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CORRELATION BETWEEN PSOAS MUSCLE MEASUREMENTS USING COMPUTED TOMOGRAPHY AND HOSPITAL STAY OF PULMONARY EMBOLISM PATIENTS.

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ABSTRACT

Introduction: Sarcopenia, characterized by the loss of skeletal muscle mass, is linked to aging and chronic diseases, and is associated with poor outcomes in critically ill patients. The psoas muscle index (PMI), derived from computed tomography (CT) scans, can serve as a marker for sarcopenia. This study aimed to evaluate the correlation between PMI measured by CT and hospital stay duration in pulmonary embolism (PE) patients, considering death status as a prognostic factor.

Materials and Methods: This retrospective study was conducted using data from 2021-2022 at King Abdulaziz University Hospital. Medical records of 66 PE patients were reviewed and grouped based on comorbidity status: no comorbidity (7), cancerous/malignant (33), and non-malignant/chronic medical illness patients (26). Psoas muscle measurements were obtained using axial CT images at the L4 vertebra. PMI was calculated, and statistical analysis was performed using SPSS version 24.0 to assess the correlation between PMI and hospital stay duration.

Results: The mortality rate was significantly higher in cancerous/malignant patients (57.6%) compared to non-malignant (30.8%) and no comorbidity patients (0%). After excluding patients who died, the analysis focused on 38 surviving patients. PMI was significantly higher in male patients (7.4 $\pm$ 2.32) compared to female patients (5.65 $\pm$ 1.6). Psoas muscle measurements tended to be lower in cancerous patients, though differences between groups were not statistically significant. A significant positive correlation between LPMH and hospital stay was observed in the no comorbidity group ($r = 0.847$, $P < 0.05$), while significant correlations between PMI, LPMW, LPMA, and hospital stay were noted in cancerous/malignant patients.

Conclusion: PMI and other psoas muscle measurements correlated with hospital

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stay in PE patients, particularly in cancerous/malignant and no-comorbidity groups. These findings suggest PMI could serve as a prognostic marker for hospital stay duration in PE patients, especially when factoring in sarcopenia and comorbidities.

1. INTRODUCTION

Acute pulmonary embolism (PE) is a fatal cardiovascular disease caused by embolic occlusion of one or more pulmonary arteries. It has a 30-day mortality rate ranging from 0.5% to > 20%, sometimes reaching 60%. Additionally, chronic thromboembolic pulmonary hypertension (CTEPH) may result from PE. It can be symptomatic or asymptomatic and can be detected accidentally when the patient performs imaging procedures [1–3].

The simplified Pulmonary Embolism Severity Index (PESI) and clinical features such as myocardial dysfunction, injury, shock, cardiac or respiratory conditions, cancer, and age $\geq$ 75 years are used to measure the prognosis of patients with PE. Sarcopenia is a condition highly associated with critically ill patients and different clinical conditions [1, 3].

Pulmonary embolism (PE) is a potentially fatal cardiovascular condition that can present with various symptoms, posing a significant risk of morbidity and mortality, particularly in hospitalized patients. Critical cases often require intensive care unit (ICU) admission. The prognosis for PE patients depends on several factors, including right ventricular failure, hypoxemia, and frailty, particularly in elderly individuals. Underlying conditions such as cancer, cardiac, or respiratory diseases further complicate PE prognosis [4].

Sarcopenia, characterized by the loss of skeletal muscle mass and strength, is a crucial component of frailty and a key indicator of poor outcomes in critically ill patients. Sarcopenia is often associated with aging and chronic diseases and can be assessed using various methods, including medical imaging. Among imaging modalities, computed tomography (CT) is widely used for the quantitative evaluation of muscle mass. While whole-body CT assessments are comprehensive, measuring the psoas muscle area at the lumbar spine (L4 vertebra) provides an efficient and reliable estimate of muscle mass [4].

