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Original Article

Associations among Preoperative Malnutrition, Muscle Loss, and Postoperative Walking Ability in Intertrochanteric Fractures: A Retrospective Study

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Sarcopenia and malnutrition are increasing in older adults and are reported risk factors for functional impairment after hip fracture surgery. This study aimed to investigate the associations between skeletal muscle mass loss, malnutrition, and postoperative walking ability in patients with hip fracture. We retrospectively reviewed patients who underwent intertrochanteric fracture surgery at our institute. The psoas muscle index, controlling nutritional status score, and functional ambulation category (FAC) were used to evaluate skeletal muscle mass, nutritional status, and walking ability, respectively. Six months after surgery, walking ability was assessed as either "gait disturbance" or "independent gait". Multivariate binomial logistic regression analysis, with skeletal muscle mass, nutritional status, and other factors, was used to predict the risk of being assigned to the gait disturbance group. This study included 95 patients (mean age, 85.2 years; 70 women). Sixty-six patients had low skeletal muscle mass, 35 suffered from malnutrition, and 28 had both. Malnutrition and low skeletal muscle mass were significantly associated with postoperative gait disturbance (FAC < 3). Preoperative low skeletal muscle mass and malnutrition were risk factors for postoperative poor walking ability. Further preventive interventions focusing on skeletal muscle mass and nutritional status are required.

Key words: sarcopenia, nutrition, geriatric hip fracture, psoas muscle index, controlling nutritional status score

The global incidence of hip fractures has steadily increased from 1.26 million in 1990 and is projected to reach 4.5 million by 2050; hence, hip fracture can be said to represent a global public health issue [1]. Many patients with hip fractures lose their walking ability and have difficulty returning to independent community living. Patients with intertrochanteric fractures are at greater risk of functional loss six months after surgery than those with femoral neck fractures [2]. Therefore, assessing the risk factors for functional impairment after intertrochanteric fracture surgery is clinically important.

Sarcopenia is defined as an age-related loss of skele-

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tal muscle mass and function [3] and is one of the reported risk factors for poor outcomes after intertrochanteric fractures, including physical disability, poor quality of life, and mortality [4].

Malnutrition is also associated with poor functional outcomes, complications, and mortality after hip fractures [5]. Previous reports have indicated that the controlling nutritional status (CONUT) score is a reliable and objective tool that represents nutritional status and general condition [6,7] and helps predict mortality and postoperative complications after hip fracture surgery [8,9].

Although low skeletal muscle mass and poor nutritional status have been shown to be associated with poor functional outcomes, few studies have reported the associations among skeletal muscle mass, nutritional status, and postoperative walking ability specifically. This study aimed to investigate the associations among skeletal muscle mass, nutritional status, and walking ability after surgical treatment of geriatric intertrochanteric fractures.

Materials and Methods

Study participants. The medical records of patients 65 years of age or older who had undergone surgery for intertrochanteric fractures at our institute (31A1 and 31A2 fractures according to the AO/OTA classification) between January 2015 and June 2020 were retrospectively reviewed. The records of 126 patients were screened. The exclusion criteria were as follows: (1) less than six months of follow-up, (2) severe dementia, difficulty in understanding instructions and rehabilitation, (3) high-energy trauma or pathological fracture, (4) inability to walk without assistance before the injury, and (5) nonunion or implant failure after surgery. Thirty-one patients were excluded, leaving 95 patients as subjects for this study (Fig. 1).

Assessment of skeletal muscle mass. The psoas muscle index (PMI), which uses the area of the psoas muscles at the level of the L3 vertebra, is reported to be strongly associated with skeletal muscle mass. PMI can be used to represent whole-body skeletal muscle mass [10] and to diagnose sarcopenia [11]. The PMI was calculated by dividing the patient's cross-sectional area of the bilateral psoas muscles on computed tomography (CT) by the patient's height squared (cm^2/m^2) (Fig. 2) [11,12]. The cross-sectional area of the bilateral psoas muscles was measured by applying the free-hand region-of-interest tool of the Picture Archiving and Communication System to the CT taken upon admission (Liber Works Co., Tokyo), selecting the slice in which the spinous process was most contiguous with the

