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ORIGINAL RESEARCH

Measurement of psoas muscle size using existing computed tomography to predict patient outcomes in emergency departments

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Abstract

Sarcopenia is a major physical factor of frailty and can be predicted by existing patient computed tomography (CT) scans. The objective of this study was to investigate the relationships between prognosis of elderly patients visiting the emergency department and psoas muscle size measurements from CT scans that were acquired in other purpose. This was a retrospective study in a single center. The psoas muscle size (cross-section) and attenuation at the L3 vertebra were measured on CT scans. Logistic regression analysis was used to determine the association between mortality and muscle size and muscle attenuation after adjustment of basic characteristics. Also, we constructed receiver operating characteristic curves. A total of 279 patients were enrolled with diagnoses categorized from 13 chapters from on International Classification of Diseases-10th Revision (ICD-10). There were 56 patients (20.1%) admitted to the ICU, and 51 patients (18.3%) died in the hospital during the clinical process. The area under the receiver operating characteristic (AUROC) of muscle size for prediction of ICU admission was 0.706 (0.649–0.759), and the cut-off value was 390.18 with 51.8% sensitivity and 87.9% specificity. The AUROC of muscle size for prediction of death was 0.904 (0.864–0.936), and the cut-off value was 587.41 with 92.2% sensitivity and 78.5% specificity. Using existing CT can be an appropriate method for an early diagnosis of sarcopenia in older patients. In this study, measurement of muscle size using CT was shown to be a feasible modality for predicting poor prognoses for older patients.

Keywords

Psoas muscle; Sarcopenia; Frail elderly; Emergency departments; Computed tomography

1. Introduction

Frailty is defined as a syndrome of multi-system impairment associated with increased vulnerability to stressors [1, 2]. It is related to a higher risk of mortality, disability, and hospitalization and can lead higher healthcare needs, which may place substantial burdens on elderly patients and their caregivers in terms of cost and resources [3]. Population aging is a global phenomenon. Like the rest of the world, South Korea is also aging faster than ever before. The proportion of people aged 65 or older in Korea increased from 7.0% in 1999 to 14.3% in 2018 and is expected to reach 25% in 2030 [4]. As a society ages, the importance of frailty has emerged as a hallmark of aging, and sarcopenia has been shown to be a major physical factor of frailty.

After the age of 50, muscle mass is reduced at a rate of 1–2% annually. Between the ages of 50 and 60, muscle strength decreases by 1.5%, and then by 3% per year [5, 6]. Sarcopenia, a term first described in 1989 by Rosenberg, has been defined as age-dependent loss of skeletal muscle mass [7]. Further studies have demonstrated that sarcopenia involves not only muscle mass, but also muscle strength and physical performance and is associated with morbidity and mortality in elderly [8, 9]. Sarcopenia is primarily disease in the elderly and is associated with falls, fractures, infections, and metabolic disorders [10, 11] leading to lower life quality and higher cost of healthcare.

Body composition measurements refer to the evaluation of muscle mass and body fat, and include body mass index (BMI), fat mass (FM), fat-free mass (FFM), FFM/FM ratio, and changes of muscle mass. Previous studies have shown that body weight or BMI alone is insufficient to predict the outcome of sarcopenia [12, 13]. Interestingly, visceral fat infiltration was shown to be a better indicator of cardiovascular risk and average life expectancy than body weight, BMI, or total fat mass [14]. Recently, the importance of skeletal muscle mass has emerged, and many studies have been reported on the association between skeletal muscle mass and several different diseases [15–17].