There is growing interest in using the Psoas Muscle Index (PMI), derived from psoas muscle area measurements on CT scans, as a prognostic tool for various conditions. Studies have suggested that low psoas muscle mass is associated with longer hospital stays and worse outcomes in critically ill patients, including those with PE. However, the relationship between PMI and hospital stay duration in PE patients, particularly in relation to sarcopenia and comorbidities, remains underexplored.

The aim of this study is to evaluate the correlation between PMI, as measured by CT, and the duration of hospital stay in PE patients. By investigating the impact of sarcopenia on the prognosis of PE patients with and without comorbidities, this study aims to provide insights into the potential use of PMI as a prognostic marker in clinical practice.

2. MATERIALS AND METHODS

This retrospective study was conducted at King Abdulaziz University Hospital, utilizing pre-collected data from 2021 to 2022. Ethical approval was obtained prior to commencing the study.

Study Population: The medical records of 66 patients diagnosed with pulmonary embolism (PE) were reviewed. Patients were categorized into three groups based on comorbidity status: no comorbidity/negative patients (n=7), cancerous/malignant patients (n=33), and non-malignant/chronic medical illness patients (n=26). The mortality rates within these groups were assessed, and patients who died during hospitalization were excluded from further analysis, resulting in a focus on 38 surviving patients.

Data Collection: Relevant clinical data collected from the medical records included age, sex, body weight (kg), height (cm), body mass index (BMI), hospital stay duration, comorbidities, and death status.

Psoas Muscle Measurements: CT scans of the abdomen were performed to assess the psoas muscle area. An axial plane image passing through the middle part of the fourth lumbar vertebra (L4) was utilized for measurements. The right and left psoas muscle widths (RPMW and LPMW) and heights (RPMH and LPMH) were measured using the Paxera ruler tool. Additionally, the psoas muscle areas (RPMA and LPMA) were obtained by outlining the edges of the psoas muscles using the Paxera freehand tool. These measurements were conducted manually by three trained observers to ensure accuracy.

Psoas Muscle Index (PMI) Calculation: The PMI was calculated using the following formula (Rodge et al., 2023):

$$\text{PMI} = \frac{\text{total psoas muscle area (right + left)}}{\text{square of the patient height}} \frac{\text{cm}^2}{\text{m}^2}$$

Statistical Analysis: Data were analyzed using SPSS software version 24.0. Continuous variables were expressed as means with standard deviations (SD) for normally distributed data. Group comparisons for parametric measurements of psoas muscle variables were conducted using t-tests or one-way ANOVA as appropriate. Non-parametric data for hospital stay duration were analyzed using the Kruskal-Wallis test. Spearman's correlation was

employed to assess the relationship between psoas muscle measurements and hospital stay duration. A P-value of <0.05 (two-sided test) was considered statistically significant.

3. RESULTS

A total of 66 patients were included in the study, from whom psoas muscle measurements were obtained using CT scans. Among these patients, 7 (10.6%) had no comorbidity, 33 (50%) were cancerous/malignant patients, and 26 (39.4%) were non-malignant/chronic medical illness patients. The demographic characteristics of the studied patients are summarized in Table 1. No significant differences were observed between the patient groups in terms of age, sex, weight, BMI, and hospital stay duration (Table 1).

Table 1 Demographics characteristics of studied patients

	No comorbidity / negative patients (n= 7)	**Cancerous / malignant patients (n= 14)**	**Non-malignant / chronic medical illness patients (n= 17)**	**P-value**
Age$_{mean\ (SD)}$	49 (16)	53 (13)	50 (16)	0.679 [a]
Sex$_{n\ (n\%)}$				
Male	5 (71.4%)	6 (42.9%)	7 (38.9%)	0.32[b]
Female	2 (28.6%)	8 (57.1%)	11 (61.1%)	
Weight (kg) $_{mean\ (SD)}$	79.6 (12)	74.5 (18.8)	73.8 (16.1)	0.72[a]
BMI$_{mean\ (SD)}$	28.8 (4.6)	27.3 (5.6)	28.6 (6.7)	0.793[a]
Hospital stay (days) $_{median\ (IQR)\ for\ negative}$	12 (4)	9.5 (21.5)	8 (14)	0.727 [c]

