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ORIGINAL RESEARCH

Evaluating sarcopenia in emergency department triage: implications for hospitalization and critical care

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Abstract

Background: Sarcopenia, characterized by age-related declines in skeletal muscle mass, strength, and physical performance, is common in older adults yet remains under-recognized in emergency medical settings. Despite its strong association with frailty and adverse clinical outcomes, sarcopenia is not routinely assessed in emergency department (ED) triage. This study aimed to determine the prevalence of possible sarcopenia among elderly adults presenting to the ED and evaluate its association with hospital admission and length of stay (LOS). **Methods**: A prospective cohort study was conducted in a tertiary urban ED in Taiwan between December 2020 and April 2021. Patients aged ≥65 years were consecutively enrolled and assessed for possible sarcopenia. Frailty was evaluated using the Edmonton Frail Scale and the Eastern Cooperative Oncology Group performance status. The primary outcomes included ED disposition (hospital admission versus discharge) and unfavorable discharge outcomes. Secondary outcomes comprised hospital LOS and National Health Insurance (NHI) reimbursement points. Linear regression and multivariable logistic analyses were conducted, along with receiver operating characteristic (ROC) analysis. **Results**: Of the 890 patients enrolled, 481 (54.0%) were sarcopenic and were significantly older, had lower body weight, and exhibited higher frailty scores ($p < 0.001$). Sarcopenia was associated with higher rates of hospital admission ($p < 0.001$) and prolonged LOS ($p < 0.001$). After adjustment, sarcopenia independently predicted hospital admission (adjusted odds ratio (aOR) 1.39; 95% Confidence Interval (CI), 1.04–1.87) and extended LOS (aOR 3.29; 95% CI, 1.78–4.80). ROC analysis demonstrated moderate predictive capability (Area Under the Curve (AUC) = 0.706). Additionally, NHI reimbursement points and unfavorable discharge outcomes were significantly associated with sarcopenia. **Conclusions**: Sarcopenia is both prevalent and independently associated with adverse clinical outcomes among elderly adults in the ED. Incorporating sarcopenia assessment into triage protocols may improve early risk stratification and support more informed clinical decision-making in this population. **Clinical Trial Registration**: NCT04862936, retrospectively registered.

Keywords

Sarcopenia; Emergency department; Frailty; Hospital admission; Intensive care unit

1. Introduction

Sarcopenia is a geriatric syndrome characterized by progressive declines in skeletal muscle mass, strength, and physical performance, and it poses significant challenges to healthcare systems worldwide [1]. Among older adults, sarcopenia has been associated with a wide range of adverse clinical outcomes, including increased risk of falls, hospitalization, prolonged recovery, institutionalization, and elevated mortality rates [2]. In the emergency department (ED), a setting where rapid clinical decisions and timely resource allocation are essential, sarcopenia may influence triage accuracy, clinical management, and patient disposition. Nonetheless, despite increasing awareness, sarcopenia assessment has not been routinely integrated into ED workflows [3].

While sarcopenia and frailty are closely related, frailty represents a broader clinical phenotype encompassing reduced physiological reserve and heightened vulnerability to stressors [4, 5]. Several validated tools, including the Edmonton Frail Scale (EFS), Clinical Frailty Scale (CFS), and the Eastern Cooperative Oncology Group (ECOG) performance status, have been employed in acute care settings to evaluate frailty, predict patient outcomes and guide clinical decision-making [6], and have demonstrated predictive value for key outcomes, such as intensive care unit (ICU) admission and mortality [7]. However, the independent prognostic contribution of

sarcopenia, an important biological determinant of frailty, remains insufficiently explored in the ED context [8, 9]. Unlike frailty, sarcopenia offers a quantifiable marker of biological vulnerability through objective measures, such as muscle mass and strength, yet, its use in risk stratification during emergency care is limited. Globally, major triage systems categorize patient acuity based on physiological parameters, presenting complaints, and urgency of the clinical condition [10], but they fail to capture underlying geriatric vulnerabilities, particularly those related to frailty and sarcopenia [11]. Thus, incorporating frailty assessment into triage protocols has improved risk stratification and reduced under-triage of older adults at high risk of deterioration [12]. For example, incorporating the CFS into the Taiwan Triage and Acuity Scale (TTAS) has improved the prediction of critical event rates in elderly ED patients [10]. Other geriatric screening tools, such as the Identification of Seniors at Risk (ISAR) and the Acutely Presenting Older Patient (APOP) screener, have also shown prognostic utility [13]. However, these instruments often rely on self-reported information, limiting their applicability in patients with cognitive impairment or severe acute illness [14].

Recent evidence has further associated sarcopenia with increased hospital length of stay (LOS), higher ICU admission rates, greater healthcare expenditures, and diminished functional recovery [15–17]. In addition, sarcopenic patients are more susceptible to infections, exhibit impaired immune responses, experience delayed wound healing, and are at increased risk of rehospitalization [18]. These findings underscore the clinical importance of early recognition and timely intervention, particularly in high-acuity environments such as EDs. Despite these associations, the role of sarcopenia as an independent predictor of ED-related outcomes has yet to be clearly defined [19]. A recent systematic review recommended incorporating sarcopenia screening into emergency care to facilitate the early identification of vulnerable older adults [20]. However, no standardized protocol currently exists for implementing sarcopenia assessment in the ED setting [21]. Integrating sarcopenia evaluation with established frailty tools may strengthen the predictive value for adverse outcomes, but this approach requires further validation. Therefore, this study aimed to assess whether possible sarcopenia independently predicts key ED outcomes. We hypothesized that older adults with sarcopenia are more likely to require hospital admission, utilize greater healthcare resources, and experience prolonged hospital stays compared with their non-sarcopenic counterparts [22]. Clarifying the independent contribution of possible sarcopenia may improve risk stratification in ED triage, enhance resource planning, and support better outcomes for the aging population.

