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ORIGINAL RESEARCH

Body composition analysis and handgrip strength as predictors of 12-month mortality in hospitalized adults receiving parenteral nutrition: A descriptive cohort study

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Abstract

Background: Nutrition assessment in patients receiving parenteral nutrition often relies on classical parameters with limited prognostic value. Morphofunctional tools such as phase angle and handgrip strength measurement offer a more comprehensive evaluation of nutrition status and may better predict clinical outcomes.

Objective: To evaluate the predictive value of phase angle and handgrip strength for 12-month mortality in hospitalized patients receiving parenteral nutrition.

Methods: A retrospective observational study was conducted in 614 patients treated with parenteral nutrition. Anthropometric assessments were realized. Morphofunctional assessments included bioelectrical impedance analysis to determine phase angle and dynamometry to measure handgrip strength. Survival analysis was performed using Cox proportional hazards models and Kaplan-Meier curves and cutoff values by receiver operating characteristic curve analysis.

Results: Six hundred fourteen patients received parenteral nutrition, with a mean age of 64 ± 14.6 years; 58.2% were male. After 1 year, the mortality rate was 26.1%, and the average hospital stay was 27.9 ± 23.8 days. Twelve-month survival was reduced in patients with low phase angle (57%) and low handgrip strength (62.8%) compared with those with preserved values (84% and 82.2%, respectively). In the multivariable logistic regression model adjusted for age, sex, and body mass index, each unit increase in phase angle and handgrip strength was associated with a 4% and 2% reduction in mortality odds, respectively (phase angle: odds ratio [OR], 0.6; 95% CI, 0.5–0.7; $P < 0.001$; handgrip strength: OR, 0.9; 95% CI, 0.9–1.0; $P = 0.03624$).

Conclusion: Phase angle and handgrip strength are predictors of 12-month mortality in patients receiving parenteral nutrition.

KEYWORDS

bioelectrical impedance vector analysis, handgrip strength, phase angle, total parenteral nutrition

INTRODUCTION

Parenteral nutrition is an essential therapeutic strategy for providing nutrition support to patients who are unable to use their gastrointestinal tract effectively, delivering all necessary nutrients intravenously to maintain metabolic homeostasis. It can replace enteral nutrition, which is considered more physiological.[1] However, its use carries significant risks, particularly central line–associated infections[2] and metabolic complications, because of its high carbohydrate, lipid, or micronutrient content.[3] In these patients, early detection of malnutrition and muscle deterioration is essential to guide therapeutic decisions and improve long-term outcomes. Recently, advances in body composition analysis have highlighted the potential of bioelectrical impedance vector analysis and functional assessments such as handgrip strength as prognostic markers.[4,5] Studies have consistently demonstrated that a reduced phase angle is linked with increased morbidity and mortality in various patient populations; for example, in patients with cancer, a phase angle <4° has been observed to be associated with increased mortality.[6–8] In the setting of parenteral nutrition, in which fluid shifts and inflammatory states are common, bioelectrical impedance vector analysis offers a reliable means to assess the true nutrition state beyond conventional anthropometry.[9] Complementing the insights from bioelectrical impedance vector analysis, handgrip strength has emerged as an objective measure of muscle strength that correlates with nutrition status and predicts adverse clinical outcomes.[9–11]

The morphofunctional assessment has been developed emphasizing the evaluation of both body composition (morphology) and physical performance (functionality). Techniques used in this assessment, such as vectorial bioelectrical impedance analysis and handgrip strength measurements, serve as predictive indicators, representing a valuable and promising strategy.[12,13]

Given that parenteral nutrition is often the sole means of nutrition support in patients who are unable to receive oral intake, establishing reliable prognostic markers is imperative. Køhler et al evaluated the predictive value of body composition and muscle strength in relation to clinical outcome in patients who have chronic intestinal failure and receive long-term home parenteral nutrition, concluding that both a low fat mass index and a low phase angle were independent risk factors for predicting mortality.[14–17]