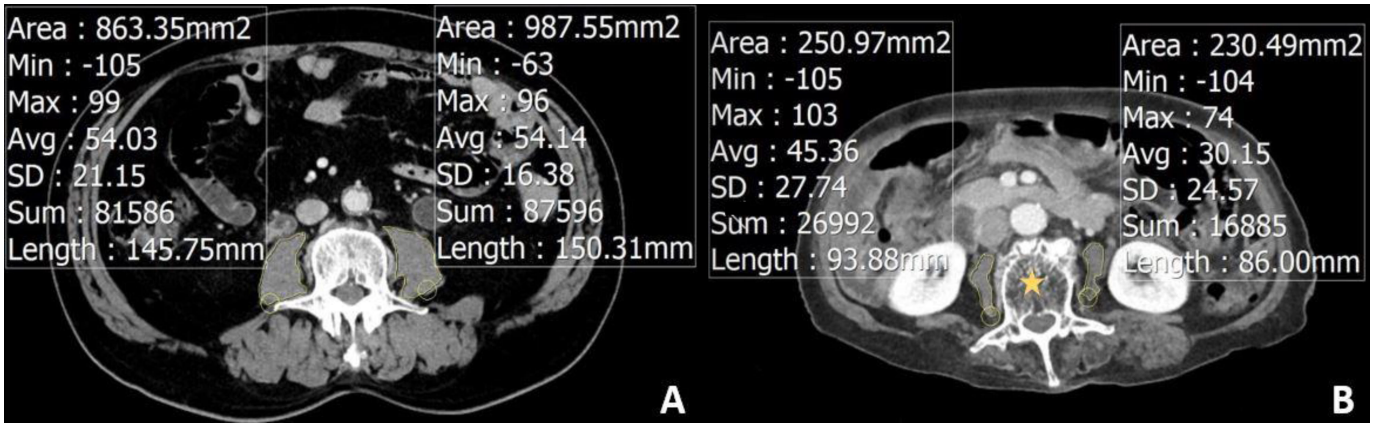

FIGURE 1. Axial abdominal and pelvic CT images outlining the psoas muscles bilaterally were obtained at L3 level in two different patients (yellow stars). (A) 69-year-old man, image presents a cross-sectional area (yellow outline) measuring left side and right side which were 987.55 mm^2 and 863.35 mm^2 and mean attenuation measuring left side and right side which were 54.14 HU (SD: 16.38) and 54.03 HU (SD: 21.15), respectively. (B) 77-year-old woman, image presents a cross-sectional area (yellow outline) measuring left side and right side which were 230.49 mm^2 and 250.97 mm^2 and mean attenuation measuring left side and right side which were 30.15 HU (SD: 24.57) and 45.36 HU (SD: 27.74), respectively.

Computerized tomography (CT) is both a screening and diagnostic tool. Recent studies have shown increases in CT utilization worldwide [18]. One report demonstrated that CT utilization in the emergency department (ED) increased more than 3-fold between 1996 and 2007 [19], and another study showed that this growth has continued [20]. Using existing patient CTs conducted for other purposes to predict sarcopenia could save both health care costs and time without the need for further examination.

Previous studies have demonstrated that psoas muscle size, measured using CT, is useful to predict patient outcomes with various diseases [21, 22], including outcomes for patients with trauma, in need of surgery, and with internal medical diseases such as pulmonary embolism or diabetes mellitus [23, 24]. We would like to find out if sarcopenia is associated with the prognosis of the patient in the elderly over the age of 65, not with a specific disease. If the association is demonstrated, even if the vital sign or laboratory test is mild, more attention may be cared to the treatment of patients with sarcopenia. This is important because limited medical resources can be used more intensively in patients whose prognosis is expected to be poor. The objective of this study was to investigate the relationships between prognosis of elderly patients visiting the ED and psoas muscle size measured by CT acquired for the diagnosis, treatment, or follow up procedures of various diseases.

2. Material & methods

2.1 Study design

This study was conducted retrospectively in a single-center using the Electronic Medical Records (EMRs) of patients who visited in our institution and underwent abdominal and pelvic CT (APCT) during the ED stay. This study was approved by the Institutional Review Board of our institution (No. 2021-01-014), and the requirement for written informed consent was waived.

2.2 Study population

This study investigated patients who visited a tertiary-care university hospital from March 2015 through December 2016. The criteria for inclusion were (1) patients aged 65 years old or older who visited the ED, and (2) patients whose APCT was performed simultaneously in the ED. The criteria for exclusion were (1) patients who visited the ED for non-medical purpose, (2) patients who have metal prostheses due to previous fracture or surgery, which may result in metal artifact on APCT, and (3) patients who transferred to another facility or left against medical advice, which leads to insufficient patients data.