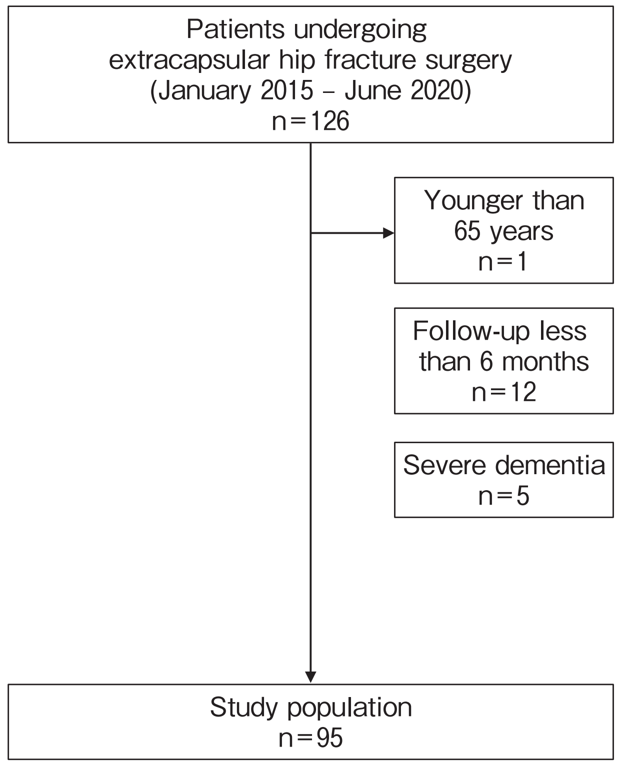

Fig. 1 Flowchart of the study population and patient recruitment process.

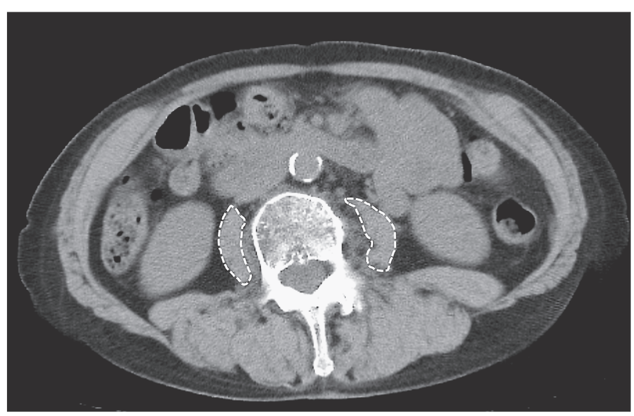

Fig. 2 Measurement of the psoas muscle index using cross-sectional computed tomography images at the L3 level.

L3 vertebral body. Low muscle mass was defined as a PMI lower than 6.36 cm^2/m^2 in men and 3.92 cm^2/m^2 in women per the criteria reported by Hamaguchi *et al.* [11].

Assessment of nutritional status. Preoperative CONUT scores were calculated using blood samples on admission. The serum albumin concentration, peripheral lymphocyte count, and total cholesterol concentration were assessed. According to the severity of decrease, the lymphocyte count and total cholesterol concentration were each assigned a value of 0, 1, 2, or 3 points, and the albumin concentration decrease was assigned a value of 0, 2, 4, or 6 points. Based on the sum of these values, nutritional status was classified as severe (> 8 points), moderate (5-8 points), or mild (2-4 points) undernutrition, or normal nutrition (0-1 points) [6]. In the current study, a CONUT score of 5 or more was defined as malnutrition.

Assessment of walking ability. Walking ability was assessed six months postoperatively using the functional ambulation category (FAC) score [13, 14]. The FAC score is a single-item rating scale ranging from 0 to 5 (higher scores indicate better ambulation) and evaluates ambulation status by determining the amount of physical support required [15, 16]. A FAC score of 3 represents the ability to walk under supervision but without assistance. Patients with a FAC score of less than 3 were assigned to the gait disturbance (DG) group, and patients with a FAC score of 3 or more were assigned to the independent gait (IG) group.

Statistical analyses. Descriptive statistics are presented as means ± standard deviations for continuous variables and as numbers and percentages for categorical variables. Fisher's exact test was used to compare the DG group (FAC < 3) with the IG group (FAC ≥ 3). We set the age cut-off value at 75 years, which is the definition of "older adults" in the Joint Committee of the Japan Gerontological Society and the Japan Geriatrics Society [17]. The healthy weight body mass index (BMI) value range was 18.5 kg/m^2 to 25 kg/m^2 according to World Health Organization BMI categories. The cut-off value of time between injury and surgery was ≤ 2 days vs > 2 days, as a waiting time of more than 2 days has been reported to increase morbidity and mortality [18]. Multivariate binomial logistic regression analysis was performed to predict the risk of being assigned to the DG group based on sex, age, BMI, time between injury and surgery, CONUT score, and PMI. These variables were selected because of their clinically important significance for walking ability. Values of $P < 0.05$ were considered statistically significant. The variance inflation factor (VIF) was used to check for multicollinearity. Statistical analyses were performed using EZR software (Saitama Medical Center, Jichi Medical University, Tochigi, Japan) [19].

