ORIGINAL RESEARCH

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Calf Circumference and Short-Term Prognosis in Older Patients Receiving Palliative Care

Funda Yıldırım Borazan

Aydın State Hospital Palliative Care Unit, Clinic of Geriatrics, Aydın, Türkiye; Gazi University Faculty of Medicine, Department of Internal Medicine, Division of Geriatrics, Ankara, Türkiye

Abstract

Objective: To evaluate the association between calf circumference and short-term prognosis in older adults receiving palliative care and to investigate the independent prognostic value of calf circumference.

Materials and Methods: This retrospective, observational study included older adult patients who were admitted to a palliative care unit from January 2024 to December 2025. Demographic characteristics, comorbidities, laboratory parameters, and calf circumference measurements were extracted from hospital records. The primary outcome was mortality within three months. Survivors and non-survivors were compared using appropriate statistical tests. Variables showing a p-value below 0.10 in the univariate analysis were incorporated into a multivariable logistic regression model. Receiver operating characteristic (ROC) analysis was conducted to evaluate the discriminative ability of calf circumference and to identify its optimal cut-off value for predicting mortality.

Results: One hundred forty seven patients (median age: 79 years) were included; 72 (49.0%) died within 3 months. Non-survivors were older and had significantly lower calf circumference, higher Charlson Comorbidity Index scores, elevated C-reactive protein concentrations, and reduced albumin levels. In multivariable logistic regression, calf circumference remained independently associated with mortality: each 1-cm increase was associated with a 15.5% reduction in mortality risk. ROC analysis showed an area under the curve of 0.707. A calf circumference cut-off of ≤34 cm yielded 48.6% sensitivity and 86.6% specificity for predicting mortality.

Conclusion: Calf circumference is independently associated with 3-month mortality in geriatric patients receiving palliative care. As a simple, inexpensive measurement that is applicable at the bedside, it may provide valuable prognostic information and support risk stratification in this vulnerable population.

Keywords: Calf circumference, palliative care, mortality, older adults, prognostic factor

Introduction

As life expectancy increases worldwide, older population is rapidly growing, and consequently, chronic diseases, multimorbidity, and functional dependence are becoming more common (1). Older patients, especially those receiving palliative care, are at high-risk for adverse outcomes due to their high comorbidity burden, frailty, immobilization, and malnutrition (2). Identifying readily applicable prognostic indicators of short-term mortality in this group is crucial for guiding clinical decision-making and improving patient management.

Malnutrition and sarcopenia are significant determinants of mortality and morbidity in elderly individuals (3). Sarcopenia, defined as a progressive decrease in muscle mass and muscle function due to aging, is associated with loss of physical performance, falls, hospitalizations, and an increased risk of death. Under palliative care, muscle loss becomes more pronounced due to chronic inflammation, malnutrition, immobilization, and comorbidities (4).Therefore, accurate assessment of skeletal muscle mass may provide valuable prognostic information and contribute to mortality risk stratification in older adults receiving palliative care.

Address for Correspondence: Asst. Prof. Funda Yıldırım Borazan, Aydın State Hospital Palliative Care Unit, Clinic of Geriatrics, Aydın, Türkiye; Gazi University Faculty of Medicine, Department of Internal Medicine, Division of Geriatrics, Ankara, Türkiye
E-mail: dryildirimfunda@gmail.com **ORCID:** orcid.org/0000-0003-0232-2081
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However, assessing muscle mass in palliative care patients presents several challenges. A significant number of these patients are bedridden and have severe functional limitations and multiple comorbidities. Therefore, assessment tools, including dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA) handgrip strength testing or walking speed measurement, are often not feasible due to the final stages of their illness and to their bedridden status (4,5). Clinical practice requires readily applicable, cost-effective, and objective measurements, especially at the bedside.

Calf circumference is a simple and reliable anthropometric measurement used to assess muscle mass and nutritional status in older adults (6,7). Calf circumference has been reported to correlate with appendicular muscle mass and can be used to screen for sarcopenia (8,9). Furthermore, low calf circumference is associated with frailty, functional dependence, hospitalization, and mortality (10,11). Because it is rapid, noninvasive, and suitable for bedside use, calf circumference is a practical assessment tool, particularly for patients with palliative care needs.

