Original Research

BODY CELL MASS AND ITS ASSOCIATION WITH NUTRITIONAL STATUS IN PATIENTS WITH LIVER CIRRHOSIS

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ABSTRACT

Aims: Malnutrition is frequent in liver cirrhosis and contributes to adverse outcomes. Body cell mass (BCM), the metabolically active component of fat-free mass, may provide useful information on nutritional depletion. This study examined the association between BCM and nutritional and clinical characteristics in patients with cirrhosis.

Methods: This cross-sectional study enrolled 133 adult patients with cirrhosis. Nutritional status was assessed using the Subjective Global Assessment (SGA). Body composition parameters, including body cell mass (BCM), were estimated by direct segmental multi-frequency bioelectrical impedance analysis (InBody S10, InBody Co., Ltd., Seoul, Korea). Correlation analysis and multivariable linear regression with backward elimination were performed to identify factors independently associated with BCM.

Results: The mean age was 57.99 ± 11.33 years, and 89.5% were male. According to SGA, 30.1% were well nourished, 58.6% had moderate or suspected malnutrition, and 11.3% had severe malnutrition. BCM decreased across worsening SGA categories, from 30.56 ± 4.12 kg in SGA A to 29.55 ± 4.78 kg in SGA B and 26.91 ± 5.30 kg in SGA C. In multivariable analysis, severe malnutrition (SGA C), older age, and sex remained independently associated with BCM, whereas Child–Pugh score was not.

Conclusion: In patients with cirrhosis, BCM was independently associated with severe malnutrition, age, and sex, but not with liver disease severity. BCM may therefore reflect nutritional and body composition impairment rather than hepatic functional severity alone.

Keywords*: body cell mass, cirrhosis, malnutrition,SGA, body composition, bioelectrical impedance analysis.*

I. INTRODUCTION

Liver cirrhosis represents the end stage of chronic liver disease and remains a major cause of morbidity and mortality worldwide. Patients with cirrhosis frequently develop metabolic disturbances and nutritional impairment due to reduced dietary intake, altered nutrient metabolism, chronic inflammation, and increased energy expenditure. As a result, malnutrition is highly prevalent in this population and is associated with increased complications, reduced quality of life, and poorer survival. Previous studies estimate that 20–60% of patients with cirrhosis experience malnutrition, depending on disease severity and the assessment method used [1].

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Doi: 10.56283/1859-0381/1027.
Received: 17 Mar 2026 Revised: 21 Mar 2026
Accepted: 31 Mar 2026
Published online: 1 April 2026

Assessment of nutritional status in cirrhosis is particularly challenging. Conventional anthropometric indicators such as body weight and body mass index (BMI) may be unreliable because of fluid retention, including ascites and peripheral edema. Similarly, biochemical markers can be influenced by impaired liver function and systemic inflammation. For this reason, international guidelines recommend a multimodal approach combining clinical assessment with body-composition analysis for evaluating nutritional status in patients with liver disease [2].

Body cell mass (BCM) represents the metabolically active cellular component of fat-free mass and reflects tissues responsible for energy expenditure, oxygen consumption, and protein metabolism. Because BCM corresponds to the functional cellular compartment of the body, it has been proposed as a sensitive indicator of nutritional status. Bioelectrical impedance analysis (BIA) provides a non-invasive method for estimating BCM and other body-composition parameters in clinical practice. Previous studies have reported that BCM may be reduced in cirrhotic patients and is associated with alterations in body-water distribution and nutritional status [3].

However, the relationship between BCM and clinical characteristics in cirrhosis remains incompletely understood. In particular, it is unclear whether BCM is primarily related to nutritional status or to the severity of liver dysfunction. Therefore, this study aimed to evaluate the association between BCM and clinical as well as nutritional parameters in patients with liver cirrhosis.

II. METHODS

2.1. Study design and participants

This cross-sectional study included adult patients with cirrhosis admitted to the Department of Gastroenterology, Military Hospital 103, Hanoi, Vietnam. Cirrhosis was diagnosed based on compatible clinical manifestations, laboratory abnormalities, and imaging findings of chronic liver disease. Liver disease severity was assessed using the Child–Pugh score [4, 5].