Although body composition has been shown to predict mortality in patients receiving parenteral nutrition, there is limited evidence regarding whether phase angle and handgrip strength—as simple, bedside functional measures—independently predict 12-month mortality in hospitalized patients receiving parenteral nutrition. We designed a study aimed at evaluating the prognostic utility of morphofunctional parameters—specifically phase angle and handgrip strength—in a large cohort of hospitalized patients receiving parenteral nutrition. Unlike previous studies focused on specific diseases or settings, our work explores these biomarkers within a heterogeneous inpatient population where nutrition support is entirely dependent on parenteral routes. By doing so, we aim to provide new evidence to support the integration of functional assessment into routine clinical practice for better risk stratification and outcome prediction in this vulnerable group.

MATERIAL AND METHODS

Study design and participants

In this retrospective observational study conducted within a single center, a cohort of patients requiring parenteral nutrition for diverse clinical indications was recruited. Anthropometric assessments, bioelectrical impedance vector analysis, and handgrip strength evaluations were conducted during the period extending from November 2019 to November 2024. The study included adult patients (>18 years old) with parenteral nutrition and long hospital stay (>72 h). The study excluded patients based on specific criteria, including pediatric individuals, pregnant patients, and those with a brief hospital stay (defined as <72 h postadmission), as well as individuals who declined participation and those unable to undergo bioelectrical impedance analysis because of confounding factors such as ethnicity, extensive dermatological lesions, fluid extravasation, localized hematomas, or amputations (Supporting Information S1: Figure 1).

Demographic, clinical, and anthropometric measurements

Demographic characteristics, comorbidities, and clinical and anthropometric data, as well as additional nutrition assessments, were meticulously documented as part of routine hospital practice upon patient admission (first day). Within 72 h after the start of parenteral nutrition treatment, a qualified nurse visited participants in their respective rooms to collect the necessary information.

The anthropometric assessments encompassed measurements of weight and height. Weight was accurately obtained in kilograms using a scale with a precision of 100 g, whereas height was assessed in meters using a laser rod with a precision of 2 mm. Body mass index (kg/m²) was calculated.

Bioelectrical impedance analysis and bioelectrical impedance vector analysis

The body composition of the patients participating in the study was evaluated via bioelectrical impedance analysis within 72 h after receiving treatment with parenteral nutrition, performed by endocrinology nursing staff in the mornings. Whole-body bioimpedance assessments were performed by using a single-frequency bioelectrical impedance analysis apparatus (Nutrilab Whole Body Bioimpedance Vector Analyzer; Akern). Phase angle is expressed in degrees as arctan (reactance/R) × (180°/π). Bioelectrical impedance vector analysis measurements of patients were standardized for sex and age using data from healthy Italian adults.[18–20]

Handgrip strength

Muscle strength was tested by handgrip strength using a JAMAR hand dynamometer: The patient was in a sitting position with the elbow at 90°, using the dominant hand, and we performed three attempts; the median of the best hand was used; the assessment of strength was recorded in kilograms; we provided verbal encouragement.[21]

Malnutrition and sarcopenia diagnosis

The Global Leadership Initiative on Malnutrition includes five criteria to diagnose malnutrition in adults in a clinical setting.[22] The Global Leadership Initiative on Malnutrition criteria for disease-related malnutrition combine both phenotypic and etiologic factors.

European Working Group on Sarcopenia 2 defines sarcopenia as the presence of both low muscle strength and low muscle mass quantity.[23]

Outcome measures

Hospital stay was recorded as the number of days hospitalized. Lastly, mortality was defined as death within 1 year of follow-up, either during hospitalization or after discharge, and patients' deaths were identified through a review of their medical records.