However, studies investigating the prognostic value of calf circumference in older patients receiving palliative care are limited. The relationship between calf circumference and short-term mortality, particularly in older adults receiving palliative care, remains insufficiently elucidated. This study aimed to evaluate the association between calf circumference and short-term prognosis and mortality among patients aged ≥60 years who were followed in a palliative care service.

Materials and Methods

Ethical approval was obtained from the Gazi University Ethics Committee (approval no: 2026-1008, date: 04.06.2026), and the study was conducted in accordance with the Declaration of Helsinki. Given the retrospective nature of the study, informed consent was waived.

Study Design and Population

This retrospective observational study was carried out in the palliative care unit of a secondary-level hospital and assessed patients admitted between January 2024 and December 2025. Patients admitted to the palliative care department were primarily those with advanced chronic illnesses requiring supportive care, including severe sequelae of cerebrovascular disease, end-stage dementia, and advanced malignancies. Of the 189 patients, those under 60 years of age and those with missing calf circumference measurements or incomplete 3-month outcome data were excluded. In addition, patients with lower-limb amputation and severe peripheral edema were excluded to avoid bias in calf circumference assessment, resulting in a total of 147 patients.

Data Collection

Demographic data, clinical characteristics, comorbidity burden, and laboratory parameters were extracted from hospital records. Charlson Comorbidity Index (CCI) was calculated to quantify the comorbidity burden (12). Laboratory variables included hemoglobin, mean corpuscular volume (MCV), alanine aminotransferase (ALT), aspartate aminotransferase, blood urea nitrogen (BUN), creatinine, C-reactive protein (CRP), albumin, neutrophil and lymphocyte counts.

Calf circumference was assessed and expressed in centimeters as a marker of nutritional status and muscle mass. Calf circumference was measured at the point of maximum calf girth using a nonelastic tape measure while the patient was seated with the knee flexed to 90°. Measurements were performed in the supine position when sitting was not feasible. The main outcome measure was 3-month mortality, defined by survival status within 90 days following hospitalization (survivor vs. non-survivor). Mortality data were obtained from the national death notification system and hospital electronic records.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as counts and percentages. Normality of continuous variables was assessed using the Kolmogorov-Smirnov test and histogram inspection. Normally distributed data are expressed as mean ± standard deviation, and non-normally distributed data as median (minimum-maximum). Student's t-test and the Mann-Whitney U test were used for parametric and non-parametric comparisons, respectively. The chi-square test was used for categorical variables. A p-value <0.05 was considered statistically significant.

Binary logistic regression analysis was performed for variables with $p < 0.10$ in univariate analyses to identify factors independently associated with mortality. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Multicollinearity was assessed using the variance inflation factor and correlation analysis. Albumin was not included in the multivariable model because both albumin and calf circumference reflect nutritional status, and including highly correlated nutritional markers in a relatively small sample size could result in model instability and redundancy. Similarly, among the remaining variables that were significant in the univariate analyses, only those considered both most clinically relevant and independently contributing to the multivariable model were retained to avoid overfitting and to preserve model stability given the relatively small cohort. Model fit was evaluated using the Omnibus test of model coefficients, Nagelkerke R^2, and the Hosmer-Lemeshow goodness-of-fit test. A p-value <0.05 was considered statistically significant. Receiver operating characteristic (ROC) curve analysis was conducted

using MedCalc software to evaluate the discriminative ability. The optimal cut-off value was determined using the Youden index.

Results

A total of 147 patients (60-98 years) were included. Of these, 75 (51.0%) were survivors, and 72 (49.0%) were non-survivors. Regarding the primary indications for admission to the palliative care unit, 69 patients (46.9%) had severe sequelae of cerebrovascular disease, 44 patients (29.9%) had end-stage dementia, and 16 patients (10.9%) had advanced malignancy. The remaining 18 patients (12.2%) were admitted for other advanced chronic diseases, such as end-stage organ failure and neurodegenerative diseases.

Non-survivors were significantly older than survivors ($p < 0.001$). Calf circumference was significantly lower in non-survivors ($p < 0.001$). The CCI was higher in non-survivors ($p = 0.020$). CRP levels were significantly higher in non-survivors ($p < 0.001$), whereas albumin levels were significantly lower ($p = 0.035$). Creatinine, ALT, neutrophil count, and lymphocyte count also differed significantly between groups, whereas length of hospital stay, hemoglobin, MCV, and AST did not differ significantly between groups (Table 1).