[a] P-value obtain by one-way ANOVA
[b] P-value obtain by Chi-square test
[c] P-value obtain by Kruskal-Wallis test
Significant P-values are shown in bold

PMI in age and sex groups is shown in Figure 1. PMI mean was 7.4 $\pm$ 2.32 in male patients (n=18) and 5.65 $\pm$ 1.6 in female patients (n=21) and this difference was significant (P <0.01, t-test). PMI was not significantly different between age groups.

Mortality Rates: The mortality rate was 0% among the no comorbidity/negative patients, while the cancerous/malignant group experienced a significantly higher mortality rate of 57.6%. The non-malignant/chronic medical illness patients had a mortality rate of 30.8%. These differences in mortality rates were statistically significant (p < 0.01, data not shown).

Patient Cohort Analysis: After excluding patients who died during hospitalization, a total of 38 patients were analyzed: 7 (18.4%) had no comorbidity, 14 (36.8%) were cancerous/malignant patients, and 17 (44.7%) were non-malignant/chronic medical illness patients. The demographic characteristics of this cohort are shown in Table 1. No signif-

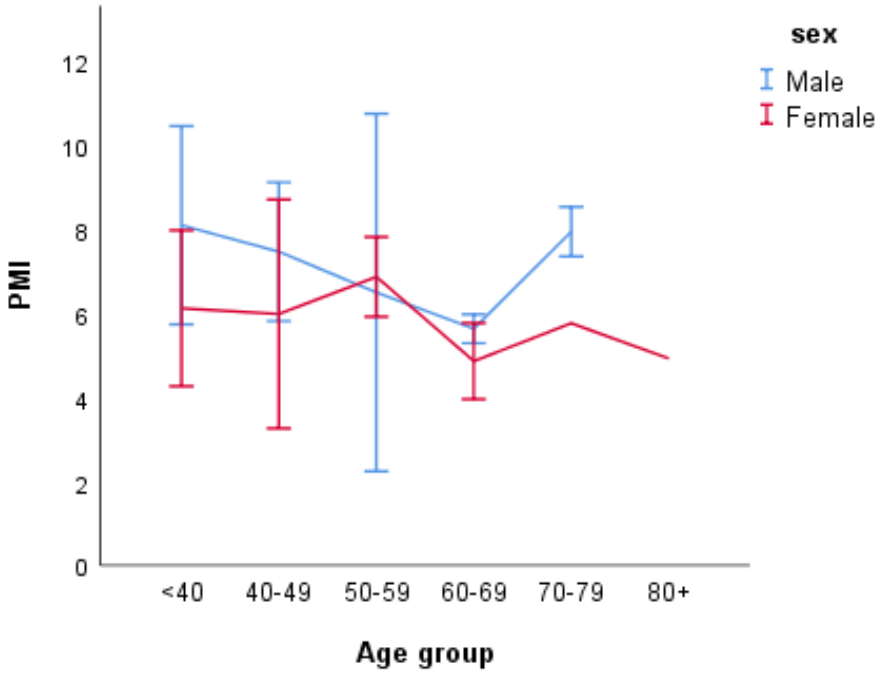

Figure 1 PMI in age and sex groups. Data are mean and SD.

icant differences were found between groups in terms of age, sex, body weight, and BMI (Table 1).

Hospital Stay Duration: The median duration of hospital stay for patients who did not succumb to death was 12 days (IQR: 4) for the no comorbidity/negative patients, 9.5 days (IQR: 21.5) for cancerous/malignant patients, and 8 days (IQR: 14) for non-malignant/chronic medical illness patients, with no significant differences observed between the groups (Table 1).