2.3 Data collection and outcome measurement

A board-certified emergency physician collected EMR data from patient hat were stored in an image archiving and communication system (PACS) (Maroview 5.4, Infinitt, Seoul, Korea). The variables included patient demographics information, including age and sex; vital signs at the initial ED visit, laboratory results in the ED, and ED disposition such as discharge, general ward (GW) admission, and intensive care unit (ICU) admission. Length of hospital stay, length of ICU stay, and mortality also included. Altered mental status was meant non-alert mental state, such as verbal response, painful response, and unresponsiveness.

The primary endpoint was for predicting in-hospital mortality. The mortality group included patients who died in the ED and patients who died during admission for treatment. The secondary endpoint was to predict admission to the ICU. ICU-positive group was referred to as the patients admitted to the ICU, and ICU-negative group was referred to as the patients admitted to the GW or discharged from the ED.

2.4 Image acquisition, the method for measuring muscle size and attenuation

In our institution, APCT scans are performed using a 64-slice multidetector CT scanner (Somatom Perspective ONE Dynamic Volume CT, Siemens Healthineers Corporation, Erlangen, Germany). Images were obtained with software, PACS. CT images were retrospectively and independently evaluated by two board-certified emergency physicians with 10 and 5 years of experience. Both physicians did not participate in patient enrollment and were blinded to the diagnosis and prognosis of each patient. Measurements were performed in random order for radiographic image and patient numeric code. Measurements were taken on axial images with a free hand ROI around the psoas muscle at the L3 pedicle level, which is the most widely used measurement reported in the literature [25, 26] (Fig. 1). Muscle size and attenuation (measured as Hounsfield units [27]) were measured on both the right and left sides and then averaged.

2.5 Statistical analysis

Continuous variables are expressed as the mean with standard deviation (SD), while categorical variables are expressed as the count and percentage. The independent *t*-test or Mann-Whitney U test was used for continuous variables, and Pearson's chi-square test for categorical variables.

To assess the predict factors for prognosis of patients (in-hospital mortality and ICU admission), we conducted multivariate logistic regression using statistically significant variables in univariate analysis. In multivariate analyses, adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were presented.

Area under the receiver operating characteristic (AUROC) curve was used to identify prognosis predict performance. AUROC levels from 0.8 to 0.9 are regarded as good, from 0.7 to 0.8 are regarded as adequate, and from 0.6 to 0.7 are regarded poor [27]. An optimal cut-off value was defined as the point at which the value of "sensitivity+specificity-1" was maximum (Youden's index) [28]. The intraclass correlation coefficients (ICCs) were calculated to determine inter-reviewer reliability. ICCs from 0 to 0.20 indicate poor agreement, from 0.21 to 0.40 indicate fair agreement, from 0.41 to 0.60 indicate moderate agreement, from 0.61 to 0.80 indicate good agreement, and from 0.81 to 1.00 indicate excellent agreement [29]. Statistically significance level was considered as p value < 0.05. This study used SPSS 26.0 (SPSS Inc., Chicago, IL, USA) for performing statistical analysis. And AUROC curve analysis was conducted by DeLong method using the MedCalc Statistical Software version 19 (MedCalc Software Bvba, Ostend, Belgium).

3. Results

3.1 Baseline characteristics

In total, 279 patients were registered during the study period. Table 1 presents the patients' demographic data, vital signs, initial laboratory results, and outcomes. The mean age of the patients was 77 ± 7.1 years, and 121 patients (43.4%) were male. Altered mental status was identified in 31 (11.1%) patients. 56 patients (20.1%) were admitted to the ICU, and 51 patients (18.3%) died in the hospital during the clinical process.

TABLE 1. Demographic characters, laboratory and clinical results of patients (Total n = 279).

