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Original Article

Low psoas major muscle area as a risk factor for contralateral hip fracture following intertrochanteric fracture

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Abstract

Objective: This study aimed to investigate the relationship between the psoas major muscle area as a risk factor and subsequent contralateral hip fractures in patients with initial intertrochanteric fractures. **Methods**: Of 136 treated for intertrochanteric fractures, 104 female patients had computed tomography done to assess their fractures at initial stage and had been followed up for more than 2 years. These patients were then divided into 2 groups: i.e. those who had a contralateral hip fracture (CF) (n=16) and those who did not (NF) (n=88) groups. We mainly assessed the relationship between the corrected psoas major muscle area (CPMA) at initial fracture and the occurrence of contralateral hip fracture. **Results**: The CF group had significantly lower CPMA than the NF group (p=0.001). There was positive correlation between the CPMA and the period from the initial to the contralateral hip fracture in the CF group. The CPMA cutoff value of 480.98 mm^2/m^2, was showed sensitivity of 63.6% and specificity of 87.5% in receiver operating characteristic curve analysis for all patients. **Conclusions**: The lower CPMA was associated with the contralateral hip fracture within 2 years from initial intertrochanteric fracture. The low CPMA would be a risk factor for contralateral hip fracture.

Keywords: Contralateral hip fracture, Intertrochanteric fracture, Low psoas major muscle area, Sensitivity, Specificity

Introduction

Globally, the number of intertrochanteric fractures of the femur is currently on the increase and is likely to reach 4.5 million fractures in 2050. This is an immense increase considering that there were only 1.25 million proximal femur fractures reported in1990[1].

Intertrochanteric fractures mainly occur due to the fragile bone structure in older patients with osteoporosis. This then leads to poor quality of life and an increase in mortality among the elderly[1-3]. Moreover, following the treatment of an initial hip fracture, contralateral hip fractures are prevalent. The frequency of contralateral hip fractures following initial hip fracture is said to be 5-10%[1]. Additionally, the socioeconomic burden shouldered by patients and year one mortality outcomes are higher among patients with a subsequent contralateral hip fracture compared to patients with an initial hip fracture only[4-6]. Therefore, the identification of risk factors for contralateral hip fractures could provide useful information to aid in the prevention of subsequent fractures. According to previous reports, contralateral hip fractures frequently occurred within one to two years of treatment of the initial fracture. In a previous meta-analysis, Zhu et al. (2014) reported that being female, having dementia, visual impairment, respiratory disease, heart disease, Parkinson's disease, and dwelling in an institute for the elderly as risk factors for contralateral hip fractures after the initial intertrochanteric fracture[7]. Nevertheless, short-term alteration of these risk factors may be difficult.

The European Working Group on Sarcopenia in Older People (EWGSOP) defines sarcopenia as the presence of both the loss of muscle mass and a decline in muscle function.

The authors have no conflict of interest.

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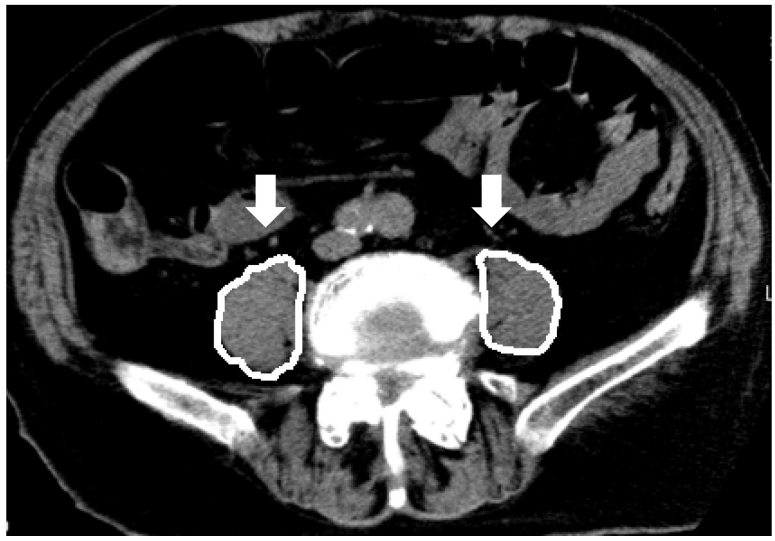

Figure 1. The measurement of corrected psoas major muscle area (CPMA). Psoas muscle major areas (white arrow) at the L4/5 intervertebral disc height was measured by CT. CPMA was obtained by dividing the sum of both psoas major muscle areas by the square of stature.