Psoas Muscle Measurements: The mean right and left psoas muscle widths were highest in the no comorbidity/negative group (3.16 ± 0.69 cm and 3.21 ± 0.71 cm, respectively), followed by the non-malignant/chronic medical illness group (3.05 ± 0.63 cm and 3.17 ± 0.49 cm) and the cancerous/malignant group (2.78 ± 0.93 cm and 2.62 ± 0.97 cm). Although the differences were not statistically significant for the right psoas muscle width (RPMW), a trend towards significance was observed for the left psoas muscle width (LPMW) ($p = 0.088$, one-way ANOVA; Table 2).

The mean right and left psoas muscle heights displayed a similar pattern, with the no comorbidity/negative group having the highest means (3.9 ± 0.53 cm and 4.03 ± 0.68 cm), followed by the non-malignant/chronic medical illness group (3.51 ± 0.63 cm and 3.65 ±

Table 2 Measurements of the psoas muscle and psoas muscle index for patient groups and their correlation with the duration of hospital stay for all patients

	No comorbidity / negative patients (n= 7)	Cancerous / malignant patients (n= 14)	Non-malignant / chronic medical illness patients (n= 18)	P-value
RPMW				
Mean (SD)	3.16 (0.69)	2.78 (0.93)	3.05 (0.63)	0.464
Correlation with HS	-0.036	0.161	0.171	
LPMW				
Mean (SD)	3.21 (0.71)	2.62 (0.97)	3.17 (0.49)	0.088
Correlation with HS	0.342	-0.141	-0.031	
RPMH				
Mean (SD)	3.9 (0.53)	3.72 (0.66)	3.51 (0.63)	0.346
Correlation with HS	0.234	0.399	-0.191	
LPMH				
Mean (SD)	4.03 (0.68)	3.68 (0.67)	3.65 (0.62)	0.412
Correlation with HS	**0.847***	0.403	-0.416	
RPMA (cm^2)				
Mean (SD)	9.5 (2.63)	8.53 (4.17)	8.43 (3.08)	0.774
Correlation with HS	0.396	0.297	-0.221	
LPMA (cm^2)				
Mean (SD)	10.07 (3.01)	8.28 (4.44)	8.79 (2.82)	0.547
Correlation with HS	0.342	0.132	-0.223	
L4 height				
Mean (SD)	2.7 (0.29)	2.56 (0.4)	2.45 (0.29)	0.235
Correlation with HS	0.721 (P=0.068)	**0.716****	0.262	
PMI				
Mean (SD)	7.02 (1.87)	6.05 (2.6)	6.56 (1.86)	0.607
Correlation with HS	0.396	0.218	-0.365	

RPMW, right psoas muscle width; LPMW, left psoas muscle width; RPMH, right psoas muscle height; LPMH, left psoas muscle height; RPMA, right psoas muscle area; LPMA, left psoas muscle area; PMI, psoas muscle index

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

P-value column was obtained using one-way ANOVA with Bonferroni correction

0.62 cm), and the cancerous/malignant group (3.72 ± 0.66 cm and 3.68 ± 0.67 cm). These differences were not statistically significant (Table 2).

The areas of the right and left psoas muscles were largest on average in the no comorbidity/negative group (9.5 ± 2.63 cm^2 and 10.07 ± 3.01 cm^2), followed by the non-malignant/chronic medical illness group (8.43 ± 3.08 cm^2 and 8.79 ± 2.82 cm^2), and the cancerous/malignant group (8.53 ± 4.17 cm^2 and 8.28 ± 4.44 cm^2). Again, these differences were not statistically significant (Table 2 and Figure 2).

Correlation Analysis: There was a significant positive correlation between left psoas muscle height (LPMH) and duration of hospital stay in the no comorbidity group ($r = 0.847$, $P < 0.05$, Spearman's correlation; Table 2). In contrast, the correlation between PMI and hospital stay duration exhibited a trend towards significance in the no comorbidity group ($r = -0.714$, $P = 0.071$; Table 3).

