8)	5(13.5)	0.722
Rheumatic diseases, n(%)	1(2.6)	6(3.3)	0.813	1(2.7)	2(5.4)	0.556
Renal Disease, n(%)	1(2.6)	10(5.5)	0.445	1(2.7)	2(5.4)	0.556
Dementia, n(%)	3(7.7)	4(2.2)	0.075	3(8.1)	2(5.4)	0.643
Parkinsonism, n(%)	2(5.1)	5(2.7)	0.441	2(5.4)	3(8.1)	0.643
Cancer, n(%)	2(5.1)	13(7.1)	0.650	2(5.4)	2(5.4)	1

Abbreviation, BMI, body mass index

Table 2 The skeletal muscle indices, adipose indices and intraoperative characteristics of the raw cohort samples and propensity matched participants at institutions 1

	Institution 1			Propensity-matched institution 1		
variable	**Death group($n=39$)**	**Survival group($n=182$)**	**P**	**Death group($n=37$)**	**Survival group($n=37$)**	**P value**
SMI, (cm^2/m^2)	25.54(21.53–28.86)	30.61(26.13–34.16)	< 0.001	25.54(21.52–28.86)	30.16(26.17–34.90)	< 0.001
VFI, (cm^2/m^2)	35.63(21.71–60.99)	54.51(31.81–81.28)	0.005	41.47(21.34–63.70)	47.66(29.31–78.14)	0.121
SFI, (cm^2/m^2)	18.63(8.79–31.61)	21.23(13.16–38.38)	0.103	18.63(7.73–32.04)	19.85(12.21–43.02)	0.220
VSR	1.81(1.53–2.50)	2.16(1.79–2.72)	0.024	1.91(1.63–2.51)	2.10(1.82–2.65)	0.220
LOS	8(7–11)	8(7–10)	0.435	8(7–11)	7(6–10)	0.228
Surgery duration, (hours)	60(60–90)	60(60–80)	0.830	60(60–80)	60(60–80)	0.452
Intraoperative blood Loss, (ml)	100(100–200)	100(100–200)	0.401	100(100–200)	100(100–200)	0.437
Intraoperative blood transfusion, n(%)	4(10.3)	21(11.5)	0.819	9(24.3)	4(10.8)	0.127
ASA score, n(%)			0.002			0.348
I or II	19(48.7)	135(74.2)		19(51.4)	23(62.2)	
III or above	20(51.3)	47(25.8)		18(48.6)	14(37.8)	
Anesthesia, n(%)			0.834			1
General anesthesia	16(41.0)	78(42.9)		16(43.2)	16(43.2)	
Other anesthesia method	23(59.0)	104(57.1)		21(56.8)	21(56.8)	
Fracture type, n(%)			0.101			0.816
Intertrochanteric fracture	21(53.8)	72(39.6)		19(51.4)	18(48.6)	
Femoral neck fracture	18(46.2)	110(60.4)		18(48.6)	19(51.4)	
Surgical procedure, n(%)			0.245			0.787
PFNA	21(53.8)	72(39.6)		19(51.4)	18(48.6)	
Hip arthroplasty	16(41.0)	94(51.6)		16(43.2)	18(48.6)	
Cannulated screws	2(5.1)	16(8.8)		2(5.4)	1(2.7)	

Abbreviation, SMI, Skeletal muscle index; VFI, Visceral fat index; SFI, Subcutaneous fat index; VSR, Visceral-to-subcutaneous ratio of fat area; LOS, Length of stay hospital; ASA, American Society of Anesthesiologists; PFNA, Proximal Femoral Nail Antirotation

Table 3 Conditional logistic regression analysis of selected skeletal muscle indices and adipose indices

Influence factors	B	S.E	Ward	OR	95%CI	*P*
SMI, (cm^2/m^2)	-0.224	0.084	7.058	0.799	0.677–0.943	0.008
VFI, (cm^2/m^2)	-0.024	0.013	3.449	0.976	0.952–1.001	0.063
VSR	-0.825	0.448	3.388	0.438	0.182–1.055	0.066

Abbreviation, SMI, Skeletal muscle index; VFI, Visceral fat index; VSR, Visceral-to-subcutaneous ratio of fat area

postoperative mortality (OR=0.799,95%CI 0.677–0.943, *P*=0.008), making SMI an independent predictor. VFI (OR=0.976,95%CI 0.952–1.001, *P*=0.063) and VSR (OR=0.438,95%CI 0.182–1.055, *P*=0.066) did not significantly affect the risk.