Sarcopenia is associated with physical disability, poor quality of life, and an increased risk of adverse outcomes such as death[8]. Moreover, sarcopenia is a known risk factor for initial hip fractures[5,9]. However, it is not known whether sarcopenia predisposes patients to contralateral hip fractures. Therefore, we focused our investigation on sarcopenia as a risk factor for contralateral hip fractures. To diagnose sarcopenia, muscle quality is usually evaluated using dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis. Then, the walking speed is included in the diagnostic criteria. However, it is difficult to examine all hip fracture patients for the purpose of diagnosing sarcopenia preoperatively. It is also difficult to measure walking speed.

The psoas major muscle plays an essential role in hip flexion and walking movements. The cross-sectional area of the psoas major muscle is known to decrease with age. This cross-sectional area is also directly correlated with the muscle mass in the extremities. Therefore, in recent years, this area has been used to evaluate for the presence of sarcopenia[8]. Several studies have reported a relationship between a decrease in the psoas major muscle area and adverse surgical events[10-12]. Robert et al. who measured the psoas major muscle area in patients with proximal femoral fractures using preoperative computed tomography (CT), reported that patients with low psoas major muscle area had a significantly higher mortality rate than those with larger psoas muscle area[13]. Thus, we selected the psoas major muscle cross-sectional area measured using preoperative CT as an assessment method to identify sarcopenia.

We hypothesized that patients with low psoas major muscle area would have a high probability of contralateral hip fractures within a few years after the initial fracture because they would have a higher risk of falling. In this study, we investigated whether there was a difference in the psoas major muscle areas between the patients with and without subsequent contralateral hip fractures. Then, the relationship between the psoas major muscle area and the period from initial fracture to contralateral hip fracture were examined. Furthermore, we calculated the validity of using cross-sectional area of the psoas muscle to predict future contralateral hip fracture.

Methods

One hundred thirty-six patients with an initial unilateral intertrochanteric fracture treated from July 2017 to April 2018 were retrospectively enrolled in this study. For patients with intertrochanteric fractures, an accurate diagnosis of the fracture pattern using CT was reported is essential in preventing postoperative complications such as nonunion and cut out of the lag screw[14]. We, therefore, selected our research period to coincide with when we began performing CT for all patients with the intertrochanteric fracture. We excluded patients whose imaging range did not include the L4/5 level (n=4) and who had not been followed-up for at least 2 years (n=12). We also excluded male patients (n=16) due to gender differences in muscle mass and patients with subcapital fracture, who had not undergone preoperative CT examination. Of the 136 patients, 104 were eligible for inclusion in the final analysis. The patients were divided into two groups: one who had contralateral intertrochanteric hip fracture within 2 years of the initial fracture (CF group)

Table 1. Comparison of NF group and CF group.

	NF group (n=88)	CF group (n=16)	P value
Age (year)	85.4±7.8	88.6±4.5	0.12
BMI (kg/m²)	21.27±4.31	19.65±4.55	0.17
Alb (g/dl)	3.55±0.53	3.41±0.47	0.32
CPMA (mm²/m²)	515.68±107.82	400.00±90.78	0.0001
Barthel Index	80.2±21.5	79.1±13.9	0.84
Walking ability			
Walking alone	34 (38.6%)	4 (25.0%)	0.67
Waling with a cane	27 (30.7%)	5 (31.3%)	
Walker	18 (20.5%)	5 (31.3%)	
Wheelchair	9 (10.2%)	2 (12.5%)	
Living environment			
Living in house	67 (76.1%)	10 (62.5%)	0.35
Living institution	21 (23.9%)	6 (37.5%)	
Hospital	0 (0%)	0 (0%)	

NF: no fracture, CF: contralateral hip fracture, BMI: body mass index, Alb: albumin, CPMA: corrected psoas major muscle area.

and the other who did not have a contralateral hip fracture within the same time period, the no fracture group (NF group). We retrospectively collected information regarding age, sex, body mass index (BMI), blood albumin (Alb) value, psoas major muscle area by CT, Barthel Index, walking ability before the initial fracture, and the patient's living environment at the time of initial fracture as the candidate of risk factors for contralateral hip fracture from the medical records of all patients. We then compared the groups using this information.