Variable	Value[a]
Age (years)	77 ± 7.1
Sex	
Male	121 (43.4)
Female	158 (56.6)
Systolic Blood Pressure (mmHg)	130.3 ± 31.8
Diastolic Blood Pressure (mmHg)	73.5 ± 14
Pulse rate (beats/min)	89.4 ± 18.6
Respiratory rate (breath/min)	20.9 ± 3.4
Body temperature (°C)	36.8 ± 0.9
Mental status	
Alert	248 (88.9)
Verbal response	24 (8.6)
Painful response	7 (2.5)
Unresponsive	0
Laboratory test	
Hemoglobin (g/dL)	11.9 ± 2.6
Hematocrit (%)	35.2 ± 7.1
White blood cell (10^9/L)	11.5 ± 6.2
Platelet (10^9/L)	233.4 ± 102.6
C-reactive protein (mg/dL)	7.4 ± 8.8
Aspartate aminotransferase (IU/L)	48.1 ± 79.8
Alanine aminotransferase (IU/L)	32.8 ± 80.6
Blood urea nitrogen (mg/dL)	24.2 ± 17
Creatinine (mg/dL)	1.1 ± 1
Glucose (mg/dL)	150.2 ± 63.7
Albumin (g/dL)	3.6 ± 0.7
Sodium (mmol/L)	134.8 ± 5.4
Potassium (mmol/L)	3.9 ± 0.6
PT (INR)	1.1 ± 0.3
PTT (sec)	30.7 ± 8.1
Hospital Length of stay (day)*	12 (17)
ICU admission	56 (20.1)
In-hospital mortality	51 (18.3)
Psoas muscle size (mm^2)	
Reviewer 1	744.1 ± 354.5
Reviewer 2	725.3 ± 346.7
Muscle attenuation (HU)	
Reviewer 1	56 ± 14.4
Reviewer 2	56 ± 14.7

[a] *The values are presented as mean (standard deviation) or number (%).*
** The values are presented as median (IQR).*

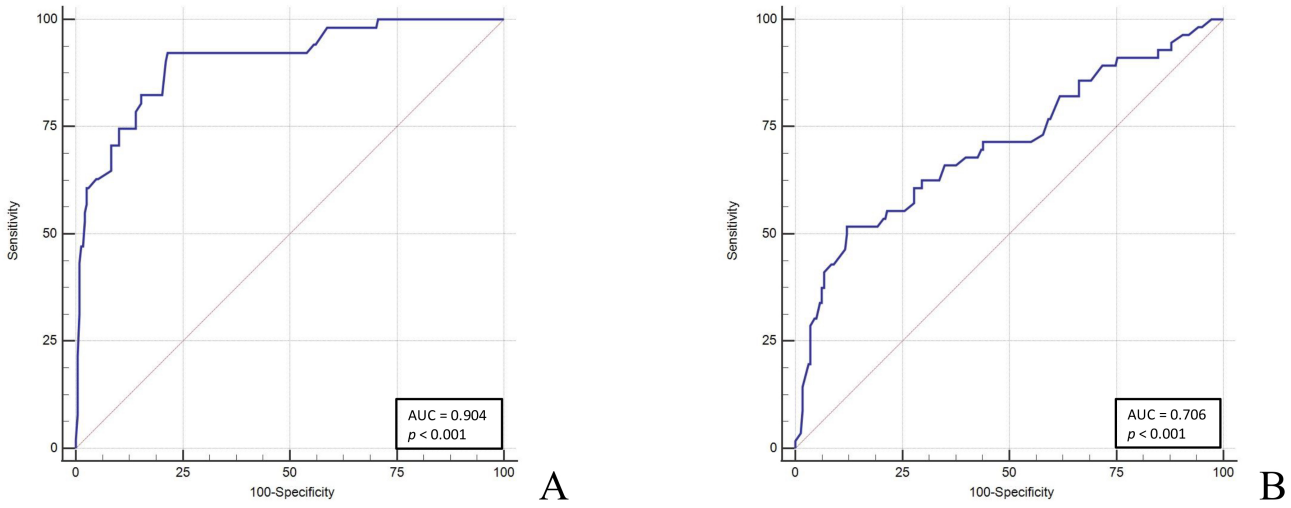

FIGURE 2. The AUROCs of psoas muscle size for the prediction of outcomes. (A) The area under the receiver operating characteristic (AUROC) curve for the prediction of mortality. (B) The area under the receiver operating characteristic (AUROC) curve for the prediction of ICU admission.