Statistical analysis

The statistical analysis in this study incorporated both parametric and nonparametric tests to compare groups and assess associations between variables. The Shapiro-Wilk test was used to assess normality. For variables with a normal distribution ($P > 0.05$), Student t test was applied, whereas for nonnormally distributed variables ($P < 0.05$), the Mann-Whitney U test was used. Correlations were evaluated using Pearson correlation coefficient for normally distributed variables and Spearman rank correlation for nonparametric associations; they are significant if $P < 0.05$. To determine optimal cutoff values for mortality risk prediction, receiver operating characteristic (ROC) curve analysis was performed for phase angle and handgrip strength. The identified cutoff values were then dichotomized and applied in the Kaplan-Meier survival analysis, categorizing patients into high-risk and low-risk groups. Although literature-based thresholds for phase angle and handgrip strength exist, they often vary depending on population characteristics such as age, sex, underlying pathology, and clinical setting. Given that our study focused on a specific and clinically complex population—hospitalized patients receiving parenteral nutrition—we opted to define cutoff points based on 12-month mortality using ROC curve analysis. This approach allowed us to identify sex-specific thresholds with the best prognostic performance in our cohort. Log-rank tests were used to compare survival distributions between these groups. Finally, Cox proportional hazards regression was conducted in two distinct contexts. First, univariable Cox regression was applied separately for phase angle and handgrip strength in relation to the Kaplan-Meier survival curves, to evaluate the individual prognostic impact of each variable on 12-month mortality. Subsequently, a separate multivariable logistic regression model was developed to generate a predictive model incorporating morphofunctional and demographic variables. In this model, both univariable and multivariable odds ratios (ORs) were reported for phase angle and handgrip strength, alongside age, body mass index, and sex, allowing for adjustment and identification of independent predictors. We used the Jamovi statistical program (The Jamovi Project) to analyze patient data. Significance testing was performed with the use of a two-sided alpha level of 0.05.

Ethics

Our study was approved by the Ethics Committee of the Regional Hospital Malaga (VMF_NPT2025), adhering to the Declaration of Helsinki principles. Written informed consent was obtained from patients or their authorized representatives.

RESULTS

In this study, we examined data from 614 patients with parenteral nutrition. The average age of participants was 64 ± 14.6 years, and slightly more than half were men (58.2%, $n = 358$). At 1 year of follow-up, the mortality rate was 26.1% (n = 160). The mean length of admission was 27.9 ± 23.8 days.

Some differences in general, nutrition, and functional status were observed between survivors and nonsurvivors. Survival showed significant differences ($P < 0.05$) between variables, with younger patients (62.7 years), higher mean values for weight (71 vs 66.7 kg), body mass index (25.4 vs 24.2 kg/m^2), phase angle (4.9° vs 4.2°), body cell mass (24.7 vs 20.8 kg), appendicular skeletal muscle mass index (7.2 vs 6.8 kg/m^2), and handgrip strength (19.4 vs 15 kg). Other variables also demonstrated significant differences between survivors and nonsurvivors (Table 1). The data concerning the other variables obtained from the bioelectrical impedance analysis in estimated form are shown in Supporting Information S2: Table 1. In addition, the same variables have been calculated specific to sex to see the differences in Supporting Information S2: Table 2.

Malnutrition and sarcopenia status

In the overall sample, 63.9% met the Global Leadership Initiative on Malnutrition criteria for malnutrition, and 20.6% were identified as having sarcopenia. The following frequencies were also observed in men: 34.3% met Global Leadership Initiative on Malnutrition criteria for undernutrition, and 29.1% were identified as sarcopenic. In women, 23.9% met Global Leadership Initiative on Malnutrition criteria for undernutrition, and 9.2% were identified as sarcopenic.

TABLE 1 Anthropometric parameters, nutrition tools, bioelectrical impedance analysis, and functional test by survival or nonsurvival with PN.