2. Methods

2.1 Study design and setting

This prospective cohort study was conducted in the ED of a large urban tertiary referral medical center in Taiwan between 01 December 2020 and 30 April 2021. The ED functions as a major regional hub, managing approximately 80,000 annual visits from patients aged over 65 years. According to prior data, an estimated 6.63% of adult patients presenting to EDs are classified as TTAS level 4 or 5, with approximately 3.4% subsequently requiring ICU admission or experiencing mortality. The study setting provides comprehensive emergency services, including stabilization, diagnostic evaluation, and specialist consultations across various disciplines. This high-volume, high-acuity environment, representative of tertiary care institutions, offered an appropriate context for assessing possible sarcopenia and its implications for emergency care among older adults.

2.2 Participants

Patients aged $\geq$65 years who presented to the ED during the study period were considered eligible for inclusion. Patients were excluded under the following criteria: (1) incomplete or missing medical documentation, (2) presentation with traumatic injuries, (3) immediate transfer to the resuscitation room upon arrival, and (4) refusal to participate or withdrawal of informed consent (Fig. 1). These criteria were designed to ensure a representative and analyzable cohort for evaluating sarcopenia-related outcomes in the emergency care setting.

To ensure sufficient statistical power, a minimum sample size of 808 patients was calculated to detect meaningful differences at a significance level of 5% and with over 80% power. By anticipating a potential dropout rate of up to 10%, the target recruitment was set at a minimum of 889 participants to maintain statistical validity.

2.3 Procedure

Patient recruitment was conducted by trained research assistants with triage experience at each participating site. To ensure broad temporal coverage and minimize sampling bias, a convenience sampling strategy was employed across rotating 8-hour shifts—day, evening, and night. After triage, eligible patients were approached, and written informed consent was obtained prior to enrollment. After consent, research staff proceeded with assessments of possible sarcopenia and frailty-related indicators.

According to the diagnostic algorithm proposed by the Asian Working Group for Sarcopenia (AWGS) 2019, sarcopenia is defined by the presence of low muscle mass in conjunction with either low muscle strength or low physical performance. When all three criteria are satisfied, the condition is classified as severe sarcopenia. Given the practical limitations of conducting bioelectrical impedance analysis (BIA) in the ED, including time constraints, equipment availability, and variable patient cooperation, calf circumference (CC) was used as a surrogate marker for low muscle mass. CC was measured at the widest point of the right lower leg with the patient in a seated or supine position. A CC of $<$34 cm for men and $<$33 cm for women was considered indicative of low muscle mass, as recommended by AWGS 2019 [14, 23, 24].

Muscle strength was evaluated using hand grip strength (HGS), measured with a Jamar hydraulic hand dynamometer. The test was performed on the patient's dominant hand. Each participant was instructed to exert maximal grip force across three consecutive trials, with brief rest intervals between attempts; the highest recorded value was used for analysis.

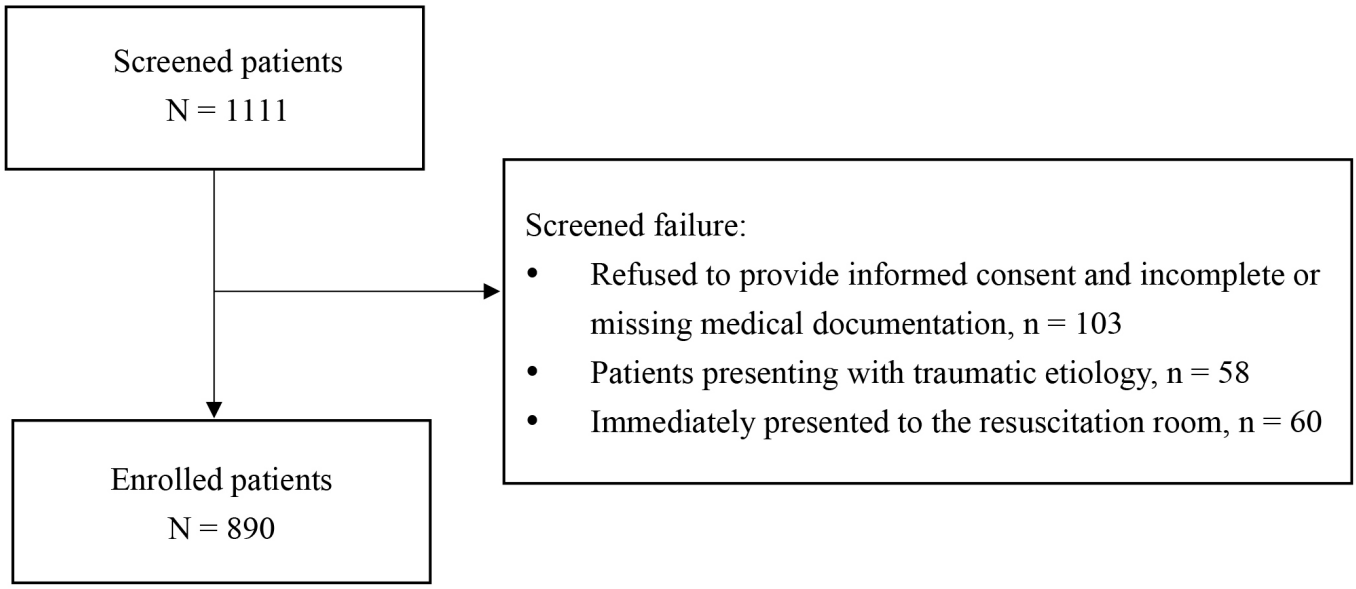

FIGURE 1. Flow diagram of patient selection and enrollment.