3.2 Psoas muscle size and attenuation

The psoas muscle size and attenuation were measured twice by two reviewers. In the case of reviewer 1, the mean muscle sizes (mm^2) on the left, right, and average were 755.3, 732.9, and 744.1, respectively; the mean attenuation (HU) values on the left, right, and average were 56.0, 56.0, and 56.0, respectively. In the case of reviewer 2, the mm^2 on the left, right, and average were 728.7, 721.9, and 725.3, respectively; the HU values on the left, right, and average were 56.0, 56.0, and 56.0, respectively. The reliability of the measurements between the two reviewers was excellent. ICCs between the two reviewers for muscle size on the left and right were 0.983 [95% CI: 0.978–0.986] and 0.987 [95% CI: 0.983–0.990], respectively. ICCs for muscle attenuation on left and right sides were 0.977 [95% CI: 0.971–0.982] and 0.975 [95% CI: 0.968–0.980], respectively.

3.3 Clinical variables associated with patients' prognosis

Table 2 shows that the association between clinical and laboratory data and in-hospital mortality. In the univariate analysis, age, PR and RR were statistically significantly higher in deaths than in surviving patients. In laboratory tests, the mortality group had statistically significantly higher AST, BUN, Cr, and albumin levels. Also, psoas muscle size and attenuation were statistically significantly lower in the mortality group. In the multivariate logistic analysis, Cr and psoas muscle size were statistically significant variable for predicting mortality.

Clinical factors according to ICU admission are presented in Table 3. In univariate analysis, SBP, DBP, albumin, and altered mental status were statistically significantly lower while PR, RR, CRP, AST, ALT, BUN, Cr, and PTT were higher in the ICU (+) group patients. Muscle size and attenuation were low in the ICU (+) group, which was statistically significant. In the multivariate logistic regression analysis, SBP, RR, AST, ALT, Cr, and psoas muscle size were statistically significant variables for predicting ICU admission.

3.4 Predictive performance of psoas muscle measurement

In multivariate logistic analyses, attenuation was not predictive factor for in-hospital mortality and ICU admission. The ROC curves of significant factors are presented in Fig. 2. The AUROC of muscle size for predicting in-hospital mortality was 0.904 [95% CI: 0.864–0.936], and the cut-off value was 587.41 with 92.2% sensitivity and 78.5% specificity. For prediction of ICU admission, the AUROC of muscle size was 0.706 [95% CI: 0.649–0.759], and the cut-off value was 390.18 with 51.8% sensitivity and 87.9% specificity (Table 4).

4. Discussion

Sarcopenia is related to decrease in muscle mass and muscle strength due to aging. As aging progresses, skeletal muscle is replaced by non-contractile components such as lipids, which leads to increases in the incidence of falls and physical dysfunction [30]. There have been several previous studies that have assessed the relationship between sarcopenia and the incidence of fracture [31–33]. Moreover, other studies showing an associated between sarcopenia and many systemic diseases, such as diabetes, cancers, and cardiovascular diseases [22, 23] suggest that these associations are causally linked to fat infiltration. In contrast to subcutaneous adipocytes, the visceral adipocytes infiltrating the muscles of sarcopenia patients secrete pro-inflammatory cytokines like IL-6 and TNF-alpha [34]. In addition, increases in skeletal muscle adiposity have been reported that can result in mitochondrial dysfunction and impaired oxidative metabolism [35, 36]. Because of the associated morbidity, sarcopenia is considered a geriatric syndrome that could reduce quality of life and increase health care costs.

As the aging population increases, many studies are focusing on risk factors related to diseases in the elderly. Our study focused on evaluating sarcopenia by measuring muscle mass size and fat infiltration through imaging rather than using

TABLE 2. Logistic regression analysis for predicting in-hospital mortality.