Parameters	Total	Survival	Nonsurvival	*P* value
N	614	454 (73.9%)	160 (26.1%)	
	64 ± 14.6	62.7 ± 14.7	67.4 ± 13.9	<0.001
Height, cm	166 ± 9.48	166.7 ± 9.57	165.7 ± 9.25	0.279
Male sex	356 (58.1%)	265 (74.4%)	91 (25.6%)	0.720
Weight, kg	69.9 ± 18.0	71 ± 18	66.7 ± 17.7	0.009
BMI, kg/m^2	24.6 ± 5.6	25.4 ± 5.6	24.2 ± 5.8	0.021
Rz, ohms	514 ± 120	506.3 ± 107.9	535 ± 147.6	0.009
Xc, ohms	42.5 ± 14.1	43.6 ± 14	39.2 ± 14	<0.001
PA, °	4.7 ± 1.2	4.9 ± 1.2	4.2 ± 1	<0.001
SPA	−1.2 ± 1.4	−1.0 ± 1.4	−1.6 ± 1.4	<0.001
Hydration, %	73.8 ± 5.4	76.4 ± 5.1	78.0 ± 6.1	0.001
Nutrition	679.0 ± 210	737.4 ± 204.5	623.2 ± 202.4	<0.001
BCM, kg	23.7 ± 7.4	24.7 ± 7.2	20.8 ± 7	<0.001
Na/K	1.3 ± 0.5	1.3 ± 0.4	1.6 ± 0.6	<0.001
HGS, kg	17.8 ± 10.5	19.4 ± 10.7	15 ± 10.1	<0.001
Enteral nutrition, %	53.6%	56.8% (79)	41% (16)	0.08
Surgical indication, %	50.8%	55.4% (77)	33.3% (13)	0.02
Prealbumin, mg/dl	15.5 ± 9.42	16.3 ± 9.9	12.9 ± 7	0.06
CRP/prealbumin ratio	1.3 ± 1.7	1.3 ± 1.8	1.3 ± 1.4	0.86
PN bags (numbers)	14.5 ± 14.8	12.5 ± 11	21.1 ± 22.6	0.01
Energy, kcal	1766 ± 243	1770.9 ± 220.4	1773.8 ± 310.2	0.49
Volume, ml	1706 ± 265	1729.5 ± 240.4	1608 ± 327.8	0.03
Protein, g nitrogen	13.6 ± 2.9	13.6 ± 2.9	13.2 ± 2.8	0.5
Carbohydrate, g	218 ± 41.9	221.9 ± 36.1	204.7 ± 57.5	0.06
Lipid, g	54.3 ± 9.2	54.2 ± 8.7	54 ± 10.2	0.93

Note: Data included are expressed as means ± standard deviations, percentages, or absolute numbers; *P* for comparison by survival and nonsurvival.

Abbreviations: BCM, body cell mass; BMI, body mass index; CRP, C-reactive protein; HGS, handgrip strength; Na/K, sodium-potassium ratio; PA, phase angle differentiated by sex; PN, parenteral nutrition; Rz, resistance; SPA, standardized phase angle; Xc, reactance.

Malnutrition was significantly more frequent among nonsurvivors, following Global Leadership Initiative on Malnutrition criteria (75.6% vs 51.7%), as was recent weight loss (48.5% vs 21.4%) ($P < 0.001$ for all). Indicators of muscle mass and function, including reduced appendicular skeletal muscle mass index and sarcopenia, were also more prevalent in nonsurvivors ($P < 0.001$). Low handgrip strength was more common among nonsurvivors (75.6% vs 50.6%, $P < 0.001$).

Phase angle and handgrip strength for predicting mortality

The cutoff points for phase angle and handgrip strength as predictors of mortality, differentiated by sex, are represented in Table 2. For women, a phase angle value of 4.2° shows moderate sensitivity (69.1%) and specificity (64.9%) with acceptable predictive accuracy (area under the curve [AUC] = 0.685). In men, a slightly higher phase angle cutoff of 4.7° demonstrates similar diagnostic capability (sensitivity of 65.6%, specificity of 64.8%, and AUC = 0.690). Regarding handgrip strength, women exhibit moderate sensitivity (67.6%) and low specificity (53.6%) at a 13.1-kg cutoff, resulting in modest overall predictive value (AUC = 0.604). Conversely, in men, a cutoff of 21 kg provides moderate sensitivity (66.3%) and specificity (56.9%) with a slightly higher predictive accuracy (AUC = 0.634). Overall, phase angle shows superior predictive accuracy for mortality compared with handgrip strength in both sexes (Table 2; Figure 1).