Institution 2

A total of 113 patients were enrolled at institution 2. Patients were divided into two groups based on whether they died one year after surgery: 19 died and 94 survived. There were statistically significant differences between the two groups in age, SMI, VSR, surgery duration, intraoperative blood loss, ASA score (all P values<0.05). Moreover, there were no statistically significant differences between the two groups in BMI, VFI, SFI, LOS, intraoperative blood transfusion, gender, anesthesia, fracture type, surgical procedure, smoking, drinking (Details are shown in Table 4).

Age, SMI, VSR, SFI, Surgery duration, intraoperative blood loss, ASA score were analyzed during the univariate analysis (Table 5). The significant parameters ($p<0.05$): Age, SMI, VSR, ASA score was included in multiple logistic regression analysis. The results showed that age (OR=1.081, 95%CI 1.005–1.163, *P*=0.036), SMI (OR=0.881, 95%CI 0.784–0.991, *P*=0.035) were independent predictors of one-year postoperative mortality in elderly hip fracture patients.

Receiver operator characteristics analysis

Table S1-S2 presents the accuracy of various indices in predicting one-year postoperative mortality. Using death or survival as the state variable, ROC curves (Figs. 3–4) were plotted for Institution 1 (tested with SMI, VFI, VSR) and Institution 2 (tested with SMI, Age). The ROC analysis revealed area under the curve (AUC) values for Institution 1: SMI (0.738 (95%CI 0.626–0.851), significant), VFI (0.605 (95%CI 0.476–0.734)), VSR (0.583 (95%CI 0.451–0.715)). For Institution 2: SMI (0.742 (95%CI 0.612–0.872), significant), Age (0.775 (95%CI 0.677–0.874), significant). Additionally, for Institution 1, at the optimal cut-off value of 29.065, SMI achieved a positive predictive value (PPV) of 0.667 (95% CI: 0.529–0.804) and a negative predictive value (NPV) of 0.759 (95% CI: 0.603–0.914). In Institution 2, with a cut-off value of 28.653, SMI demonstrated a PPV of 0.613 (95% CI: 0.441–0.784) and an NPV of 0.085 (95% CI: 0.025–0.146). These findings indicate that SMI was an independent predictor of one-year postoperative mortality in elderly hip fracture patients.

Discussion

This study analyzed the preoperative clinical characteristics, as well as surgical and anesthesia records, of patients who underwent hip fracture surgery between January and April 2023. The findings indicate that SMI was an independent predictor of worse survival in patients, even after adjusting for age, comorbidities, and other relevant factors. Both Institution 1 and Institution 2 independently demonstrate that a 1-unit decrease in SMI is significantly associated with an increased 1-year mortality risk following hip fracture surgery in elderly patients. Specifically, mortality risk increases by approximately 20.1% (OR=0.799) and 11.9% (OR=0.881), respectively. In contrast, VFI, SFI, and VSR were found to have no significant relevance.

Sarcopenia, a condition marked by reduced muscle mass and function linked to frailty, can impair physical function, lower quality of life, and raise mortality rates [24, 25]. Previous studies indicate a 37% prevalence of sarcopenia in hip fracture patients aged 65 and over [15]. Age-related muscle loss is a key factor in hip fractures and leads to poor outcomes post-surgery, such as refractures, complications, and death [26–28]. Ursula et al. reported that measurements of SMI at the T12 vertebra could facilitate the diagnosis of sarcopenia and may aid in guiding long-term prognostication in geriatric trauma patients [29, 30]. Over the past few decades, sarcopenia has been investigated for its predictive value in cancer patients [31, 32]. Limited research exists on sarcopenia's impact on postoperative mortality in elderly hip fracture patients, necessitating further investigation into its relationship with orthopedic procedures.