There are various measurement methods to determine the psoas major muscle area in the previous reports[9-11]. In this study we employed the methods used by Lruzu et al.[15]. The corrected psoas major muscle area (CPMA) was obtained by dividing the sum of the two psoas major muscle areas at the L4/5 intervertebral disc height by the square of stature (Figure 1). The images were analyzed using a medical image information system SYNAPSE (Fuji Film Medical Co., Ltd.).

To evaluate patients' walking ability and living environment, we referred to reports by Hassan et al. (2019)[16]. The walking ability was rated on a four-point scale as follows: 1 walking alone, 2 walking with a cane, 3 walking with a walker, and 4 using a wheelchair. The living environment before the initial hip fracture, which may have been at home, in an institution, or in a hospital, was also described[16]. Moreover, receiver operating characteristic (ROC) curves were plotted and the areas under the curves (AUC) were calculated to assess the predictive values of CPMA in forecasting future contralateral hip fracture. The sensitivity, specificity, and cutoff values were then calculated using the Youden method[17]. In the CF group, the correlation between the CPMA and the period from the initial intertrochanteric fracture to the contralateral hip fracture was computed.

The EZR statistical software was used for the statistical analysis. The t-test for age, sex, BMI, Alb value, CPMA, and Barthel Index and Fisher's exact test for walking ability and living environment were used to comparing the groups, and $P<0.05$ was considered significant. Each value of age, sex, BMI, Alb value, CPMA, and Barthel Index was presented as mean value ± standard deviation. The correlation between the CPMA and the period from initial fracture to contralateral hip fracture was then analyzed using the Pearson product moment correlation coefficient. The EZR statistical software (Jichi medical university) was used for the statistical analysis. The usefulness of EZR has been reported[18].

The trial protocol was approved by the Ethics Committee and Institutional Review Board of Tokuyama Central Hospital (K408-20210303).

Results

The CF group had 16 patients and the NF group had 88 patients. All cases in both groups were female. All the patients in the CF group had the intertrochanteric fractures. The mean age was 85.4±7.8 in the CF group and 88.6±4.5 years in the NF group. BMI was 19.65±4.55 in CF group and 21.27±4.31 in NF group. Alb values were 3.41±0.47 g/dl in the CF group and 3.55±0.53 g/dl in the NF group. The Barthel index was 79.1±13.9 in the CF group and 80.2±21.5 in the NF group. Age, BMI, Alb values, and Barthel Index did not significantly differ by group (p values were 0.12, 0.17, 0.32, and 0.84, respectively). The CPMA was 400.00 ± 90.78 mm²/m² in the CF group and 515.68±107.82 mm²/m² in the NF group, and the value in CF group was significantly lower than that in NF group ($P=0.0001$) (Table 1). In ROC curve analysis of CPMA, comparisons of the CF and NF groups showed

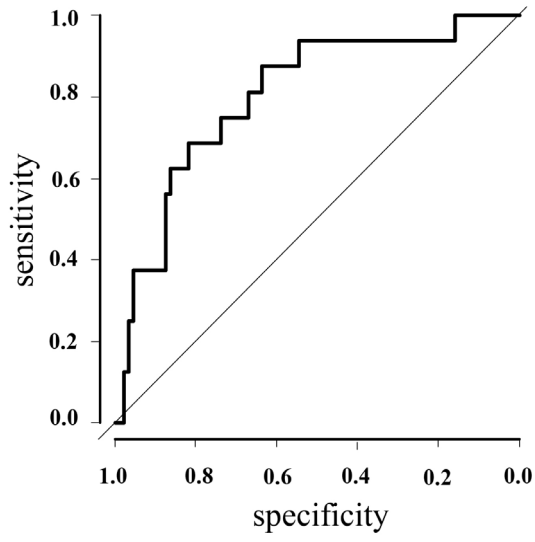

Figure 2. The relationship between the CPMA and contralateral hip fracture was defined as the ROC curve. With cut-off value of 480.98 mm^2/m^2, the Sensitivity 0.636 and specificity were 0.875, respectively. The area under the ROC curve was 0.80. CPMA: corrected psoas major muscle area, ROC: receiver operating characteristic.