Patients with preserved phase angle showed a 12-month survival rate of 84% (95% CI, 79.6%–89.0%), whereas those with low phase angle had a survival rate of 57% (95% CI, 49.7%–65.0%). Similarly, individuals with normal handgrip strength had a 12-month survival of 82.2% (95% CI, 77.1%–87.73%), compared with 62.8% (95% CI, 56.2%–70.3%) in those with low muscle strength. The Kaplan-Meier survival curves represented a significantly lower survival probability in the group with low phase angle and handgrip strength, with clear separation between curves and a log-rank test ($P < 0.0001$). Low phase angle and handgrip strength were defined using sex-specific cutoff points derived from ROC curve analysis (Figure 2).

In the multivariable logistic regression model, lower phase angle and handgrip strength were associated with higher mortality risk, adjusted for age, sex, and body mass index. Each unit increase in phase angle and handgrip strength was associated with a 40% and 2% reduction in mortality odds, respectively (phase angle: OR, 0.6; 95% CI, 0.5–0.7; $P < 0.001$; handgrip strength: OR, 0.9; 95% CI, 0.9–1.0; $P = 0.036$) (Table 3).

DISCUSSION

In the present study, we evaluated the prognostic significance of bioelectrical impedance vector analysis and handgrip strength in predicting 12-month mortality among hospitalized patients receiving parenteral nutrition. One key result of this investigation is that lower phase angle, derived from bioelectrical impedance vector analysis, was significantly associated with increased 12-month mortality. Our data confirm previous reports suggesting that lower phase angle values reflect compromised cellular integrity, reduced body cell mass, and poor nutrition status, all indicative of unfavorable clinical outcomes.[5,24] Specifically, we established optimal phase angle cutoff points predictive of mortality at 4.2° for women and 4.7° for men, with moderate sensitivity and specificity. These findings are in agreement with previous studies demonstrating that reduced phase angle is an independent prognostic marker in hospitalized and critically ill populations.[25–28]

In addition to bioelectrical impedance vector analysis, our analysis supports the prognostic relevance of handgrip strength. Patients exhibiting reduced handgrip strength (according to European Working Group on Sarcopenia in Older People 2 criteria of <27 kg in men and <16 kg in women) demonstrated notably higher mortality rates, with sex-specific cutoff values (13.1 kg for women and 21 kg for men) showing varied predictive capabilities. Handgrip strength has provided us with moderate sensitivity and specificity in predicting mortality, highlighting its importance as a useful tool for identifying patients at risk. Previous investigations reinforced the notion that diminished handgrip strength reflects both functional impairment and muscle wasting, strong predictors of poor clinical outcomes in diverse patient populations.[29,30] In our study, the cutoff points are lower than those found in other studies in the literature, because they focus on those at risk of mortality. This discrepancy highlights the need for context-specific benchmarks.

Interestingly, when comparing phase angle and handgrip strength, our ROC analysis indicated a superior predictive accuracy for phase angle in both sexes. One explanation could be that handgrip strength, although indicative of overall muscular function, is

TABLE 2 PA and HGS cutoff points for predicting mortality with parenteral nutrition.

Parameters	Sex	Cutoff point	Sensitivity, %	Specificity, %	AUC	*P* value
PA	Female	4.2	69.1	64.9	0.685	<0.001
PA	Male	4.7	65.6	64.8	0.690	<0.001
HGS	Female	13.1	67.6	53.6	0.604	<0.001
HGS	Male	21	66.3	56.9	0.634	<0.001

Note: *P* for comparison by sex.

Abbreviations: AUC, area under the curve; HGS, handgrip strength; PA, phase angle.