Variable	Univariate analysis[a]			Multivariate analysis[b]		
	Non-mortality group	Mortality group	*p*-value	OR	B	*p*-value
	n = 228	n = 51				
Age (years)	76.5 ± 7.1	79 ± 6.4	**0.024**	1.03 (0.97–1.09)	0.027	0.397
Sex; Male	93 (40.8)	28 (54.9)	0.068			
Systolic Blood Pressure (mmHg)	131.7 ± 29.5	124.1 ± 40.4	0.121			
Diastolic Blood Pressure (mmHg)	74.2 ± 13.2	70.4 ± 16.7	0.080			
Pulse rate (beats/min)	87 ± 15.5	99.8 ± 26.6	<**0.001**	1.02 (1.00–1.04)	0.021	0.065
Respiratory rate (breath/min)	20.6 ± 2.5	22.2 ± 5.9	**0.008**	1.00 (0.88–1.13)	–0.005	0.933
Body temperature (°C)	36.8 ± 0.9	36.7 ± 0.9	0.252			
Altered mental status	24 (10.5)	7 (13.7)	0.512			
Laboratory test						
Hemoglobin (g/dL)	12 ± 2.5	11.3 ± 3.1	0.083			
Hematocrit (%)	35.5 ± 6.8	33.9 ± 8.4	0.137			
White blood cell (10^9/L)	11.7 ± 6.1	10.9 ± 6.4	0.418			
Platelet (10^9/L)	234.7 ± 95.3	227.7 ± 131.5	0.660			
C-reactive protein (mg/dL)	7.1 ± 8.5	8.9 ± 9.8	0.181			
Aspartate aminotransferase (IU/L)	38.3 ± 41.9	91.6 ± 158	**0.001**	1.00 (0.99–1.01)	0.002	0.455
Alanine aminotransferase (IU/L)	27.4 ± 70.9	57.1 ± 112	0.056			
Blood urea nitrogen (mg/dL)	22.1 ± 15.5	33.7 ± 20.2	<**0.001**	0.99 (0.97–1.02)	–0.006	0.660
Creatinine (mg/dL)	1 ± 0.6	1.7 ± 2	**0.001**	1.47(1.05–2.04)	0.383	**0.023**
Glucose (mg/dL)	148.2 ± 55.5	158.8 ± 92.1	0.288			
Albumin (g/dL)	3.7 ± 0.6	3.3 ± 0.7	<**0.001**	0.86 (0.43–1.73)	–0.150	0.673
Sodium (mmol/L)	134.9 ± 5.6	134.3 ± 4.6	0.468			
Potassium (mmol/L)	3.9 ± 0.6	4 ± 0.8	0.201			
PT (INR)	1.1 ± 0.3	1.2 ± 0.3	0.243			
PTT (sec)	30.2 ± 8.2	32.6 ± 7.7	0.069			
Hospital length of stay (days)*	5 (10)	9 (15)	0.068			
ICU admission	31 (13.6)	25 (49.0)	<**0.001**			
Psoas muscle size (mm^2)	826.3 ± 330.9	376.5 ± 180.9	<**0.001**	0.99 (0.99–0.99)	–0.008	<**0.001**
Muscle attenuation (HU)	59 ± 13.6	42.6 ± 9.6	<**0.001**	0.99 (0.96–1.03)	–0.007	0.710

[a] *The values are presented as mean (standard deviation) or number (%).*
[b] *Data in parentheses are 95% CI, conducted on variables with a $p < 0.05$ on univariate analysis.*
** The values are presented as given median (IQR).*
OR, odds ratio; B, regression coefficient.
Boldface type indicates statistical significance (p value < 0.05).

clinical, easily accessible laboratory tests and vital signs. If the emergency physicians promptly predict the prognosis of patients visiting the ED, they can expect to provide appropriate treatment. Therefore, we conducted a study on the elderly patient population visiting the ED but did not look for specific diseases. When the final diagnosis of enrolled patients was classified by the International Classification of Diseases-10th Revision (ICD-10), selected patient diseases could be categorized into 13 different chapters.