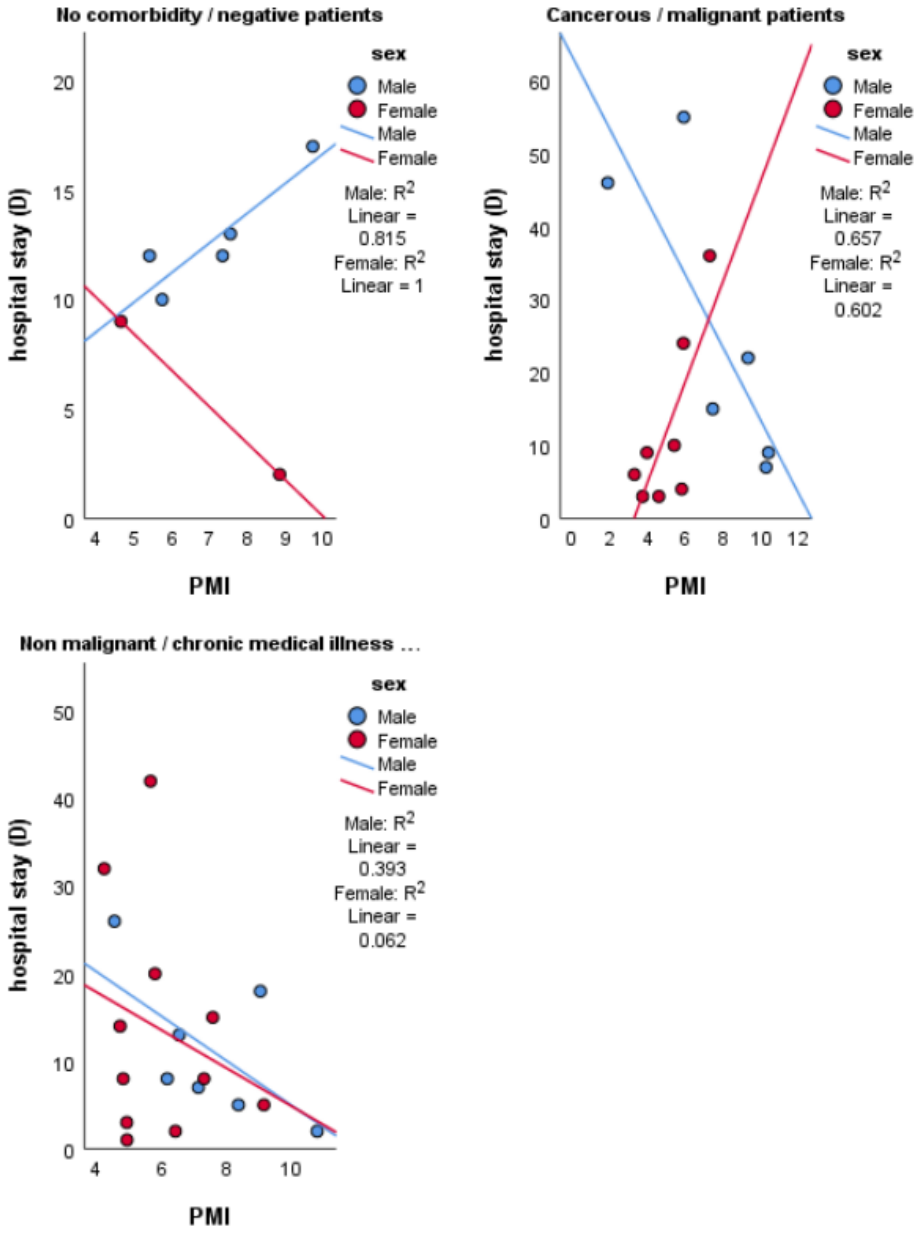

Figure 2 Correlation of PMI with the duration of hospital stay in days.