Based on AWGS 2019 criteria, HGS values <28 kg for men and <18 kg for women were considered reflective of reduced muscle strength. Physical performance was primarily assessed through gait speed. In instances where gait speed measurement was not feasible, physical performance was classified as impaired if the patient was bedbound, required a wheelchair for mobility, or relied on walking aids. Patients fulfilling the AWGS 2019 diagnostic criteria based on these parameters were categorized as having possible sarcopenia.

Frailty was additionally assessed using the EFS and the ECOG performance status. Measurements of upper extremity strength were also documented for each participant, and de-identified patient data were extracted from each institution's electronic medical record system using a standardized data abstraction protocol. Collected variables included demographic characteristics (age, sex, body weight), initial vital signs, body composition indices (upper arm and CC), and ED visit outcomes, such as disposition, admission status, and hospital LOS (Fig. 1).

2.4 Variables

Patient age, recorded in years at the time of the ED visit, was calculated from the date of birth as listed in hospital records and treated as a continuous variable. Sex (male or female) was obtained from the ED registration system or the medical chart for each patient. Body weight, measured in kilograms, was recorded during ED triage using a calibrated standard scale, with patients wearing light clothing and no shoes. When on-site measurement was not feasible, the most recently documented weight in the electronic medical record was used. This value was also treated as a continuous variable.

The TTAS is a five-level triage system adapted from the Canadian Triage and Acuity Scale (CTAS). It classifies patients based on the urgency of required medical care, with Level 1 indicating life-threatening conditions requiring immediate resuscitation and Level 5 representing non-urgent cases. TTAS integrates presenting symptoms, vital signs, and clinical modifiers to determine triage levels, and is widely implemented in EDs across Taiwan for prioritizing care and allocating resources. EFS is a validated, multi-domain frailty assessment instrument with a maximum score of 17 points. It evaluates multiple domains, including cognition, general health status, functional independence, social support, medication use, nutrition, mood, continence, and mobility. Higher EFS scores denote more severe frailty. In this study, trained research nurses administered the EFS through direct patient interviews and performance-based evaluations during the ED visit. The highest level of frailty identified was recorded for each participant. The ECOG Performance Status is a five-point functional performance scale ranging from 0 (fully active with no physical limitations) to 4 (completely disabled and bedbound). An ECOG score was assigned by the research nurse based on each patient's baseline ability to perform daily activities, as reported by the patient or caregiver, and confirmed through observation during the ED assessment. For example, a patient who could care for themselves but was unable to perform physically demanding tasks was assigned a score of 2, whereas a patient requiring assistance with most self-care activities was scored as 3. This scale provided a standardized measure of functional status at baseline.

Comorbidities were quantified using the Charlson Comorbidity Index (CCI), which assigns weighted scores to 19 predefined chronic conditions. The total CCI score is the sum of these weights and reflects the cumulative burden of comorbid illness. For each patient, past medical history was reviewed and extracted from the electronic medical record. The CCI score was then calculated by cataloging all relevant diagnoses and applying the Charlson scoring algorithm.

In accordance with the pre-specified protocol, patients with incomplete data on any key study variable were excluded from the analysis. Specifically, exclusion was applied to any participant lacking measurements for CC, grip strength, gait speed (or alternative assessment of mobility status), ED disposition, EFS score, or ECOG performance status.

2.5 Outcome measures

The primary outcome was the patient's ED disposition status, defined as a composite measure comprising hospital admission or return to the ED within 72 hours, versus direct discharge from the index ED visit. Patients who were discharged home and did not revisit the ED within 72 hours were classified as having achieved direct discharge without a short-term return. These outcomes were determined using the hospital's electronic medical record system and cross-referenced with admission logs. Additionally, unfavorable discharge outcomes from inpatient departments (IPDs), such as transfer to long-term care facilities or in-hospital death, were recorded. Secondary outcomes included healthcare utilization metrics: hospital LOS and total National Health Insurance (NHI) reimbursement points accrued during the hospitalization. LOS was defined as the time from ED triage to final disposition from the hospital. The total NHI reimbursement points were calculated for each patient based on the cumulative billing during the hospital stay. Both LOS and NHI points were treated as continuous outcome variables in subsequent analyses.

2.6 Statistical analysis

Baseline characteristics of the study population were summarized using descriptive statistics, where categorical variables were reported as counts and percentages and compared using Chi-square tests, and continuous variables expressed as means $\pm$ standard deviation (SD) or medians with interquartile ranges (IQR), based on their distribution. Normality was assessed using the Shapiro-Wilk test. For comparisons between groups, independent samples *t*-tests were used for normally distributed variables, while the Mann-Whitney U test was applied for non-normally distributed variables. To evaluate associations between possible sarcopenia and clinical outcomes, univariable and multivariable logistic regression models were employed for categorical outcomes. Hospital LOS, treated as a continuous variable, was analyzed using linear regression models. Covariates for multivariable models were selected through a two-step process: (1) identification of clinically relevant variables based on prior literature and domain knowledge (*e.g.*, age, sex, TTAS level, frailty measures, and CCI), and (2) statistical significance in univariable analyses ($p < 0.10$), which ensured appropriate control for potential confounding while maintaining model simplicity and interpretability [25]. Receiver operating characteristic (ROC) curve analysis was conducted to assess the discriminative performance of possible sarcopenia in predicting hospital admission or ED revisit within 72 hours. The area under the ROC curve (AUC) and corresponding 95% confidence intervals (CI) were calculated for each model. A two-sided *p*-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