The sample size for the descriptive objective was calculated using the single-proportion formula, (n = Z^2p(1-p)/d^2). Assuming an SGA defined malnutrition prevalence of 50%, a 95% confidence level, and an absolute precision of 0.085, the minimum required sample size was 133 patients. Accordingly, 133 eligible patients were included [6].

Eligible participants were adults aged ≥18 years with confirmed cirrhosis. Patients were recruited by consecutive sampling, meaning all eligible patients presenting during the study period were invited to participate until the target sample size was reached. Exclusion criteria were conditions likely to invalidate bioelectrical impedance analysis (BIA), including implanted electronic devices, pregnancy, severe edema unrelated to cirrhosis, or acute critical illness [7].

2.2. Nutritional and clinical assessment

Nutritional status was assessed using the Subjective Global Assessment (SGA), based on recent weight change, dietary intake, gastrointestinal symptoms, functional capacity, and physical examination findings, including loss of subcutaneous fat, muscle wasting, edema, and ascites. Patients were categorized as

SGA A (well nourished), SGA B (moderately malnourished), or SGA C (severely malnourished) [8].

Body weight and height were measured using standardized procedures. In patients with fluid retention, body weight was interpreted using estimated dry weight. Dry weight was obtained from post-paracentesis weight or pre-fluid retention weight when available; otherwise, measured body weight was adjusted by subtracting 5%, 10%, and 15% for mild, moderate, and severe ascites, respectively, with an additional 5% deducted for bilateral pedal edema, in accordance with EASL recommendations [2, 9]. Body mass index (BMI) was calculated as weight (kg)/height (m^2), but was used for descriptive purposes only and was not included in the primary multivariable model because of potential distortion by fluid retention and conceptual overlap with SGA in cirrhosis. Demographic, clinical, and laboratory data, including age, sex, cirrhosis etiology, disease duration, Charlson Comorbidity Index (CCI), hemoglobin, albumin, neutrophil-to-lymphocyte ratio (NLR), and platelet count, were extracted from medical records.

2.3. Bioelectrical impedance analysis

Body composition was assessed using a direct segmental multi-frequency bioelectrical impedance analyzer (InBody S10, InBody Co., Ltd., Seoul, Korea) in the supine position under standardized conditions. The device provides impedance-derived estimates of body composition, including body cell mass (BCM), total body water (TBW), extracellular water (ECW), intracellular water (ICW). In this study, BCM was treated as an MF-BIA-derived estimate rather than a direct reference-method measurement [7]. BCM was the primary outcome variable.

2.4. Statistical analysis

Statistical analyses were performed using SPSS version 26.0. Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), as appropriate, and categorical variables as number (percentage). Group comparisons were performed using one-way ANOVA or Welch's ANOVA, depending on variance assumptions. Correlations between BCM and clinical variables were assessed using Pearson or Spearman correlation coefficients, as appropriate.

To identify factors independently associated with BCM, multivariable linear regression was performed. Candidate variables included SGA category, age, sex, CCI score (Charlson Comorbidity Index), Nutritional Impact Symptoms (NIS score), Child–Pugh score, disease duration, and alcohol-related etiology. SGA A was used as the reference category. A backward elimination approach was applied to derive the final parsimonious model. Regression coefficients, 95% confidence intervals, and standardized beta coefficients were reported. Multicollinearity was assessed using variance inflation factors (VIFs). A two-sided p value <0.05 was considered statistically significant.

2.5. Ethics

The study protocol was approved by the Scientific Council of the Military Medical University (Decision No. 3424, August 15, 2025). All procedures were

conducted in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants before enrollment. Data use and publication were authorized by Military Hospital 103, all data were anonymized prior to analysis, and the authors declared no conflicts of interest.