In the unadjusted analysis, calf circumference was significantly associated with mortality. Calf circumference remained independently associated with mortality in the multivariable logistic regression model. For each 1-cm increase in calf circumference, the odds of mortality decreased by 15.5% (OR = 0.845, 95% CI: 0.762-0.937, $p < 0.001$). Higher CRP levels were independently associated with increased mortality risk ($p = 0.005$). Age, CCI, and BUN were not significant predictors in the adjusted model (Table 2). The protective effect of calf circumference remained robust following adjustment for age, comorbidity burden, inflammatory markers, and renal function.

ROC curve analysis demonstrated that calf circumference had a moderate ability to predict mortality (area under the curve =0.707). The optimal cut-off point determined by the Youden Index was ≤34 cm, with a sensitivity of 48.6% and a specificity of 86.7%. Positive and negative predictive values were 77.8% and 63.7%, respectively (Table 3), and the ROC curve was presented in Figure 1.

Discussion

This study demonstrates that calf circumference is independently associated with 3-month mortality among elderly patients receiving palliative care. Patients who died within three months had significantly lower calf circumferences than survivors, and each 1-cm increase in calf circumference was associated with a 15.5% decrease in mortality risk after adjusting for age, comorbidity burden, inflammatory status, and renal function. Moreover, a calf circumference threshold of ≤34 cm had high specificity in identifying patients at increased risk of short-term mortality. These findings suggest that calf circumference may serve as a simple and clinically useful adjunctive prognostic marker for risk stratification in older adults receiving palliative care, rather than as a standalone predictor of mortality.

Table 1. Demographics and baseline characteristics of the patients.

Parameters	Total (n = 147)	Survivors (n = 75)	Non-survivors (n = 72)	p-value
Age, years	79 (60-98)	76 (60-95)	83 (66-98)	**<0.001**
Sex, female, n (%)	77 (52.4%)	33 (44.4%)	44 (61.1%)	0.070
Length of stay, day	14 (1-288)	16 (1-288)	13 (1-159)	0.778
Calf circumference, cm	36 (22-44)	37 (27-43)	35 (22-44)	**<0.001**
CCI	5 (1-10)	5 (1-9)	5 (2-10)	**0.020**
Hb (g/dL)	11.2 (6.3-16.5)	11.7 (7.2-16.5)	11.1 (6.3-15.5)	0.260
MCV	88 (59.6-108.2)	89.5 (65.2-108.2)	88.4 (59.6-107.5)	0.614
ALT (U/L)	15 (2-126)	17 (2-126)	12 (2-94)	**0.002**
AST (U/L)	22 (5-186)	24 (9-186)	21 (5-109)	0.502
BUN (mg/dL)	22.4 (6.5-99.5)	19.6 (6.5-99.5)	24 (6.5-98.4)	**0.050**
Cr (mg/dL)	0.8 (0.15-4.9)	0.7 (0.1-4.9)	0.9 (0.3-4.5)	**0.031**
CRP (mg/L)	35.5 (0.2-259)	13.6 (0.2-167)	54 (1.3-259.6)	**<0.001**
Alb (g/L)	2.9 (1.5-4.1)	3.0 (1.4-4.2)	2.8 (1.6-4)	**0.035**
Neut, 10^9/L	6.5 (2.1-18.2)	5.8 (2.1-16.4)	7.2 (2.7-18.2)	**0.007**
Lymph, 10^9/L	1.4 (0.3-5.2)	1.5 (0.5-5.2)	1.2 (0.3-4.4)	**0.026**

Data were presented as numbers and percentages for categorical variables, mean ± SD for normally distributed continuous variables, and median (min-max) for non-normally distributed continuous variables.
SD: Standard deviation, Hb: Hemoglobin, MCV: Mean corpuscular volume, CRP: C-reactive protein, Alb: Albumin, BUN: Blood urea nitrogen, Cr: Creatinine ratio, AST: Aspartate aminotransferase, ALT: Alanine transaminase, CCI: Charlson Comorbidity Index.

Table 2. Multivariate analysis of the calf circumference on mortality.