3. Results

A total of 890 older adults were enrolled in the study, among whom 481 (54.0%) were identified as having possible sarcopenia. Compared with non-sarcopenic patients, those with sarcopenia were significantly older (mean age: 78.6 $\pm$ 8.3 *vs.* 74.4 $\pm$ 6.9 years, $p < 0.001$), more likely to be female (54.3% *vs.* 46.9%, $p = 0.030$), and had lower body weight and smaller anthropometric measurements (all $p < 0.001$) (Table 1). Sarcopenic individuals also exhibited greater frailty, with 48.0% scoring $\geq$8 on the EFS compared to only 1.2% in the non-sarcopenic group ($p < 0.001$). Similarly, ECOG performance scores of $\geq$2 were recorded in 93.3% of sarcopenic patients versus 18.3% in those without sarcopenia ($p < 0.001$).

In terms of ED outcomes, patients with sarcopenia demonstrated significantly higher rates of hospital admission or ED revisit within 72 hours (69.0% *vs.* 55.5%, $p < 0.001$) and longer median hospital stays (6 *vs.* 1 day, $p < 0.001$). After adjusting for age, sex, comorbidity burden, and frailty measures, multivariable regression analyses confirmed that possible sarcopenia was independently associated with hospital admission (adjusted odds ratio (aOR) 1.39; 95% confidence interval (CI), 1.04–1.87; $p = 0.027$) and increased hospital LOS (aOR 3.29; 95% CI, 1.78–4.80; $p < 0.001$) (Table 2).

ROC curve analysis revealed that possible sarcopenia had moderate discriminatory power for predicting hospital admission, with an area under the curve (AUC) of 0.706. This performance surpassed that of other frailty and triage instruments, including the CCI (AUC = 0.597), ECOG performance status (AUC = 0.580), EFS (AUC = 0.603), and TTAS (AUC = 0.560) (Fig. 2).

Although sarcopenic patients had longer hospital stays, no statistically significant differences were observed in total NHI reimbursement points ($p = 0.515$) or in unfavorable discharge outcomes—such as institutionalization or in-hospital mortality—between the sarcopenic and non-sarcopenic groups ($p = 0.519$).

Table 3 presents the prevalence of possible sarcopenia, frailty status, and associated clinical outcomes across TTAS levels. The prevalence of sarcopenia significantly varied by TTAS classification, being highest in patients triaged as TTAS level 1 (76.9%), followed by level 2 (62.1%), level 4 (53.7%), level 3 (51.2%), and lowest in level 5 (20.0%) ($p = 0.003$). A similar trend was observed for frailty, with higher EFS scores ($\geq$8) and ECOG scores ($\geq$2) more frequently associated with more severe TTAS classifications (both $p < 0.001$). Furthermore, patients in higher-acuity TTAS categories (levels 1 and 2) exhibited significantly higher rates of hospital admission or 72-hour ED revisit, longer hospital stays, increased NHI reimbursement points, and more frequent unfavorable discharge outcomes compared with those in lower-acuity categories (all $p < 0.001$; Table 3).

4. Discussion

This study demonstrates that possible sarcopenia is highly prevalent among older adults presenting to the ED and is independently associated with increased hospital admission rates and prolonged hospital stays. These findings support our hypothesis that sarcopenia constitutes an important, yet under-recognized, risk factor influencing ED outcomes and could be integrated into future triage and care protocols for older patients. The observed prevalence of possible sarcopenia in our cohort (54.0%) is consistent with previous reports,

TABLE 1. Patients' demographic and clinical characteristics.

Variables	Possible Sarcopenia		*p*-value
	Yes (n = 481)	No (n = 409)	
Age, yr	78.6 ± 8.34	74.4 ± 6.94	<0.001
Sex			
Female	261 (54.3)	192 (46.9)	0.030
Male	220 (45.7)	217 (53.1)	
Body weight, kg	58.2 ± 11.75	64.3 ± 12.81	<0.001
Upper arm circumference, cm	26.7 ± 3.65	28.4 ± 3.41	<0.001
Thigh circumference, cm	40.0 ± 6.25	44.5 ± 6.07	<0.001
Calf circumference, cm	27.9 ± 4.29	30.9 ± 4.13	<0.001
Chest width, cm	45.2 ± 5.79	47.8 ± 5.21	<0.001
Waist width, cm	49.7 ± 8.19	52.1 ± 8.18	<0.001
Waist circumference, cm	94.9 ± 14.17	96.4 ± 12.30	0.118
Edmonton total score			
<8	250 (52.0)	404 (98.8)	<0.001
≥8	231 (48.0)	5 (1.2)	
ECOG			
<2	32 (6.7)	334 (81.7)	<0.001
≥2	449 (93.3)	75 (18.3)	
TTAS			
1, 2	117 (24.3)	62 (15.2)	0.001
3, 4, 5	364 (75.7)	347 (84.8)	
Vital sign			
HR, bpm	87.5 ± 20.34	87.4 ± 20.02	0.964
SBP, mmHg	145.8 ± 32.88	154.7 ± 30.35	<0.001
DBP, mmHg	76.2 ± 17.23	82.9 ± 16.25	<0.001
RR, times/min	19.1 ± 4.33	18.5 ± 4.64	0.070
BT, °C	36.6 ± 1.03	36.5 ± 0.87	0.405
SPO_2, %	95.6 ± 3.73	96.0 ± 5.70	0.252
GCS			
3–8	12 (2.5)	2 (0.5)	<0.001
9–14	43 (8.9)	2 (0.5)	
15	426 (88.6)	405 (99.0)	
Pain (VAS)	0 (0–3)	0 (0–4)	0.033
CCI	2 (1–5)	1 (0–3)	<0.001
ED final status			
Discharge from ED	149 (31.0)	182 (44.5)	<0.001
ED to IPD or Revisited in 72 h	332 (69.0)	227 (55.5)	
NHI Reimbursement Point Value	4006 (2424–7030)	3681 (2046–7136)	0.150
Hospital stays, d	6.0 (0.5–11.0)	1.0 (0.5–7.0)	<0.001
Unfavorable discharge from IPD	72 (22.6)	47 (21.0)	0.660