Ethical statement. The institutional review board of Okayama University Hospital approved this study (approval number 2101-025). The need for patient informed consent was waived owing to its retrospective design.

Results

The demographic and baseline characteristics of the 95 patients (25 male patients and 70 female patients) are shown in Table 1. The mean age was 85.2 ± 8.6 years, the mean BMI was 20.1 ± 3.9 kg/m^2, and the time between injury and surgery was 2.5 ± 2.7 days.

Table 2 shows the assessment of nutritional status and skeletal muscle mass. The mean PMI and CONUT scores were 3.8 ± 1.1 cm^2/m^2 and 3.9 ± 2.2 points, respectively. Thirty-five patients (36.8%) had malnutrition, 66 (69.5%) had low skeletal muscle mass, and 28 (29.5%) had both low skeletal muscle mass and malnutrition.

Table 3 shows the differences between the DG and IG groups. The numbers of patients with a BMI less than 18.5 kg/m^2 ($p = 0.01$), malnutrition ($p < 0.001$), low skeletal muscle mass ($p = 0.002$), low skeletal muscle mass + malnutrition ($p < 0.001$), and low preinjury FAC score ($p = 0.001$) were significantly higher in the DG group than in the IG group.

In the multivariate binomial logistic regression analysis, patients with malnutrition (odds ratio, 3.47; 95% confidence interval, 1.08–11.2; $p = 0.036$), low skeletal muscle mass on admission (odds ratio, 15.6; 95% confidence interval, 2.36–103.0; $p = 0.0043$), and low preinjury FAC score (odds ratio, 0.14; 95% confidence interval, 0.04–0.49; $p = 0.0019$) had higher risks of being assigned to the DG group (Table 4). The other explanatory variables (age, sex, BMI, and time) did not show significance. None of the VIF values were greater than 5, and the mean VIF of the model was less than 2, indicating that the model had no collinearity.

Table 1 Baseline and clinical characteristics of patients (n=95) who underwent intertrochanteric fracture surgery

Variables	Patient clinical information	
Age (years)		85.2 ± 8.6
Sex	Female	70 (73.7%)
BMI (kg/m^2)		20.1 ± 3.9
Time (days)		2.5 ± 2.7
Nutritional data	Total cholesterol (mg/dl)	163 ± 30
	Lymphocytes (μl)	1,155 ± 614
	Albumin (g/dl)	3.5 ± 0.4
Preinjury FAC score		4.1 ± 0.1

Data are shown as number (%) for categorical variables or mean ± standard deviation for continuous variables. BMI, body mass index; Time, time between injury and surgery; FAC, Functional Ambulation Categories.

Table 2 Assessment of nutritional status and skeletal muscle mass of patients (n=95) who underwent intertrochanteric fracture surgery

Variables	Patient clinical information	
CONUT score (points)	Total points	3.9 ± 2.2
	Normal (0-1)	15 (15.8%)
	Light (2-4)	45 (47.4%)
	Moderate (5-8)	33 (34.7%)
	Severe (>8)	2 (2.1%)
Malnutrition		35 (36.8%)
PMI (cm^2/m^2)		3.8 ± 1.1
Low skeletal muscle mass		66 (69.5%)
Low skeletal muscle mass + malnutrition		28 (29.5%)

Data are shown as number (%) for categorical variables or mean ± standard deviation for continuous variables. PMI, psoas muscle index; CONUT, controlling nutritional status.

Table 3 Comparison of the gait disturbance (DG) and independent gait (IG) groups

Variables		DG group (FAC score <3, n=27)	IG group (FAC score ≥3, n=68)	*P*-value
Age >75 years		24 (88.9%)	60 (88.2%)	1.0
Sex	Female	20 (74.1%)	50 (73.5%)	1.0
BMI <18.5 kg/m^2		17 (63.0%)	22 (32.4%)	0.01*
BMI ≧25 kg/m^2		1 (3.7%)	8 (11.8%)	0.41
Time ≧2 days		16 (59.3%)	32 (47.1%)	0.40
Malnutrition		18 (66.7%)	17 (25.0%)	<0.01**
Low skeletal muscle mass		25 (92.6%)	41 (60.3%)	<0.01**
Low skeletal muscle mass + malnutrition		17 (63.0%)	11 (16.2%)	<0.01**
Preinjury FAC score		3.8 ± 0.1	4.2 ± 0.1	<0.01**

Data are shown as numbers (%) for categorical variables or mean ± standard deviation for continuous variables. BMI, body mass index; FAC, functional ambulation category; Time, time between injury and surgery. Asterisks indicate significant differences. *$p<0.05$, **$p<0.01$.