Models	Independent variables	OR	95% CI	p-value
Model 1 (unadjusted)	Calf circumference	0.815	0.741-0.898	**<0.001**
Model 2	Calf circumference	0.845	0.762-0.937	**<0.001**
	CCI	1.037	0.826-1.301	0.757
	Age	1.048	0.996-1.103	0.072
	CRP	1.012	1.003-1.020	**0.005**
	BUN	0.997	0.975-1.019	0.791

Binary logistic regression analysis using variables with $p < 0.10$ in univariate analyses were entered into a multivariable model to identify factors independently associated with mortality. Multicollinearity was assessed using the variance inflation factor (VIF) values and correlation analysis. All VIF values ranged between 1.12 and 1.33, indicating no evidence of multicollinearity. The Omnibus test of model coefficients was significant ($\chi^2 = 127.835$, $p < 0.001$), demonstrating that the model was statistically meaningful. The Nagelkerke R^2 was 0.311, indicating that the model explained approximately 31.1% of the variance in mortality. The Hosmer-Lemeshow goodness-of-fit test indicated good model calibration ($\chi^2 = 8.998$, $p = 0.342$). Variables entered into the model included calf circumference, age, CCI, CRP, and BUN.
OR: Odds ratio; CI: Confidence interval, BUN: Blood urea nitrogen, Cr: Creatinine, CCI: Charlson Comorbidity Index, CRP: C-reactive protein.

Table 3. ROC curve of parameters in the prediction of mortality in older palliative care patients.

Parameters	Cut-off	AUC	SE	p	95% CI	Sensitivity	Specificity	+PV	-PV
Calf circumference	≤34	0.707	0.042	<0.001	0.626-0.779	48.6%	86.6%	77.8%	63.7%

AUC: Area under the curve, SE: Standard error, CI: Confidence interval, PV: Predictive value.

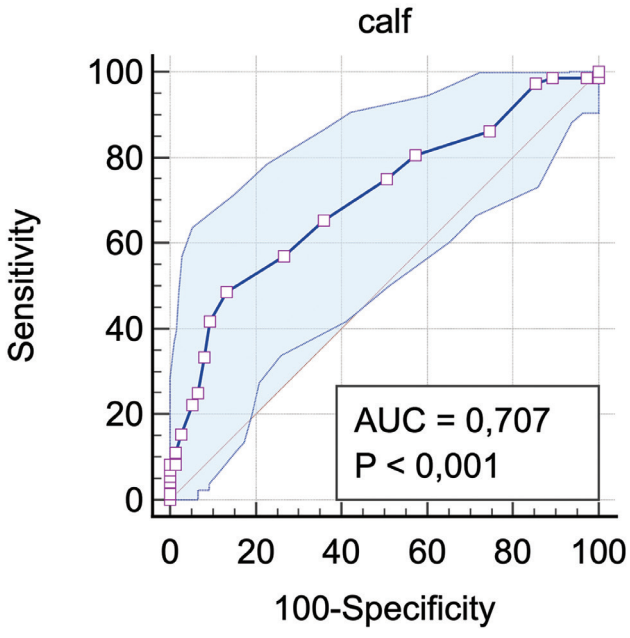

Figure 1. ROC curve analysis of calf circumference for predicting mortality in older palliative care patients (AUC = 0.707, 95% CI: 0.626-0.779, $p < 0.001$).

ROC: Receiver operating characteristic, AUC: Area under the curve, CI: Confidence interval.

The prognostic significance of calf circumference is biologically plausible because it reflects both skeletal muscle mass and nutritional reserves (13). Older adults receiving palliative care are particularly vulnerable to sarcopenia due to chronic inflammation, reduced oral intake, immobilization, multimorbidity, and catabolic processes associated with advanced disease (14).

Our results are consistent with those of previous studies that demonstrate a relationship between calf circumference, a surrogate marker of muscle mass, and survival (15). In a cohort of advanced cancer patients receiving palliative care, it was reported that anthropometric measurements, including calf circumference, were closely associated with nutritional status and survival outcomes (4). The authors emphasized that simple bedside measures may offer valuable prognostic information when more sophisticated assessments of body composition are not feasible. Similar to their findings, our results support the usefulness of calf circumference as a readily available indicator of poor prognosis in patients receiving palliative care. More recently, Back et al. (16) investigated patients receiving home enteral nutrition and found that lower calf circumference was associated with higher mortality risk. Their results highlight the importance of preserving muscle mass and nutritional status in clinically vulnerable populations.