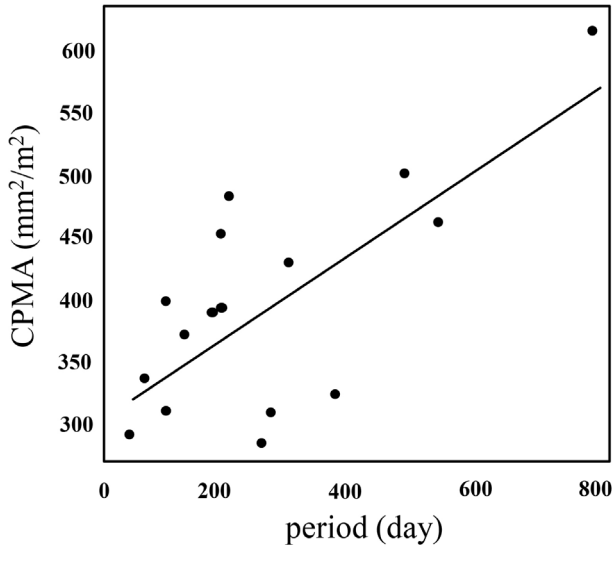

Figure 3. The correlation between the period until contralateral hip fracture and the area of the CPMA. In the CF group, a positive correlation was found with the correlation coefficient r=0.729 and p value 0.0014. CPMA: corrected psoas major muscle area, CF: contralateral hip fracture.

that the AUC was 0.80, and with a cutoff value of 480.98 mm^2/m^2 the sensitivity and specificity of CPMA in predicting latter contralateral hip fractures were 63.6% and 87.5%, respectively (Figure 2). A positive correlation was found between the CPMA and the period from the initial fracture to contralateral hip fracture in the CF group (r=0.729; P=0.0014) (Figure 3).

Regarding walking ability before the initial fracture, the rates of single walking, single cane, walker, and wheelchair were 38.6%, 30.7%, 20.5%, and 10.2% in the NF group, respectively. In CF group, the rates were 25.0%, 31.3%, 31.3%, and 12.5% respectively (Table 1). Regarding the

patient's living environment, there were fewer patients living in a house in the CF group compared to the NF group (62.5% vs. 76.1% respectively) and more patients living in an institution in the CF group compared to the NF group (37.5% vs. 23.9% respectively). There were no patients who lived in a hospital environment in either group (Table 1). Nevertheless, there was no significant difference between the two groups based on walking ability and living environment.

Discussion

In this study, we assessed the risk factors for contralateral hip fracture in patients within two years after initial intertrochanteric fracture. The CPMA in the CF group was significantly lower than that in the NF group. At a cutoff value of 480.98 mm^2/m^2, the CPMA had 63.6% sensitivity and 87.5% specificity in predicting subsequent contralateral hip fractures. Moreover, there was a positive correlation between the CPMA and the time to contralateral hip fracture. Therefore, a low psoas major muscle area was a risk factor for contralateral hip femoral fracture after initial intertrochanteric fracture. To the best of our knowledge, this is the first report highlighting the importance of the psoas major muscle area in patients with contralateral hip fractures.

Sabri et al. (2018) reported that contralateral hip fractures occurred in 3.4% to 8.0% of patients after the initial fracture. Additionally, 47.3% of these fractures occurred within the first year of the initial fracture[6]. Lee et al. (2016) reported a 1-year and 5-year mortality rate of 12.1% and 41.3% in women and 17.4% and 47.3% in men, respectively, following subsequent contralateral hip fractures. These rates were significantly higher than the mortality rates after the initial fracture[5]. Therefore, the prevention of contralateral hip fractures is essential in addressing mortality from hip fractures. In order to do that, it is necessary to identify risk factors for contralateral hip fracture that can be improved after the initial fracture.

