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Proposal for new diagnostic criteria for low skeletal muscle mass based on computed tomography imaging in Asian adults

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ABSTRACT

Objectives: Low skeletal muscle, referred to as sarcopenia, has been shown to be an independent predictor of lower overall survival in various kinds of diseases. Several studies have evaluated the low skeletal muscle mass using computed tomography (CT) imaging. However, the cutoff values based on CT imaging remain undetermined in Asian populations.
Methods: Preoperative plain CT imaging at the third lumbar vertebrae level was used to measure the psoas muscle mass index (PMI, cm^2/m^2) in 541 adult donors for living donor liver transplantation (LDLT). We analyzed PMI distribution according to sex or donor age, and determined the sex-specific cutoff values of PMI to define low skeletal muscle mass.
Results: PMI in men was significantly higher than observed in women (8.85 ± 1.61 cm^2/m^2 versus 5.77 ± 1.21 cm^2/m^2; $P < 0.001$). PMI was significantly lower in individuals ≥50 y than in younger donors in both men and women ($P < 0.001$ and $P < 0.001$, respectively). On the basis of the younger donor data, we determined the sex-specific cutoff values for the low skeletal muscle mass were 6.36 cm^2/m^2 for men and 3.92 cm^2/m^2 for women (mean − 2 SD).
Conclusion: Data from healthy young Asian adults were used to establish new criteria for low skeletal muscle mass that would be applicable for defining sarcopenia in Asian populations.

Introduction

Sarcopenia is defined as a syndrome characterized by a progressive and generalized loss of skeletal muscle mass and strength, with adverse outcomes including physical disability, poor quality of life, and death [1]. Sarcopenia has been shown to be an independent predictor of lower overall survival in various disease states [2–6]. Sarcopenia has been defined based on the criteria originally proposed by the 2010 European Working Group on Sarcopenia in Older People (EWGSOP) [1]. The EWGSOP discussed the necessity of measuring and evaluating muscle mass, muscle strength, and physical performance to diagnose sarcopenia. Low skeletal muscle mass, which is one of the components of sarcopenia, can be evaluated by various kinds of imaging techniques such as dual-energy x-ray absorptiometry (DXA), computed tomography (CT), magnetic resonance imaging (MRI), and bioimpedance analysis (BIA). Among these methods, CT seems best suited for measuring the skeletal muscle mass in a clinical setting, especially in the surgical field, as CT images are usually acquired as part of the preoperative diagnosis and during follow-ups. Additionally, CT images provide highly accurate quantitative and qualitative measurements of the body composition, including adipose tissue. In Western countries, CT imaging has been used to determine the various skeletal muscle mass cutoff values that have been used to define sarcopenia [2,3,6,7]. However, these cutoff values would most likely be different from those calculated in Asian populations, due to variances in body size, lifestyles, and ethnicities [8]. Although the Asian Working

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Group for Sarcopenia (AWGS) recently proposed the skeletal muscle mass cutoff values measured by DXA or BIA, the cutoff values calculated by CT imaging remain undetermined [8].

In the present study, we investigated the skeletal muscle mass determined from the psoas muscle mass index (PMI) that was calculated based on CT imaging data obtained from healthy donors evaluated for living donor liver transplantation (LDLT). We then attempted to use this data to establish low skeletal muscle mass cutoff values that would be suitable for defining sarcopenia in the Japanese population.

Methods

Patients

Between April 2005 and March 2015, there were 629 adult LDLT donors (age ≥20 y) at Kyoto University Hospital. We excluded 88 of these patients from the analysis as they did not undergo preoperative plain CT imaging at the third lumbar vertebrae (L3) level. Therefore, this study enrolled and evaluated the PMI in 541 patients (288 men, 253 women). The median age of the donors was 39 y (range, 20–66 y). The numbers of donors per each age decade were 108 (20%: 20–29 y), 178 (32.9%: 30–39 y), 105 (19.4%: 40–49 y), 108 (20%: 50–59 y), and 42 (7.8%: ≥60 y).

To investigate the relationship between the PMI and the BIA measured skeletal muscle mass index (SMI), and to examine the validity of the PMI cutoff values, we enrolled 230 patients who underwent adult-to-adult LDLT between January 2008 and March 2015. Table 1 presents the characteristics of these 230 patients. The study was approved by the Ethics Committee of Kyoto University and conducted in accordance with the Declaration of Helsinki of 1996.