No comorbidity / negative patients (male n= 5 and female n=2), cancerous / malignant patients (male n= 8 and female n=25), Non-malignant / chronic medical illness patients (male n= 9 and female n=17).

Table 3 Measurements of the psoas muscle and psoas muscle index for patient groups and their correlation with the duration of hospital stay for each sex group separately

	No comorbidity / negative patients (male n=5) (female n=2)	**Cancerous / malignant patients (male n=6) (female n=8)**	**Non-malignant / chronic medical illness patients (male n=7) (female n=11)**	**P-value**
RPMW				
Male				
Mean (SD)	3.09 (0.8)	3.24 (1.12)	3.37 (0.52)	0.853
Correlation with HS	0.359	-0.771	-0.643	
Female				
Mean (SD)	3.34 (0.48)	2.43 (0.61)	2.85 (0.63)	0.142
Correlation with HS		**0.755***	0.533	
LPMW				
Male				
Mean (SD)	3.25 (0.78)	2.91 (1.27)	3.21 (0.31)	0.767
Correlation with HS	0.667	**-0.886***	-0.036	
Female				
Mean (SD)	3.11 (0.78)	2.41 (0.67)	3.14 (0.59)	0.06
Correlation with HS		0.479	0.018	
RPMH				
Male				
Mean (SD)	4.04 (0.26)	4.3 (0.5)	3.85 (0.54)	0.254
Correlation with HS	0.462	-0.086	-0.360	
Female				
Mean (SD)	3.54 (1.03)	3.29 (0.39)	3.29 (0.61)	0.85
Correlation with HS		-0.072	-0.123	
LPMH				
Male				
Mean (SD)	4.35 (0.27)	4.28 (0.49)	4.11 (0.55)	0.67
Correlation with HS	0.667	-0.657	-0.500	
Female				
Mean (SD)	3.23 (0.83)	3.22 (0.35)	3.36 (0.49)	0.8

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Table 3 continued

Correlation with HS		0.299	-0.393	
RPMA (cm^2)				
Male				
Mean (SD)	9.63 (2.38)	11.56 (4.47)	10.49 (3.39)	0.674
Correlation with HS	0.821	-0.657	-0.429	
Female				
Mean (SD)	9.19 (4.32)	6.26 (2.08)	7.12 (2.08)	0.277
Correlation with HS		**0.850****	-0.068	
LPMA (cm^2)				
Male				
Mean (SD)	10.36 (2.57)	10.92 (5.41)	10.79 (2.59)	0.968
Correlation with HS	0.667	**-0.829***	-0.321	
Female				
Mean (SD)	9.37 (5.13)	6.29 (2.29)	7.51 (2.21)	0.277
Correlation with HS		0.611	-0.087	
L4 height				
Male				
Mean (SD)	2.79 (0.28)	2.78 (0.38)	2.53 (0.35)	0.345
Correlation with HS	0.667	0.371	0.607	
Female				
Mean (SD)	2.47 (0.23)	2.39 (0.34)	2.39 (0.23)	0.936
Correlation with HS		0.659	0.141	
PMI				
Male				
Mean (SD)	7.14 (1.72)	7.5 (3.26)	7.51 (2.07)	0.96
Correlation with HS	0.821	**-0.829***	-0.607	
Female				
Mean (SD)	6.74 (2.97)	4.97 (1.34)	5.96 (1.52)	0.261
Correlation with HS		0.647	-0.182	

RPMW, right psoas muscle width; LPMW, left psoas muscle width; RPMH, right psoas muscle height; LPMH, left psoas muscle height; RPMA, right psoas muscle area; LPMA, left psoas muscle area; PMI, psoas muscle index

* Correlation is significant at the 0.05 level (Spearman correlation

** Correlation is significant at the 0.01 level (Spearman correlation) a denotes significantly different than b using one-way ANOVA with Bonferroni correction

In cancerous/malignant patients, significant negative correlations were found between psoas muscle measurements (LPMW, LPMA, PMI) and hospital stay duration in male patients ($r = -0.886$, $P < 0.05$ for LPMW; $r = -0.829$, $P < 0.05$ for LPMA; $r = -0.829$, $P < 0.05$ for PMI; Table 3).