The most common body composition evaluation methods are dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA), computerized tomography (CT), and magnetic resonance imaging (MRI). While identifying sarcopenia is particularly important for older patient, the method of measurement is not completely standardized. According to the consensus of the European Working Group on Sarcopenia in Older Persons (EWGSOP), CT and MRI are the gold standards for estimating muscle mass [9]. However, these imaging tests are costly, have limited access to equipment at certain sites, and have concerns regarding radiation exposure. Thus, DXA and BIA seemed to be desirable alternative approaches to research and clinical use. However, these two techniques have some degree of inaccuracy in clinical used. DXA measures may vary depending on the device manufacturer [37]. BIA accuracy depends on the type of equations used to estimate appendicular skeletal mass as well as on hydration status [38,

TABLE 3. Logistic regression analysis for predicting ICU admission.

Variable	Univariate analysis[a]			Multivariate analysis[b]		
	Non-ICU	ICU	*p*-value	OR	B	*p*-value
	(–) group	(+) group				
	n = 223	n = 56				
Age (years)	76.7 ± 7.2	77.9 ± 6.3	0.263			
Sex; Male	94 (42.2)	27 (48.2)	0.414			
Systolic Blood Pressure (mmHg)	133.8 ± 29.8	116.6 ± 36	<**0.001**	0.99 (0.98–1.00)	–0.013	**0.041**
Diastolic Blood Pressure (mmHg)	75.1 ± 13	67.2 ± 16	<**0.001**	0.99 (0.95–1.03)	–0.007	0.727
Pulse rate (beats/min)	86.7 ± 14.8	99.9 ± 26.8	<**0.001**	1.02 (0.99–1.04)	0.015	0.159
Respiratory rate (breath/min)	20.4 ± 2.1	22.7 ± 6.1	<**0.001**	1.18 (1.05–1.31)	0.161	**0.005**
Body temperature (°C)	36.8 ± 0.8	36.9 ± 1.1	0.277			
Altered mental status	20 (9.0)	11 (19.6)	**0.027**			0.885
Laboratory test						
Hemoglobin (g/dL)	12 ± 2.7	11.5 ± 2.4	0.208			
Hematocrit (%)	35.4 ± 7.2	34.3 ± 6.7	0.264			
White blood cell (10^9/L)	11.7 ± 6.1	10.6 ± 6.3	0.240			
Platelet (10^9/L)	235 ± 90.9	227.2 ± 140.8	0.608			
C-reactive protein (mg/dL)	6.4 ± 7.9	11.2 ± 10.9	<**0.001**	1.04 (1.00–1.08)	0.035	0.066
Aspartate aminotransferase (IU/L)	40 ± 57.8	81 ± 132.4	**0.004**	1.02 (1.01–1.03)	0.019	**0.003**
Alanine aminotransferase (IU/L)	26.3 ± 49.7	58.8 ± 148.2	**0.037**	0.98 (0.96–0.99)	–0.025	**0.008**
Blood urea nitrogen (mg/dL)	21.6 ± 12.4	34.6 ± 26.5	<**0.001**	1.01 (0.99–1.04)	0.012	0.355
Creatinine (mg/dL)	1 ± 0.8	1.7 ± 1.6	**0.001**	1.46 (1.09–1.97)	0.379	**0.012**
Glucose (mg/dL)	149.5 ± 59.6	152.7 ± 78.4	0.739			
Albumin (g/dL)	3.7 ± 0.7	3.3 ± 0.6	**0.001**	0.74 (0.39–1.38)	–0.306	0.339
Sodium (mmol/L)	135 ± 4.9	134 ± 7	0.221			
Potassium (mmol/L)	3.9 ± 0.5	4 ± 0.9	0.182			
PT (INR)	1.1 ± 0.3	1.2 ± 0.3	0.149			
PTT (sec)	30.1 ± 8.2	32.8 ± 7.6	**0.036**	0.97 (0.92–1.02)	–0.032	0.222
Hospital length of stay (days)*	4 (8)	12 (17)	<**0.001**			
In hospital mortality	26 (11.7)	25 (44.6)	<**0.001**			
Psoas muscle size (mm^2)	791.1 ± 341.6	556.9 ± 345.6	<**0.001**	1.00 (1.00–1.00)	–0.002	**0.002**
Muscle attenuation (HU)	57.7 ± 13.9	49.4 ± 14.6	<**0.001**	0.99 (0.96–1.02)	–0.010	0.521

[a] *The values are presented as mean (standard deviation) or number (%).*
[b] *Data in parentheses are 95% CI, conducted on variables with a p value of <0.05 on univariate analysis.*
** The values are presented as median (IQR).*
OR, odds ratio; B, regression coefficient.
Boldface type indicates statistical significance (p < 0.05).