In this study, the CPMA was lower in the CF group, and this was associated with a shorter period from the initial fracture to the contralateral hip fracture. Sarcopenia has been reported to affect the outcome of various diseases; the reduced skeletal muscle mass and decreased physical function in sarcopenia may explain this association[10,11]. Zhang et al. (2018) also described that sarcopenia increased the risk of fractures in elderly[19]. Huan et al., (2021) reported that sarcopenia could significantly increase the risk of future hip fracture[20]. In patients with intertrochanteric fracture, 22% to 95% were found to have sarcopenia using the DXA. A decrease in skeletal muscle mass contributed to dismal postoperative survival rates[13]. As the population ages, assessing for sarcopenia as well as other comorbidities such as heart disease and diabetes is very important in patients with intertrochanteric fracture. Moreover, the evaluation for sarcopenia is useful not only for assessing the risk of postoperative complications, but also for assessing the risk of initial intertrochanteric fracture since sarcopenia lowers bone density and increases the risk of falls[21].

The EWGSOP suggests that muscle size measurement as assessed using CT is useful as alternative to the gold-standard tools for sarcopenia diagnosis[8]. Moreover, the assessment of muscle size is a standard diagnostic tool used in cancer treatment and vascular disease. In the literature, there are many reports that have documented the relationship between postoperative risk factors and other outcomes using the psoas major muscle area as a proxy for sarcopenia[8,10,11]. Therefore, measuring the psoas major muscle area is a useful form of assessment for the risk for contralateral hip fracture after the initial fracture. The role of the psoas major muscle is important for maintaining posture, hip flexion, and preventing falls. Kim et al. (2000) described that there is a positive correlation between the decrease of psoas major muscle area and the stride length, and that it is prone to atrophy with aging[22]. Roth et al. reported that to alleviate sarcopenia, both muscle resistance training and strength training interventions are needed[23]. Since a decrease in the psoas major muscle area increases the risk of falls and contralateral hip fractures, such high-risk patients should undergo rehabilitation to actively strengthen the psoas major muscle as early as possible after the initial intertrochanteric fracture.

The importance of nutritional management in fracture prevention has been reported in a previous study. Wakabayashi et al. (2014) reported that patients with proximal femoral fractures were more likely to be malnourished and to have sarcopenia. They also stated that sarcopenia progresses from a mild form to a more advanced form when rehabilitation is performed without the appropriate supportive nutritional management[24]. In the same study, active nutritional interventions such as vitamin D, calcium, and high protein improved the effects of rehabilitation as well as activities of daily living and also mitigated the extent of sarcopenia after surgery[24]. In our study, active nutritional management intervention was not possible for all patients who had contralateral hip fracture. This may have contributed to the occurrence of the contralateral hip fracture.

We did not find any differences between the groups by BMI, Alb value, Barthel Index, walking ability, and living environment at the time of initial hip fracture. Known risk factors for repeat fractures include being female, a diagnosis of dementia, having visual impairment, respiratory disease, heart disease, or neurological disease, and the type of living environment[4,6,7]. However, considering that some of these risk factors were generally found in most patients with initial fractures, it is difficult to identify patients with specific risk factors of contralateral hip fracture. Whereas, the CPMA as an indicator of sarcopenia can be increased by rehabilitation and nutritional management, which would be a more valuable risk factor for contralateral hip fracture.

This study has a few limitations. First, this study was small number of cases. However, because the frequency of contralateral hip fractures is low, and this study is considered to be valuable for the pilot study. Second, the psoas major muscle area after the initial fracture treatment was not

measured. It would be useful to assess how changes in the CPMA after the initial fracture would affect the risk of a latter contralateral hip fracture. Finally, it was not possible to incorporate treatment details concerning osteoporosis, rehabilitation, and nutritional management after the initial fracture because most patients had these treatments a performed at the other. Thus, future investigations should address these limitations.

Conclusion

This study indicated that CPMA would be an involved risk factor for contralateral hip fracture after the initial fracture. Furthermore, we found that lower the CPMA in patients with the initial intertrochanteric fracture, the earlier the subsequent contralateral hip fracture. Therefore, low CPMA is considered as a risk factor for contralateral hip fracture after initial intertrochanteric fracture. For the patients with low CPMA, more aggressive rehabilitation, nutritional management should be administered to prevent contralateral hip fracture.

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