bpm: beat per minute; BT: body temperature; CCI: Charlson Comorbidity Index; DBP: diastolic blood pressure; ED: emergency department; GCS: Glasgow Coma Scale; HR: heart rate; min: minute; n: number of patients; NHI: National Health Insurance; RR: respiratory rate; SBP: systolic blood pressure; SPO_2: oxygen saturation; TTAS: Taiwan Triage and Acuity Scale; IPD: Inpatient Department; ECOG: Eastern Cooperative Oncology Group; VAS: Visual Analogue Scale.

TABLE 2. Univariable and multivariable regression models on ED disposition outcome.

Outcome Evaluation	Comparison	Crude Model		Adjusted Model	
		OR/Beta (95% CI)	*p*-value	aOR/aBeta (95% CI)	*p*-value
ED to IPD or Revisited in 72 h					
	Possible Sarcopenia (Yes *vs.* No)	1.79 (1.36, 2.35)	<0.001	1.39 (1.04, 1.87)	0.027
	Edmonton (≥8 *vs.* <8)	1.75 (1.27, 2.43)	<0.001	1.32 (0.93, 1.86)	0.119
	ECOG (≥2 *vs.* <2)	1.81 (1.37, 2.38)	<0.001	1.42 (1.06, 1.91)	0.020
	TTAS (1, 2 *vs.* 3–5)	4.00 (2.61, 6.15)	<0.001	3.69 (2.39, 5.70)	<0.0001
	CCI	1.15 (1.09, 1.23)	<0.001	1.12 (1.05, 1.19)	<0.0001
NHI reimbursement point value					
	Possible Sarcopenia (Yes *vs.* No)	109.41 (−367.90, 586.72)	0.653	62.37 (−650.79, 526.06)	0.515
	Edmonton (≥8 *vs.* <8)	276.98 (−261.65, 815.62)	0.314	25.25 (−572.66, 522.16)	0.928
	ECOG (≥2 *vs.* <2)	190.04 (−293.28, 673.36)	0.441	74.21 (−568.31, 419.89)	0.769
	TTAS (1, 2 *vs.* 3–5)	1842.66 (1261.66, 2423.66)	<0.001	1836.88 (1250.78, 2422.99)	<0.001
	CCI	87.32 (−3.91, 178.56)	0.061	78.73 (−14.32, 171.78)	0.098
Hospital stays, d					
	Possible Sarcopenia (Yes *vs.* No)	3.99 (2.53, 5.45)	<0.001	3.29 (1.78, 4.80)	<0.001
	Edmonton (≥8 *vs.* <8)	2.89 (1.23, 4.56)	<0.001	2.06 (0.35, 3.76)	0.018
	ECOG (≥2 *vs.* <2)	3.57 (2.09, 5.05)	<0.001	2.84 (1.31, 4.37)	<0.001
	TTAS (1, 2 *vs.* 3–5)	3.51 (1.68, 5.34)	<0.001	2.83 (1.02, 4.65)	0.002
	CCI	4.47 (3.01, 5.93)	<0.001	0.19 (−0.10, 0.48)	0.197
Unfavorable discharge from IPD					
	Possible Sarcopenia (Yes *vs.* No)	1.10 (0.72, 1.66)	0.660	1.06 (0.75, 1.55)	0.519
	Edmonton (≥8 *vs.* <8)	1.30 (0.84, 2.01)	0.233	1.04 (0.66, 1.65)	0.858
	ECOG (≥2 *vs.* <2)	0.85 (0.56, 1.29)	0.437	0.64 (0.41, 1.01)	0.053
	TTAS (1, 2 *vs.* 3–5)	1.17 (0.75, 1.84)	0.482	1.24 (0.77, 1.99)	0.3749
	CCI	1.24 (1.15, 1.33)	<0.001	1.25 (1.16, 1.35)	<0.0001

Note: Model adjusted for Table 1 variables. OR: odds ratio; CI: confidence intervals; aOR: adjusted odds ratio; ED: emergency department; IPD: inpatient departments; ECOG: Eastern Cooperative Oncology Group; TTAS: Taiwan Triage and Acuity Scale; CCI: Charlson Comorbidity Index; NHI: National Health Insurance.