Previous research has established a strong correlation between adipose tissue and poor postoperative outcomes. Increased adipose mass has been shown to negatively impact the immune system and impairs the adaptation to surgical stress, thereby elevating the risk of infection, poor wound healing, and delayed recovery [33–35], Furthermore, while certain studies have indicated that adipose-related parameters exert a significant positive influence on bone mineral density, other investigations have reported either a negative correlation or no significant relationship between adipose tissue and bone mass [36, 37]. BMI has traditionally been used as an

Table 4 Clinical baseline characteristics, skeletal muscle indices, adipose indices and intraoperative characteristics of the participants at institutions 2

	Institution 2		
variable	**Death group(*n* = 19)**	**Survival group(*n* = 94)**	**P**
Age, (years)	84(82–88)	74.5(67.5–84)	< 0.001
BMI, (kg/m^2)	21.80(19.47–25.71)	22.55(20.45–24.54)	0.735
SMI, (cm^2/m^2)	27.95 ± 5.22	32.64 ± 5.60	0.001
VFI, (cm^2/m^2)	25.56(9.66–39.59)	28.83(18.10-39.67)	0.434
SFI, (cm^2/m^2)	14.35(5.19–42.14)	25.82(16.65–41.97)	0.076
VSR	1.58(1.03–2.42)	0.91(0.59–1.46)	0.004
LOS	12(10–18)	11(9–16)	0.717
Surgery duration, (hours)	60(50–80)	80(57.25-101.25)	0.027
Intraoperative blood loss, (ml)	100(50–100)	100(100–200)	0.034
Intraoperative blood transfusion, n(%)	1(5.3)	10(10.6)	0.898
Gender, n(%)			0.104
Female	9(47.4)	63(67.0)	
Male	10(52.6)	31(33.0)	
ASA score, n(%)			0.015
I or II	14(73.7)	87(92.6)	
III or above	5(26.3)	7(7.4)	
Anesthesia, n(%)			0.430
General anesthesia	0(0.0)	3(2.7)	
Other anesthesia method	19(100)	91(96.8)	
Fracture type, n(%)			0.189
Intertrochanteric fracture	11(57.9)	39(41.5)	
Femoral neck fracture	8(42.1)	55(58.5)	
Surgical procedure, n(%)			0.249
PFNA	11(57.9)	39(41.5)	
Hip arthroplasty	8(42.1)	47(50.0)	
Cannulated screws	0(0.0)	8(8.5)	
Current smoking, n(%)	1(5.3)	7(7.4)	0.735
Current drinking, n(%)	0(0.0)	8(8.5)	0.187
Hypertension, n(%)	6(31.6)	49(52.1)	0.102
Diabetes, n(%)	6(31.6)	27(28.7)	0.803
Hyperlipidemia, n(%)	1(5.3)	8(8.5)	0.626
Cardiac diseases, n(%)	4(21.1)	8(8.5)	0.106
Stroke, n(%)	3(15.8)	8(8.5)	0.117
Peptic diseases, n(%)	1(5.3)	1(1.1)	0.205
Respiratory diseases, n(%)	3(15.8)	8(8.5)	0.329
Rheumatic diseases, n(%)	0(0.0)	2(2.1)	0.521
Kidney Disease, n(%)	1(5.3)	8(8.5)	0.633
Dementia, n(%)	0(0.0)	4(4.3)	0.360
Parkinsonism, n(%)	1(5.3)	3(3.2)	0.656
Cancer, n(%)	4(21.1)	10(10.6)	0.209

Abbreviation, BMI, body mass index; SMI, Skeletal muscle index; VFI, Visceral fat index; SFI, Subcutaneous fat index; VSR, Visceral-to-subcutaneous ratio of fat area; LOS, Length of stay hospital; ASA, American Society of Anesthesiologists; PFNA, Proximal Femoral Nail Antirotation

indicator of obesity, without accounting for the distinct proportions of adipose tissue and skeletal muscle within body composition, rendering it an imprecise measure of body adipose tissue [36]. In contrast, contemporary techniques allow for the direct measurement of VFI, SFI, and VSR via CT, providing a more accurate representation of body adipose tissue [38, 39]. Consequently, this study incorporated VFI, SFI, and VSR metrics. Unexpectedly, however, VFI, SFI, and VSR the T12 level alone did not serve as valid predictors of one-year postoperative mortality.