4. DISCUSSION

Sarcopenia, characterized by the progressive loss of skeletal muscle mass, quality, and strength, is increasingly recognized as a critical factor affecting outcomes in critically ill patients. This study aimed to explore the relationship between psoas muscle measurements, specifically the psoas muscle index (PMI), and the duration of hospital stay in patients with pulmonary embolism (PE). The findings indicate a significant correlation between PMI and hospital stay duration, particularly in cancerous/malignant patients and those without comorbidities.

The results demonstrated that the no comorbidity group had the highest psoas muscle measurements, which corresponded with the shortest duration of hospital stay. Conversely, cancerous patients exhibited lower psoas muscle metrics and significantly higher mortality rates, which contributed to an overall shorter hospital stay in this group. Previous research has suggested that lower psoas muscle area correlates with prolonged hospital stays, especially in critically ill patients, reinforcing the utility of sarcopenia assessments as prognostic indicators [6].

Our findings corroborate previous studies showing that low psoas muscle mass is linked to frailty and increased risk of adverse outcomes in hospitalized patients [4, 7]. Notably, this study found a strong positive correlation between left psoas muscle height and hospital stay duration in the no comorbidity group ($r = 0.847$, $P < 0.05$). Such findings highlight the potential for psoas muscle measurements to serve as reliable indicators of functional reserve and recovery trajectory in patients admitted with PE.

While cancerous patients demonstrated significantly lower left psoas muscle area compared to their counterparts, the correlation between psoas muscle measurements and hospital stay duration was significant primarily in male patients. This suggests a need for further exploration into sex-specific differences in muscle mass and hospital outcomes, as factors such as hormonal variations and body composition may influence the correlation.

Importantly, the study highlights the potential limitations of using retrospective data. The accuracy of medical records regarding patient comorbidities and mortality may be questionable, potentially confounding the results. Furthermore, this study could not account for muscular strength or physical performance, which are critical components

of sarcopenia assessment. Additionally, the relatively small sample size and single-center data collection may limit the generalizability of the findings.

Despite these limitations, the current study provides valuable insights into the prognostic value of PMI and psoas muscle measurements in patients with PE. As healthcare systems seek to implement effective risk stratification and management strategies, integrating psoas muscle measurements into clinical practice may enhance the early identification of at-risk patients, ultimately improving patient outcomes and resource utilization in ICU settings.

5. CONCLUSION

This study highlights a significant correlation between the psoas muscle index (PMI) and the duration of hospital stay in patients with pulmonary embolism (PE). The findings suggest that PMI serves as a valuable prognostic marker for assessing hospital stay duration, particularly in patients with varying comorbidities, including cancer.

The results indicate that higher psoas muscle measurements are associated with shorter hospital stays, emphasizing the importance of sarcopenia assessment in critically ill patients. In particular, the study demonstrates that cancerous/malignant patients exhibit lower psoas muscle metrics and higher mortality rates, underscoring the need for careful monitoring and tailored management strategies for this population.

Given the relationship between sarcopenia and patient outcomes, integrating psoas muscle measurements into clinical assessments may facilitate early identification of at-risk patients and improve resource allocation in ICU settings. Further prospective studies are warranted to confirm these findings and to explore the impact of sarcopenia on hospitalization duration and overall prognosis in PE patients.

In conclusion, the PMI, derived from computed tomography measurements, can provide valuable insights into the prognostic evaluation of PE patients, paving the way for enhanced patient care and outcomes.

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