Table 4 Multivariate binomial logistic regression analysis of factors related to gait disturbance

Explanatory variables	Odds ratio	95% CI	*P*-value
Age >75 years	0.82	0.13-5.08	0.83
Sex	2.22	0.60-8.30	0.24
BMI <18.5 kg/m^2	2.11	0.64-6.92	0.22
Time ≧2 days	2.07	0.63-6.77	0.23
Malnutrition	3.47	1.08-11.2	0.04*
Low skeletal muscle mass	15.6	2.36-103.0	<0.01**
Preinjury FAC score	0.14	0.04-0.49	<0.01**

CI, confidence interval; BMI, body mass index; FAC, functional ambulation category; Time, time between injury and surgery. Asterisks indicate significant differences. *$p<0.05$, **$p<0.01$.

Discussion

In previous studies, approximately 80% of patients with hip fractures had malnutrition, and a high CONUT score was a risk factor for postoperative complications or six-month mortality [8,9]. Regarding skeletal muscle mass, the prevalence of sarcopenia in older patients with hip fractures ranged from 28% to 69% [20,21].

The present study showed that 36.8% of patients had moderate or severe malnutrition (CONUT score ≥5), and 69.5% had low skeletal muscle mass. Moreover, approximately 30% had both malnutrition and low skeletal muscle mass.

Recently, low skeletal muscle mass has been proposed as part of the definition of malnutrition according to the Global Leadership Initiative on Malnutrition Criteria [22]. Because protein and essential amino acids are important for maintaining skeletal muscle, malnutrition aggravates the loss of skeletal muscle and leads to impaired mobility, prolonged recovery, and high mortality [23,24]. Although the current study did not determine the association between malnutrition and skeletal muscle mass, both malnutrition and skeletal muscle loss were independent risk factors for deteriorating postoperative walking ability. Therefore, assessing both nutrition and skeletal muscle mass before surgery is important to predict postoperative walking ability.

Moreover, previous studies on BMI reported that patients with low BMI had a higher risk of sarcopenia [25] or that patients with low BMI showed less improvement in walking ability after fusion surgery for osteoporotic vertebral fracture [26]. In the present study, the proportion of patients with low BMI was significantly higher in the DG group; however, in multivariate analysis, low BMI was not an independent risk factor for deteriorating postoperative walking ability. This suggests that BMI alone may be insufficient to predict postoperative walking ability.

Modification of nutritional status by perioperative nutritional intervention can result in a lower complication rate after hip fracture [23,27,28]. However, previous studies on nutritional supplementation in patients with hip fractures during hospital admission have not demonstrated that perioperative nutritional intervention positively affects walking ability. Since it is difficult to improve skeletal muscle mass in patients after hip fracture, it is imperative to prevent sarcopenia before fractures occur. The detection and prevention of sarcopenia and malnutrition gain special importance from this perspective. Early assessment and treatment of sarcopenia and malnutrition as part of routine physical examinations in the older population may be beneficial, as well as public health campaigns directed at prevention of these issues.

Indeed, the use of a fracture liaison service (FLS) program, which is aimed at detecting and preventing sarcopenia and malnutrition, has been suggested to improve fracture-related outcomes [29]. Considering that the current study suggests that patients with low skeletal muscle mass and malnutrition have poor walking prognoses post surgery, we believe that assessing and improving skeletal muscle mass and nutrition during FLS may further improve fracture-related outcomes.

This study has several limitations that must be considered when interpreting the results. First, it was a retrospective study with a relatively small number of patients. However, there have been few reports on the associations between skeletal muscle loss, malnutrition, and postoperative walking ability. Second, we focused on intertrochanteric fractures because the functional outcomes after intertrochanteric fractures are worse than those of femoral neck fractures [2]. Therefore, the results are not necessarily indicative of the functional outcomes of other hip surgeries such as femoral neck fracture surgery. Third, other indicators of malnutrition and low skeletal muscle mass such as Mini Nutritional Assessment and Bioelectrical Impedance Analysis were not considered. Fourth, although skeletal muscle loss plus malnutrition was significantly more common in the DG group, it was also seen in 16.2% of the IG group. Given that our study focused mainly on nutrition and skeletal muscle mass, factors such as postoperative pain, length of hospital stay, severity of dementia, medical comorbidities, and depression were not evaluated. Further prospective studies are required to evaluate additional variables such as severity of dementia that may affect the ability to walk postoperatively.

In summary, both skeletal muscle loss and malnutrition before surgery are risk factors for poor walking ability after intertrochanteric fracture surgery. Further interventions focused on skeletal muscle mass and nutrition in the older population at risk of hip fracture may be needed in daily practice.

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