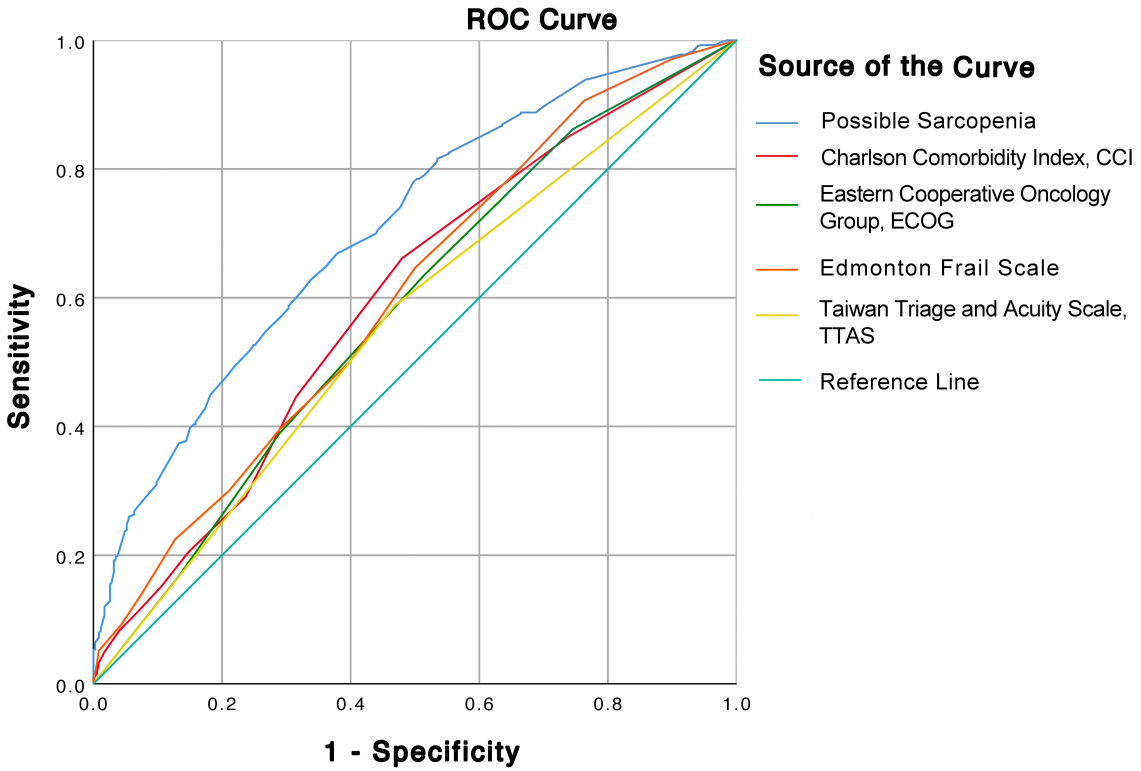

FIGURE 2. Receiver operating characteristic (ROC) curves comparing the predictive performance of various frailty and comorbidity assessment tools for hospital admission or short-term ED revisit. The x-axis represents 1—Specificity, and the y-axis represents Sensitivity. ROC curves are shown for the Taiwan Triage and Acuity Scale (TTAS), Edmonton Frail Scale, Eastern Cooperative Oncology Group (ECOG) Performance Status, Charlson Comorbidity Index (CCI), and possible sarcopenia. The diagonal line indicates the reference line for a non-discriminatory model (AUC = 0.5). The area under the curve (AUC) values were as follows: possible sarcopenia = 0.706; CCI = 0.597; ECOG = 0.580; Edmonton Frail Scale = 0.603; TTAS = 0.560.

TABLE 3. Emergency trends and frailty assessment status of patients under different Taiwan triage acuity system.

Variables	TTAS = 1 N = 39	TTAS = 2 N = 140	TTAS = 3 N = 652	TTAS = 4 N = 54	TTAS = 5 N = 5	*p*-value
Possible Sarcopenia, N (%)	30 (76.9)	87 (62.1)	334 (51.2)	29 (53.7)	1 (20.0)	0.003
Edmonton (≥8), N (%)	22 (56.4)	45 (32.1)	150 (23.0)	18 (33.3)	1 (20.0)	<0.001
ECOG (≥2), N (%)	33 (84.6)	93 (66.4)	363 (55.7)	33 (61.1)	2 (40.0)	0.001
CCI, median ± IQR	3 (2–4)	2 (1–4)	2 (1–4)	2 (1–4)	1 (0–3)	0.065
0	5 (12.8)	16 (11.4)	136 (20.9)	12 (22.2)	2 (40.0)	
1	4 (10.3)	27 (19.3)	156 (24.0)	5 (9.3)	1 (20.0)	
2	10 (25.6)	35 (25.0)	114 (17.5)	15 (27.8)	0 (0.0)	0.032
3	8 (20.5)	22 (15.7)	72 (11.1)	8 (14.8)	1 (20.0)	
4+	12 (30.8)	40 (28.6)	173 (26.6)	14 (25.9)	1 (20.0)	
ED final status, N (%)						
Discharge from ED	4 (10.3)	24 (17.1)	263 (40.3)	35 (64.8)	5 (100.0)	<0.001
ED to IPD or Revisited in 72 h	35 (89.7)	116 (82.9)	389 (59.7)	19 (35.2)	0 (0.0)	
NHI Reimbursement Point Value, median ± IQR	6215.0 (4150–8788)	4625.0 (3250–7970)	3658.5 (2056–6941)	2271.5 (1349–4239)	590.0 (430–1390)	<0.001
Hospital stays, d, median ± IQR	7 (3–20)	7 (2–12)	3 (0.5–9)	0.5 (0.5–4)	0.5 (0.5–0.5)	<0.001
Unfavorable discharge from IPD, N (%)	15 (44.1)	20 (17.9)	82 (21.6)	2 (11.1)	0 (0)	<0.001

TTAS: Taiwan Triage and Acuity Scale; ECOG: Eastern Cooperative Oncology Group; CCI: Charlson Comorbidity Index; ED: emergency department; IPD: inpatient departments; NHI: National Health Insurance; IQR: interquartile ranges.

particularly in high-acuity or hospitalized elderly populations [1, 3]. Sarcopenic individuals in this study exhibited significantly greater frailty, as measured by the EFS and ECOG performance status, reinforcing prior evidence that sarcopenia is a major biological contributor to frailty [5, 6]. Despite the well-established relationship between sarcopenia and adverse outcomes, current triage systems—such as the TTAS, do not systematically incorporate assessments of underlying geriatric syndromes. This gap may contribute to under-triage or misclassification of older adults at high risk, potentially delaying appropriate interventions and contributing to suboptimal outcomes [10, 11, 25].