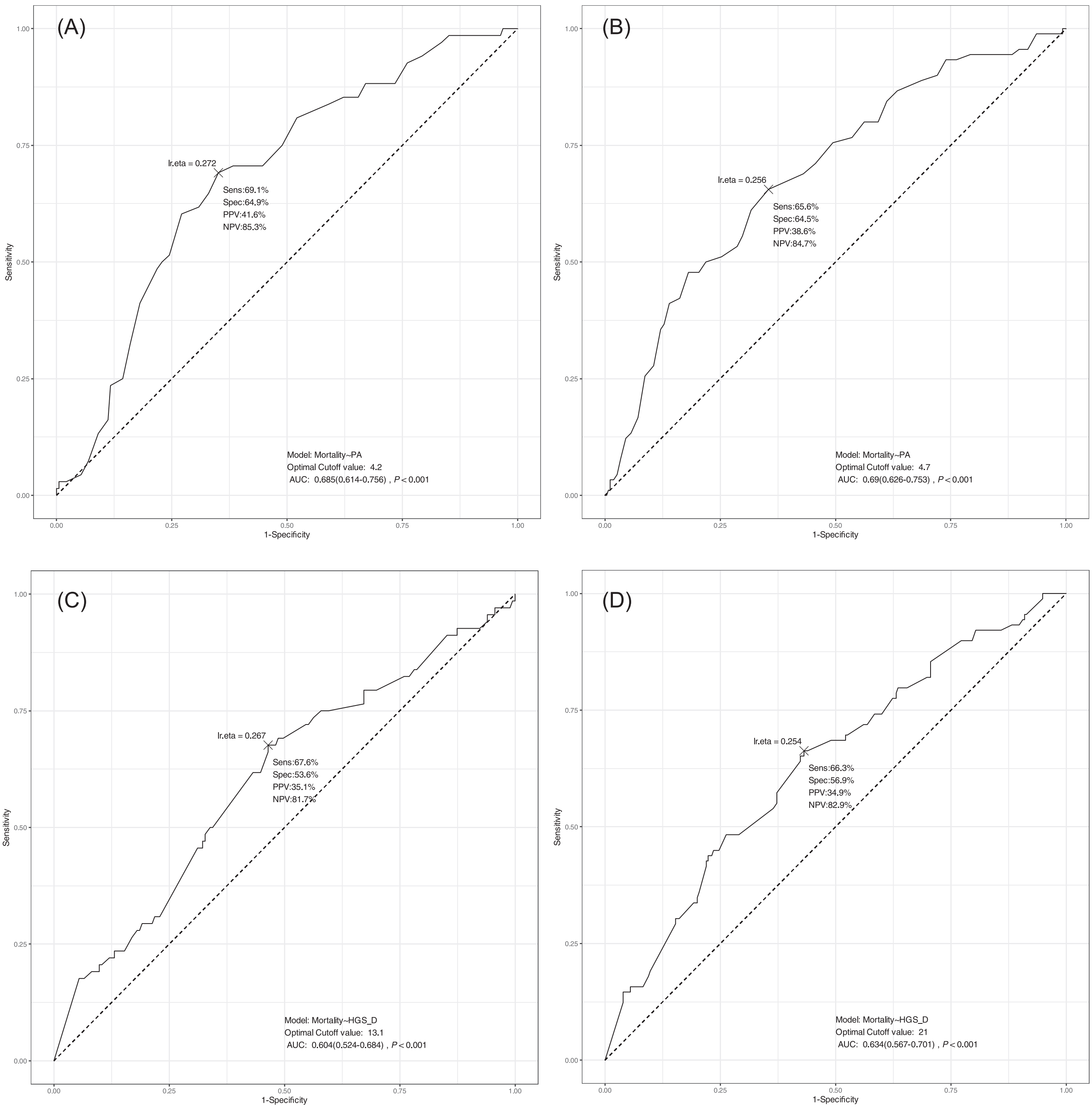

FIGURE 1 Receiver operating characteristic (ROC) curve of PA by mortality in women (A) and men (B). ROC curve of HGS by mortality in women (C) and men (D). Abbreviations: AUC, area under the curve; HGS, handgrip strength; PA, phase angle.

more susceptible to transient influences such as patient cooperation, acute illness severity, and fatigue, potentially reducing its specificity as a singular prognostic marker.[12] Despite this, both measures independently predicted mortality in the multivariable logistic regression model, highlighting their complementary role in clinical practice.