In a cohort of older adults, calf circumference demonstrated a predictive validity for mortality comparable to that of the Mini Nutritional Assessment and Appendicular Skeletal Muscle Mass Index, and demonstrated superior predictive performance compared with conventional markers such as bosy mass index and serum albumin (17). Moreover, higher calf circumference was independently associated with a lower risk of mortality during follow-up. Although we did not directly compare calf circumference to other sarcopenia or nutritional assessment methods in our study, the observed independent association of lower calf circumference with increased 3-month mortality is consistent with these findings. Taken together, the available evidence suggests that calf circumference may serve as a practical surrogate marker of nutritional and muscle status, particularly in palliative care settings where comprehensive body composition assessments are often difficult to perform.

The optimal cut-off value of ≤34 cm identified in the present study is notably consistent with prior research assessing calf circumference as a predictor of mortality (18). In a previous investigation, a calf circumference threshold of approximately 34.5 cm was recognized as a predictor of mortality among older adults, a finding that aligns closely with our own (18). Furthermore, a recent study corroborated that a lower calf circumference (30.6 cm) is independently associated with increased mortality risk, thereby reinforcing its utility as a prognostic anthropometric marker (17). Conversely, a lower calf circumference cut-off of 33 cm has been proposed for the identification of sarcopenia according to the European Working Group on Sarcopenia in Older People criteria (19). This discrepancy is anticipated, as our cut-off was established to predict short-term mortality rather than to diagnose sarcopenia; therefore, optimal calf circumference thresholds may vary depending on the specific clinical outcome sought. Although the identified cut-off demonstrates high specificity, its relatively low sensitivity suggests that calf circumference alone is insufficient as a screening tool for short-term mortality. Instead, it may be more suitably employed as an adjunct prognostic marker to complement routine clinical assessments and other established prognostic indicators in older adults receiving palliative care.

Inflammation is another important mechanism linking reduced calf circumference to mortality. Consistent with previous literature, CRP was independently associated with mortality in our cohort. Chronic inflammation promotes protein catabolism and accelerates skeletal muscle loss, resulting in sarcopenia and cachexia (20,21). Therefore, the coexistence of elevated inflammatory markers and reduced calf circumference may identify a subgroup of patients with a particularly poor prognosis. Future studies should investigate whether combining anthropometric and inflammatory parameters could improve prognostic accuracy in palliative care settings. CRP remained independently associated with mortality in the adjusted model. This aligns with previous research showing that systemic inflammation significantly influences adverse outcomes in patients in palliative care (22,23).

While age and comorbidity burden were associated with mortality in unadjusted analyses, only calf circumference and CRP remained independently associated after adjustment. This indicates that short-term outcomes among older palliative care patients may depend more on biological reserve and inflammation than on age or on cumulative comorbidities alone. Calf circumference could thus offer valuable clinical insights beyond conventional demographic and disease-related prognostic factors.

Study Limitations

This study is subject to certain limitations. The retrospective design and single-center setting may limit the generalizability of the findings, and the sample size was relatively small. In addition, the study population comprised patients with diverse underlying conditions requiring palliative care, including advanced dementia, cerebrovascular disease, malignancy, and end-stage organ failure. Although this heterogeneity reflects real-world palliative care practice, disease-specific differences may have influenced prognosis and limit the applicability of our findings to individual diagnostic groups. The inclusion of some patients with hemiplegia may have affected calf circumference measurements owing to unilateral muscle atrophy.

Conclusion

Finally, direct measures of muscle mass and function, such as DXA, BIA, handgrip strength, or gait speed, were not available. Because muscle strength and physical performance were not assessed, sarcopenia could not be diagnosed according to contemporary consensus criteria. Therefore, our findings should be interpreted as reflecting the prognostic value of calf circumference rather than the presence of sarcopenia itself. In addition, calf circumference was assessed only at admission, and longitudinal changes in muscle mass during follow-up could not be evaluated.

Calf circumference was independently associated with 3-month mortality among older adults receiving palliative care. As a simple, inexpensive, and bedside-applicable measurement, calf circumference may provide complementary prognostic information and support risk stratification when used alongside routine clinical assessment in this vulnerable population.

Ethics

Ethics Committee Approval: This study was approved by Gazi University Ethics Committee (approval no: 2026-1008, date: 04.06.2026) and conducted in accordance with the Declaration of Helsinki.

Informed Consent: Due to the study's retrospective nature, informed consent was waived.

Footnotes

Financial Disclosure: The authors declared that this study received no financial support.

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