Biologically, sarcopenia is a multifactorial geriatric syndrome that independently increases the risk of hospitalization and extends recovery time. Immunosenescence and chronic systemic inflammation, commonly referred to as "inflammaging", drive muscle catabolism through cytokine-mediated pathways involving interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α) [1, 26]. In parallel, mitochondrial dysfunction impairs adenosine triphosphate (ATP) production and promotes oxidative stress, leading to progressive muscle degeneration through insulin resistance and activation of proteolytic systems [27, 28]. Endocrine dysregulation and anabolic resistance further hinder muscle protein synthesis and regeneration. The convergence of these mechanisms results in decreased mobility, heightened frailty, and slower recovery, all of which contribute to increased healthcare utilization among sarcopenic patients [1].

Our results align with a growing body of literature emphasizing the clinical relevance of sarcopenia in acute care settings. Recent studies have reported sarcopenia prevalence rates between 30% and 50% among older ED populations, varying by diagnostic approach, closely matching the 54% prevalence observed in our cohort. In concordance with the findings of Daly *et al.* [14], we found that sarcopenia and frailty were significantly associated with increased likelihood of hospital admission. Sarcopenic patients in our study were 1.4 times more likely to be admitted, a figure that mirrors predictive values reported using the Simple Questionnaire to Rapidly Diagnose Sarcopenia (SARC-F) and Program on Research for Integrating Services for the Maintenance of Autonomy 7 item questionnaire (PRISMA-7) frailty screening tools [14, 29]. Furthermore, we observed a significantly longer median hospital LOS among sarcopenic patients (6 days *vs.* 1 day, $p < 0.001$), reinforcing the established link between frailty and increased hospitalization burden. In addition to prolonged hospitalization, sarcopenic patients in our study more frequently required high-flow oxygen therapy or ICU support, consistent with the findings of Sousa *et al.* [30], who reported that sarcopenia was associated with greater need for invasive ventilation and prolonged critical care [14]. These patterns highlight the importance of early identification of sarcopenia during the ED encounter, as it may inform both immediate clinical decision-making and downstream care planning.

Our analysis demonstrated that possible sarcopenia independently predicted both hospital admission and length of hospital stay, even after adjusting for age, sex, comorbidity burden, and frailty scores. These findings are consistent with prior research indicating that sarcopenia contributes to poor clinical outcomes, including functional decline, delayed recovery, and increased healthcare resource utilization [15–17]. Notably, possible sarcopenia exhibited moderate discriminatory ability in predicting hospital admission or short-term ED revisit, with an AUC of 0.706, which exceeded that of other conventional triage and frailty tools evaluated in this study, thereby underscoring its potential utility in early ED risk stratification. The superior performance of sarcopenia screening in this context reinforces the need for practical and efficient screening strategies that can be feasibly implemented within routine ED workflows. Interestingly, although sarcopenic patients had significantly longer hospital stays, there were no corresponding differences in NHI reimbursement points or rates of unfavorable discharge outcomes when compared with non-sarcopenic patients. This discrepancy may, in part, be explained by Taiwan's bundled case-payment reimbursement system, which limits claimable expenditures regardless of a patient's clinical complexity or prolonged care requirements. Prior studies have noted that sarcopenia is associated with increased care intensity, greater demand for functional support, and extended nursing time, factors that may not be adequately captured by conventional point-based reimbursement models [29, 31]. Consequently, standardized cost metrics may underestimate the true resource burden associated with sarcopenia management. These findings raise broader considerations regarding whether current healthcare financing structures sufficiently reflect the functional vulnerability and complexity of the care required for older adults with sarcopenia. Future investigations should consider the use of direct medical cost assessments or time-driven activity-based costing models to provide a more accurate estimation of the economic impact of sarcopenia in acute care settings.

Several existing frailty screening instruments, such as the ISAR and the APOP screeners, have demonstrated prognostic value in acute care settings [13, 14]. However, many of these tools rely heavily on patient-reported information or subjective assessments, which may be less feasible in ED populations affected by cognitive impairment, acute illness, or communication difficulties. In contrast, sarcopenia assessments based on objective measures, such as anthropometric indices or HGS, offer more standardized and reproducible alternatives. Emerging evidence further suggests that combining sarcopenia and frailty assessments may enhance the predictive accuracy for adverse outcomes [22]. Given the practical constraints of ED environments, where measuring CC, grip strength, or gait speed may not always be feasible, brief and validated screening tools could improve early recognition of at-risk patients. The SARC-F questionnaire, particularly its modified version incorporating CC (SARC-CalF), has shown improved sensitivity for identifying probable sarcopenia and may be well-suited for fast-paced clinical settings [7, 14]. Likewise, the FRAIL scale, which assesses five components: Fatigue, Resistance, Ambulation, Illnesses, and Loss of weight, has demonstrated strong predictive validity for outcomes, such as hospitalization, functional decline, and mortality [14]. Future research should evaluate the integration of these tools into ED workflows to improve risk stratification and guide timely intervention.