The present findings align with prior literature emphasizing the prognostic relevance of body composition and muscle strength parameters in patients receiving parenteral nutrition.[14,15] Notably, our results extend prior evidence by showing that both low phase angle and reduced handgrip strength were independently predictive of mortality.

The morphofunctional approach used in this study, integrating both body composition and muscle strength assessments, revealed clear associations between sarcopenia, malnutrition, and increased mortality risk. Approximately one-third of our cohort was identified

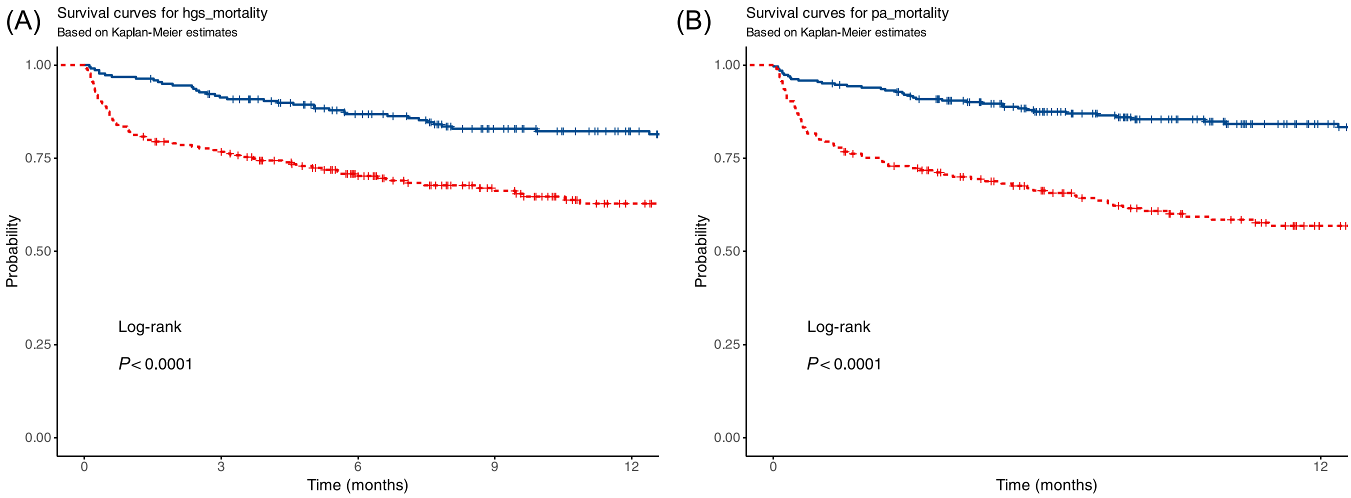

FIGURE 2 Kaplan-Meier curves of PA (A) and HGS (B), adjusted for sex, in patients receiving parenteral nutrition. Abbreviations: HGS, handgrip strength; PA, phase angle.

TABLE 3 Univariable and multivariable logistic regression analysis for mortality with parenteral nutrition.

Parameters		Survivors	Nonsurvivors	OR (Univariable)	OR (Multivariable)
Age	Mean (SD)	62.5 (14.8)	67.4 (14.0)	1.02 (1.01–1.04, $P < 0.001$)	1.01 (1.00–1.03, $P = 0.197$)
Sex	0	183 (73.2)	67 (26.8)	-	-
	1	253 (74.2)	88 (25.8)	0.95 (0.66–1.38, $P = 0.786$)	1.43 (0.93–2.21, $P = 0.103$)
BMI	Mean (SD)	25.4 (5.6)	24.2 (5.9)	0.96 (0.93–0.99, $P = 0.022$)	0.97 (0.93–1.00, $P = 0.074$)
HGS	Mean (SD)	19.3 (10.7)	15.0 (10.2)	0.96 (0.94–0.98, $P < 0.001$)	0.98 (0.95–1.00, $P = 0.036$)
PA	Mean (SD)	4.9 (1.1)	4.2 (1.0)	0.54 (0.44–0.64, $P < 0.001$)	0.60 (0.48–0.73, $P < 0.001$)

Note: *P* for comparison by survival and nonsurvival.