PMI and SMI calculation methods

A multidetector CT scanner (Aquilion 64, Toshiba Medical Systems, Tochigi, Japan) was used to obtain all of the preoperative CT imaging. CT technical parameters included 120 kV (tube voltage), 0.5 mm × 64 row (detector configuration), tube current modulation, 0.5 sec/rotation (gantry rotation), and 7 mm reconstruction thickness. Manual tracing using preoperative CT imaging at L3 level was used for measuring the cross-sectional areas of the right and left psoas muscles (Fig. 1). PMI was calculated by normalizing the cross-sectional areas for height (cm^2/m^2).

In 2008, we introduced multifrequency BIA with eight tactile electrodes (InBody 720®; Biospace, Tokyo, Japan) for body composition measurements in patients undergoing LDLT. In the present study, we used the InBody 720® to automatically measure the skeletal muscle mass of the whole body. After collection of the data, the SMI was calculated by normalizing the skeletal muscle mass for height (kg/m^2).

Table 1
Characteristics of patients undergoing living donor liver transplantation

Characteristics	Number
Recipient age, y	
Mean (SD)	51 (13.5)
Donor age, y	
Mean (SD)	44 (12.9)
Sex, n (%)	
Men	116 (50.4)
Women	114 (49.6)
Original disease, n (%)	
HCC	79 (34.3)
HBV or HCV-associated LC	46 (20)
PBC or PSC	37 (16.1)
Others	68 (29.6)
ABO compatibility, n (%)	
Identical/compatible	161 (70)
Incompatible	69 (30)
MELD score	
Mean (SD)	19.3 (8.6)
Child-Pugh classification, n (%)	
A	16 (7)
B	69 (30)
C	145 (63)
GRWR, %	
Mean (SD)	0.92 (0.21)
Graft, n (%)	
Right	129 (56.1)
Left	101 (43.9)
Operative time, min	
Mean (SD)	860 (189)
Operative blood loss, mL	
Mean (SD)	8841 (9948)
Pretransplant PMI, cm^2/m^2, mean (SD)	
Men	7.07 (1.90)
Women	4.73 (1.51)

GRWR, graft-to-recipient body weight ratio; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; LC, liver cirrhosis; MELD, model for end-stage liver disease; PBC, primary biliary cirrhosis; PMI, psoas muscle mass index; PSC, primary sclerosing cholangitis

Analyzed parameters

To evaluate whether the PMI correctly reflected the skeletal muscle mass of the whole body, we first investigated the relationship between the PMI and SMI in 35 healthy donors and 137 recipients for LDLT who were able to undergo a preoperative BIA examination. Next, after analyzing the distribution of the PMI according to sex or donor age, the sex-specific PMI cutoff values were determined to define the low skeletal muscle mass.

Statistical analysis

Continuous data are presented as mean ± SD or median (range) as appropriate. Continuous variables were nonparametrically analyzed using the Mann–Whitney U test. Correlations between the continuous variables were assessed using Pearson correlation coefficients and linear regression. A P value of <0.05 was considered significant. All statistical data were generated using JMP 11 (SAS Institute, Cary, NC, USA) and Prism 6 (GraphPad Software, Inc., La Jolla, CA, USA).

Results

Relationship between PMI and SMI

To determine whether the PMI reflected the skeletal muscle mass of the whole body, we randomly performed BIA examinations in 35 donors (19 men, 16 women). Results indicated there was a strong and significant correlation between the PMI and the SMI measured by BIA ($r = 0.737$, $P < 0.001$; Fig. 2A). Additionally, we retrospectively analyzed the correlation between the PMI and SMI by examining the data from the 137 LDLT recipients who also underwent BIA examination. Similar to our initial findings, we found a moderate but significantly positive relationship between the PMI and SMI ($r = 0.682$, $P < 0.001$; Fig. 2B). This significantly positive relationship between PMI and SMI was observed in the analyses according to sex (Fig. 2C, D). Overall, these results suggest that the PMI can be used as a parameter for evaluating the skeletal muscle mass of the whole body.

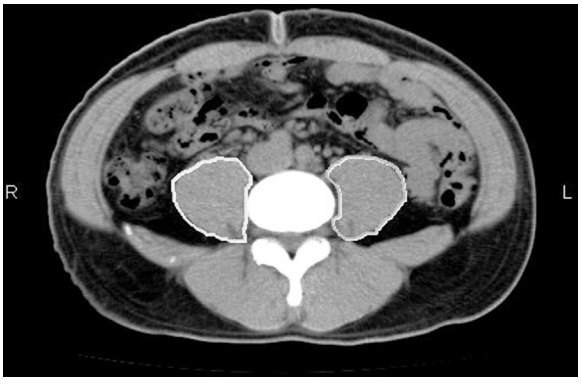

Fig. 1. Cross-sectional computed tomographic images at the umbilical level. The areas of the bilateral psoas muscle were measured by manual tracing.