Although this study focused on short-term outcomes within

the ED, key long-term endpoints, such as 30-day mortality, functional recovery, and readmission, could not be assessed. These outcomes are essential for understanding the extended prognostic impact of sarcopenia and could be incorporated into future longitudinal studies to better inform post-ED care planning. Our findings also support the inclusion of sarcopenia assessments in ED triage protocols, particularly for patients aged $\geq$65 years. Early identification may facilitate the development of individualized care plans, enable timely referral to geriatric or multidisciplinary teams, and inform decisions regarding hospital admission, observation, and discharge. Future studies should aim to develop and validate rapid sarcopenia screening tools that are specifically tailored for ED settings, requiring minimal time and resources. These tools could be embedded within existing triage algorithms to enhance efficiency and clinical utility. Longitudinal research is also warranted to examine the downstream effects of early sarcopenia detection on recovery trajectories, institutionalization risk, and long-term survival. Finally, implementation research will be essential to address practical barriers, optimize integration into clinical workflows, and promote widespread adoption of sarcopenia screening practices in emergency care settings.

This study has several limitations that should be acknowledged. First, the study was conducted in tertiary medical centers characterized by high patient acuity and access to advanced healthcare resources. As such, the generalizability of our findings to other clinical settings, such as rural hospitals or community-based EDs, may be limited. Future studies could validate these findings in more diverse healthcare environments and across varying levels of care to enhance external validity. Second, while the AWGS 2019 framework provides a validated approach for assessing sarcopenia, certain components, such as self-reported exhaustion, HGS testing, and gait speed, require patient cooperation and physical capability. These requirements may present logistical challenges in time-constrained or high-acuity ED settings, potentially limiting the feasibility of comprehensive sarcopenia assessment. Third, the present study focused exclusively on in-ED assessments and short-term outcomes. Longer-term endpoints, such as 30-day readmission, all-cause mortality, and post-discharge functional decline, were not evaluated. Given that sarcopenia has been associated with increased mortality, frequent rehospitalization, and impaired recovery following acute illness in older adults, future studies should adopt longitudinal designs to capture these downstream outcomes and inform post-discharge care strategies. Fourth, data on participants' living arrangements were not collected. Whether patients were community-dwelling or residing in institutional settings (*e.g.*, nursing homes or long-term care facilities) was unknown. As residential status may influence both the prevalence of sarcopenia and clinical outcomes, its omission may have introduced unmeasured confounding. Future research should include this variable to better contextualize findings. Fifth, this study utilized a complete-case analysis approach, excluding patients with missing data on sarcopenia or frailty assessments. Although this method ensured analytic robustness for multivariable modeling, it may have introduced selection bias. In particular, patients who were unable to complete physical performance tests—such as those with severe frailty or cognitive impairment, were more likely to be excluded, potentially leading to underestimation of sarcopenia prevalence and its impact on adverse outcomes. Future studies should consider employing multiple imputation or sensitivity analyses to address this limitation and capture data from a broader and more representative patient population.

5. Conclusions

Sarcopenia is a frequently encountered condition among older adults presenting to the ED and is associated with adverse clinical outcomes. In this study, the presence of possible sarcopenia was independently associated with higher hospital admission rates and longer hospital stays, even after adjusting for age, sex, comorbidity burden, and frailty. These findings underscore the need to recognize possible sarcopenia as a distinct and clinically relevant factor during ED triage and decision-making. Incorporating sarcopenia screening into routine ED protocols for older adults may improve early risk stratification, support timely intervention, and optimize healthcare resource utilization. Future efforts should focus on the development of rapid, feasible, and ED-compatible sarcopenia screening tools that can be operationalized in fast-paced clinical settings.

ABBREVIATIONS

AWGS, Asian Working Group for Sarcopenia; CC, calf circumference; IPD, inpatient departments; LOS, length of stay; NHI, National Health Insurance; ROC, receiver operating characteristic; AUC, area under the curve; CTAS, Canadian Triage and Acuity Scale; EFS, Edmonton Frail Scale; CFS, Clinical Frailty Scale; VAS, Visual Analogue Scale; ECOG, Eastern Cooperative Oncology Group performance status; TTAS, the Taiwan Triage and Acuity Scale; ISAR, the Identification of Seniors at Risk; APOP, the Acutely Presenting Older Patient screener; EDs, emergency departments; ICU, intensive care unit; SD, standard deviation; IQR, interquartile ranges; OR, odds ratio; aOR, adjusted odds ratio; CI, confidence intervals; HGS, hand grip strength; CCI, Charlson Comorbidity Index; BIA, bioelectrical impedance analysis; TNF-α, tumor necrosis factor-alpha; IL-6, interleukin-6; SARC-F, A Simple Questionnaire to Rapidly Diagnose Sarcopenia; PRISMA-7, Program on Research for Integrating Services for the Maintenance of Autonomy 7 item questionnaire; ATP, adenosine triphosphate.

AVAILABILITY OF DATA AND MATERIALS

Datasets used and/or analyzed in the present study were availed by the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

LCC—coordinated this case report and conceptualization. LCC, CJN, CYH and CYC—wrote the manuscript writing and recorded patient's data—assisted in information collection; analyzed and interpreted the patients' general indices. SYK—Visualization, Supervision, Writing-Review & Editing. All

authors read and ratified final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by The Chang Gung Medical Foundation Institutional Review Board of the participating hospitals, including Linkou Chang Gung Memorial Hospital (IRB approval No. 202200559B0 and IRB approval No. 202400144B0C5001), Ton Yen General Hospital (IRB approval No. 202400144B0C5001), Taoyuan General Hospital (IRB approval No. TYGH109068), Taipei City Hospital Renai Branch (IRB approval No. TCHIRB-10911003-E), and Changhua Christian Hospital (IRB approval No. 201017). This study respected the privacy of the subjects and obtained written informed consent from the patients.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Cheng Yu Chien is serving as one of the Editorial Board members of this journal. We declare that Cheng Yu Chien had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to SJB.

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