Abbreviations: BMI, body mass index; HGS, handgrip strength; OR, odds ratio; PA, phase angle; SD, standard derivation.

as malnourished according to Global Leadership Initiative on Malnutrition criteria, with a significant proportion exhibiting concurrent sarcopenia. These findings resonate with the literature emphasizing the interrelation between nutrition deterioration, muscular depletion, and adverse outcomes in hospitalized patients.[17,22]

Strengths of our study include the relatively large sample size and comprehensive methodological approach using standardized assessment protocols for bioelectrical impedance vector analysis and handgrip strength. This methodological rigor and precision significantly enhance the reliability and reproducibility of our findings. The term "morphofunctional assessment" encompasses the simultaneous evaluation of morphological (eg, body composition, phase angle) and functional (eg, handgrip strength) parameters, recognizing that the interaction between muscle mass and muscle strength is critical for clinical outcomes. This integrated approach provides a more holistic understanding of the patient's nutrition and physiological state, moving beyond traditional anthropometric measures. Future lines of research should focus on integrating morphofunctional assessment into routine clinical algorithms, exploring its utility in stratifying nutrition risk, optimizing timing and intensity of nutrition interventions, and monitoring longitudinal changes in body composition and functional capacity.

Nevertheless, several limitations should be considered. First, the retrospective and single-center design may limit the external generalizability of our results. Additionally, the absence of a control group not receiving parenteral nutrition restricts our ability to directly infer causal relationships between nutrition therapy and observed outcomes. Future studies with prospective, multicenter, controlled, and longer designs are warranted to address these limitations and validate our observations.

CONCLUSION

Our findings confirm that a reduced phase angle (<4.2° in women, <4.7° in men) and low handgrip strength (<13.1 kg in women, <21 kg in men) are independently associated with increased 12-month mortality in patients receiving parenteral nutrition, even after adjustment for age, sex, and body mass index. These morphofunctional parameters offer complementary prognostic value and underscore the importance of incorporating both functional and body composition assessments into routine nutrition evaluations to enhance risk stratification and inform clinical decision-making.

AUTHOR CONTRIBUTIONS

Natalia Montero Madrid: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision. **Raul Rodríguez Juárez**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; writing—review and editing; visualization; software; formal analysis; project administration; data curation; supervision; resources. **Rocío Fernández-Jiménez**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; visualization; validation; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources. **Alvaro Vidal Suarez**: Data curation; supervision; resources; software; formal analysis; project administration; methodology; validation; visualization; vriting—review and editing; conceptualization; investigation; funding acquisition; writing—original draft. **Patricia Guirado Peláez**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; project administration; formal analysis; data curation; supervision; resources. **Maria Angeles Martín-Fontalba**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources. **Beatriz Fernández Medina**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources. **Isabel Vegas Aguilar**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; visualization; validation; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources. **Maria del Mar Amaya Campos**: Conceptualization; funding acquisition; investigation; writing—original draft; methodology; validation; writing—review and editing; visualization; software; formal analysis; project administration; data curation; supervision; resources. **Victor Simón Frapolli**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision; eesources. **Maria Teresa Zarco Martín**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; project administration; formal analysis; data curation; supervision; resources. **Francisco Tinahones-Madueño**: Conceptualization; funding acquisition; investigation; writing—original draft; methodology; validation; visualization; writing—review and editing; formal analysis; software; project administration; supervision; data curation; resources. **Maria Luisa Fernández Soto**: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; visualization; validation; writing—review and editing; project administration; formal analysis; software; data curation; supervision; resources. **José Manuel García-Almeida**: conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; resources; supervision.

CONFLICT OF INTEREST STATEMENT

None declared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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