Hip fracture is considered one of the most severe complications of osteoporosis. Osteoporosis and hip fractures share common risk factors with various chronic diseases, including diabetes mellitus, pulmonary disorders, dementia, and cancer [40]. Furthermore, approximately

Table 5 Univariate and multifactorial logistic regression of risk factors for postoperative mortality

	Univariable			Multivariable		
Influence factors	OR	95%CI	P	OR	95%CI	P
Age, (years)	1.127	1.050–1.210	< 0.001	1.081	1.005–1.163	0.036
SMI, (cm^2/m^2)	0.841	0.753–0.940	0.002	0.881	0.784–0.991	0.035
VSR	1.666	1.069–2.597	0.024	1.523	0.880–2.637	0.133
SFI, (cm^2/m^2)	0.976	0.947–1.006	0.120			
Surgery duration, (hours)	0.992	0.976–1.008	0.320			
Intraoperative blood loss, (ml)	1.000	0.996–1.004	0.995			
ASA score, n(%)	4.439	1.235–15.947	0.022	2.932	0.660-13.018	0.157

Abbreviation, SMI, Skeletal muscle index; SFI, Subcutaneous fat index; VSR, Visceral-to-subcutaneous ratio of fat area; ASA, American Society of Anesthesiologists

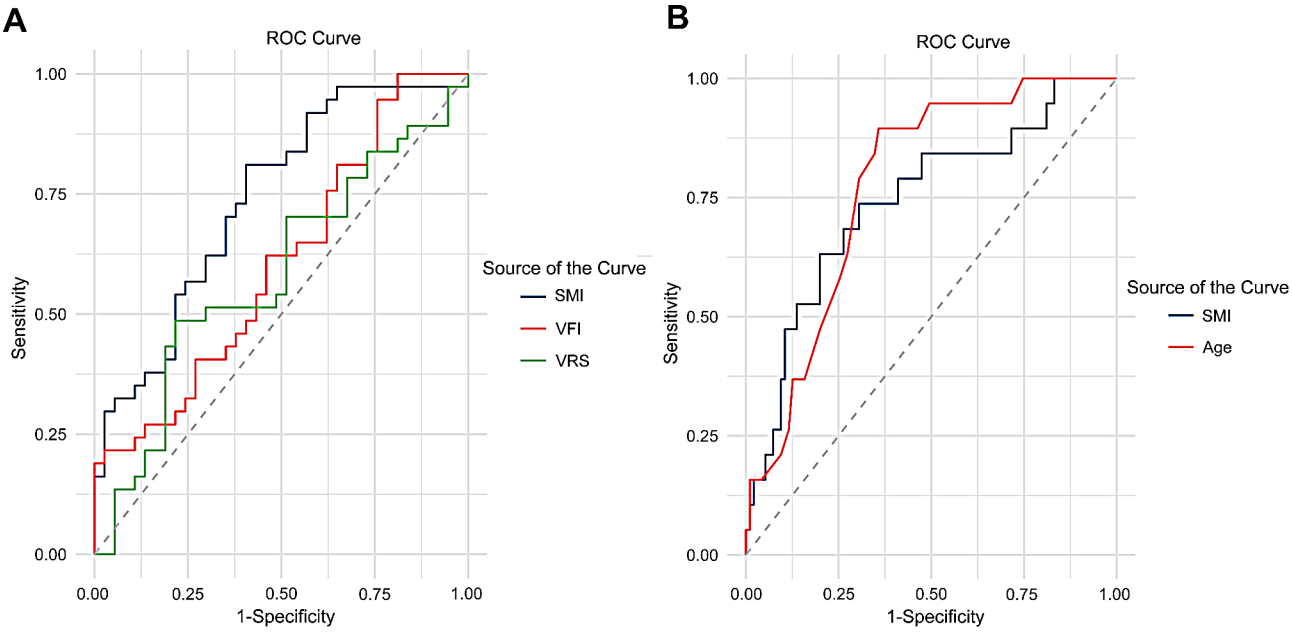

Fig. 3 Receiver operator characteristics (ROC) analysis of SMI, Age, VFI and VSR to predict one-year postoperative mortality. (**A**) The ROC curves were plotted for Institution 1 (tested with SMI, VFI, and VSR). (**B**) The ROC curves were plotted for Institution 2 (tested with SMI and Age). Abbreviation: SMI, Skeletal muscle index; VFI, Visceral fat index; VSR, Visceral-to-subcutaneous ratio of fat area