TABLE 4. Cut-off value, AUROC, sensitivity and specificity for predict prognosis.

	Cut-off value	AUROC (95% CI)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Psoas muscle size				
For predict in-hospital mortality	587.4	0.904 (0.856–0.953)	92.2 (81.1–97.8)	78.5 (72.6–83.7)
For predict ICU admission	390.2	0.706 (0.622–0.791)	51.8 (38.0–65.3)	87.9 (82.9–91.9)

AUROC, Area under the ROC curve; ICU, Intensive care unit.

39]. Using existing CT scans taken for other purposes can overcome disadvantages of the previous two methods and does not require additional costs or additional radiation.

Recently, many research have studied the application of deep learning to medical image segmentation and measurement of muscle [40, 41]. Also, deep learning has been shown to be capable of predicting the prognosis of patients in some

diseases as well as measuring image segmentation [42]. However, it is still difficult to easily conduct it to patients. Our study is expected to be used as a basis for presenting accurate criteria for automated measurement and prediction of patients' prognosis.

Our study demonstrated that only muscle size measured by CT was an independent predictor of poor prognosis for older patients visited the ED. This is consistent with other studies that demonstrate that sarcopenia is a significant factor for predicting patients' poor prognosis [24, 43]. On the other hand, psoas muscle attenuation was a significant factor for predicting in-hospital mortality and ICU admission. However, this does not mean that the only muscle size is associated sarcopenia. Some previous studies have reported that muscle attenuation is associated with patient prognosis [44, 45].

In previous studies, the size of the psoas muscle was presented as the muscle index calculated by dividing the sum of the right and left psoas muscle areas into the patient's height [24, 43]. Alternatively, there have been studies that predict prognosis using only psoas muscle area [22]. It is difficult to measure the exact height in the ED setting. Almost patients are in a supine position with lines and tubes attached, and thus obtaining a patient's height is almost impossible. In addition, ED physicians usually have limited time because they are simultaneously attending to the care of a large number of patients.

To our knowledge, this is the first study to assess the psoas muscle size and patient outcomes using only CT for elderly patients visiting the emergency room. However, there are some limitations to this study. This is a retrospective study in single-center for patients who have visited the ED. Thus, a selection bias can occur. Additional multi-centered studies with prospective designs are required before our results are generalizable. In this study, patients were selected from diverse disease groups to predict all-cause mortality. In final diagnosis of enrolled patients, categorization into chapters XI (Diseases of the digestive system) and XIV (Diseases of the genitourinary system) from the ICD-10 classification were most common. Due to, we only selected patients who took APCT for psoas muscle measurement using CT, it may be difficult to fully characterize the disease. The use of manual muscle contours to measure muscle size and attenuation can be another limitation because it could lead to incorrect inclusion of muscle fat in the measurements. However, for minimize this bias, two board certified emergency physicians measured the psoas muscles size and attenuation for included patients to verify reliability.

5. Conclusions

Simple, easy to apply, and cost-efficient methods are needed in clinical practice for early diagnosis of sarcopenia in older patients. Using existing CT can be appropriate method for this evaluation. In this study, measurement of muscle size using CT was shown to be a feasible modality for predicting poor prognoses for older patients.

AUTHOR CONTRIBUTIONS

Conception and design—SHL. Acquisition, analysis, and interpretation of data—SJB, SHL. Drafting the manuscript for intellectual content—SJB, SHL, SJY. Statistical analysis—KK. All authors reviewed, revised and approved the manuscript for submissions. Study supervision—SHL.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the institutional review board of Ewha Womans University Mokdong Hospital, and the requirement for written informed consent was waived (IRB No: 2021-01-014).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon request.

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