45–60% of hip fracture patients have one or more comorbidities [41]. Numerous studies have demonstrated a significant association between pre-fracture comorbidities and increased postoperative mortality [41, 42]. Pre-existing conditions such as heart disease, dementia, kidney disease, and chronic obstructive pulmonary disease have been identified as independent predictors of one-year postoperative mortality [42, 43]. In contrast, other studies attribute increased postoperative mortality among hip fracture patients to factors such as the fracture itself, short-term postoperative complications, and socioeconomic status [44, 45]. In our study, preoperative comorbidities were also considered; however, the results revealed no significant association between these comorbidities and increased one-year postoperative mortality following hip fracture surgery.

There is increasing concern regarding frailty and body composition in contemporary discussions, particularly in relation to their impact on treatment outcomes. This study aimed to evaluate whether muscle and adipose tissue indices, as derived from chest CT scans, are independently associated with adverse postoperative outcomes in elderly patients with hip fractures. The findings aim to help clinicians identify high-risk groups and customize prevention and treatment plans for sarcopenia, focusing on nutrition, muscle strength, and functional recovery [21, 22, 46]. Strategies may include specific nutritional supplements and personalized exercise therapy. It is advisable for surgeons to collaborate with rehabilitation physicians and dietitians during the preoperative assessment and subsequent medical care of elderly patients with sarcopenia.

This study has the following limitations: Firstly, this is a retrospective study, which is susceptible to selection bias and recall bias. However, our team employed PSM analysis and multiple statistical methods to minimize the incidence of bias. Secondly, the study measured skeletal muscle and adipose tissue area exclusively at the

T12 level, which may not accurately represent the overall muscle mass and fat mass of the entire body. Lastly, the study included a limited number of eligible patients, indicating the need for further prospective studies with larger sample sizes for validation.

Conclusion

Our study demonstrated that the T12-based SMI was independently associated with one-year mortality following hip fracture in geriatric patients, with lower preoperative SMI correlating with higher mortality rates post-surgery. Preoperative SMI holds potential as a critical prognostic tool for early risk stratification and guiding subsequent care.

Abbreviations

BMI	Body mass index
SMI	Skeletal muscle index
VFI	Visceral fat index
SFI	Subcutaneous fat index
VSR	Visceral-to-subcutaneous ratio of fat area
LOS	Length of stay hospital
ASA	American Society of Anesthesiologists
PFNA	Proximal femoral nail antirotation
DXA	Dual energy x-ray absorptiometry
SO	Sarcopenic obesity
CT	Computed tomography
MRI	Magnetic resonance imaging
FM	Fat mass
ROC	Receiver operating characteristic
PSM	Propensity score matching

Supplementary Information

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Table S1

Table S2

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Author contributions

AAll authors contributed to the study conception and design. En-Li Li: Conceptualization, Data curation, Formal analysis, Writing-original draft. Cheng-Bin Huang and Jia-Sen Hu: Formal analysis, Methodology. Zi-Hao Chen: Validation, Visualization, Data curation. Chen Jin: Validation, Resources. Run-Xun Ma: Investigation, Resources, Supervision. Si-Xiang Feng and Ya-Ping Jin: Project administration, Resources, Supervision. Lei Yang: Conceptualization, Funding acquisition, Writing - review & editing.

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Data availability

The datasets analyzed in the study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the guidelines and was approved by the Ethics Committee of The Second Affiliated Hospital of Wenzhou Medical University (2024LYYJ116) and Affiliated Yueqing Hospital of Wenzhou Medical University (YQYY202400128). As this was a retrospective study and access to the patients was not possible, the Ethics Committee of The Second Affiliated Hospital of Wenzhou Medical University and Affiliated Yueqing Hospital of Wenzhou Medical University waived the need for informed consent.

Consent for publication

Not applicable.

Clinical trial number

Not applicable.

Competing interests

The authors declare no competing interests.

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