III. RESULTS

Table 1. *Baseline demographic, clinical, laboratory, and nutritional characteristics of patients with cirrhosis (n = 133)*

Variable	Value
Age, years[a]	57.99 ± 11.33
Male, n (%)	119 (89.5)
Female, n (%)	14 (10.5)
Etiology of cirrhosis, n (%)	
Alcohol-related	88 (66.2)
Viral hepatitis (HBV/HCV) plus alcohol	22 (16.5)
Viral hepatitis (HBV/HCV) alone	21 (15.8)
Other	2 (1.5)
Disease duration, months[b]	48 (12–72)
Child–Pugh score[a]	9.05 ± 2.26
Child–Pugh class, n (%)	
A	18 (13.5)
B	65 (48.9)
C	50 (37.6)
CCI score[b]	0 (0–1)
BMI[a] based on estimated dry weight, kg/m²	19.85 ± 2.86
NLR[b]	3.22 (2.15–5.50)
Hemoglobin, g/L[a]	107.21 ± 25.38
Platelet count, ×10⁹/L[b]	92 (60–145)
Albumin, g/L[a]	29.31 ± 5.46
Nutritional status according to SGA, n (%)	
SGA A (well nourished)	40 (30.1)
SGA B (moderately malnourished or suspected malnutrition)	78 (58.6)
SGA C (severely malnourished)	15 (11.3)

Data are presented number (percentage), except for [a]mean ± standard deviation and [b] median (interquartile range).

Nutritional status was classified using the Subjective Global Assessment (SGA). BMI was calculated using estimated dry weight in patients with fluid retention. HBV, hepatitis B virus; HCV, hepatitis C virus; CCI, Charlson Comorbidity Index; BMI, body mass index; NLR, neutrophil-to-lymphocyte ratio; PLT, platelet count.

A total of 133 patients with cirrhosis were included in the study. As shown in Table 1, the mean age was 57.99 ± 11.33 years, and most patients were male

(89.5%). Alcohol-related cirrhosis was the most common etiology (66.2%). The median disease duration was 48 months (IQR: 12–72). The mean Child–Pugh score was 9.05 ± 2.26, and most patients were classified as Child–Pugh B (48.9%) or Child–Pugh C (37.6%). Regarding nutritional status, SGA B was the most frequent category (58.6%), followed by SGA A (30.1%) and SGA C (11.3%), indicating that malnutrition was common in this cohort.

Table 2. *Correlations between BCM and clinical, laboratory, and body composition variables (n = 133)*

Variable	Correlation coefficient	value
Age	-0.472[a]	<0.001
Sex	0.449 [a]	<0.001
CCI score	-0.175[b]	0.043
Child–Pugh score	-0.025 [a]	0.774
BMI, kg/m²	0.554 [a]	<0.001
NLR	-0.047 [b]	0.590
Hemoglobin, g/L	0.110 [a]	0.209
Platelet count, ×10⁹/L	-0.151 [b]	0.083
Albumin, g/L	0.118 [a]	0.175
TBW, L	0.991 [a]	<0.001
ECW, L	0.940 [a]	<0.001
ICW, L	0.999 [a]	<0.001

Correlation coefficients obtained by [a]Pearson test or [b] Spearman test

Correlation coefficients were used to assess associations between body cell mass (BCM, kg) and clinical, laboratory, and body composition variables. Pearson correlation was applied for normally distributed variables, whereas Spearman rank correlation was used for non-normally distributed variables. *Sex was analyzed as a dichotomous variable according to the study coding scheme (Male=1; Female=0). CCI, Charlson Comorbidity Index; BMI, body mass index; NLR, neutrophil-to-lymphocyte ratio; TBW, total body water; ECW, extracellular water; ICW, intracellular water.

Correlations between BCM and clinical, laboratory, and body composition variables are summarized in Table 2. BCM was significantly inversely correlated with age ($r = -0.472$, $p < 0.001$) and CCI score ($r = -0.175$, $p = 0.043$), and positively correlated with sex ($r = 0.449$, $p < 0.001$; sex coded as 0 = female and 1 = male) and dry BMI ($r = 0.554$, $p < 0.001$). No significant correlations were found between BCM and Child–Pugh score, NLR, hemoglobin, platelet count, or albumin. As expected, BCM showed very strong positive correlations with body composition parameters, including TBW ($r = 0.991$, $p < 0.001$), ECW ($r = 0.940$, $p < 0.001$), and ICW ($r = 0.999$, $p < 0.001$).

BCM according to nutritional status and liver disease severity is presented in Table 3. Mean BCM decreased across worsening nutritional status, from 30.56 ± 4.12 kg in SGA A to 29.55 ± 4.78 kg in

SGA B and 26.91 ± 5.30 kg in SGA C. The overall difference was significant by ANOVA (p = 0.038), although the result did not remain significant in Welch's test (p = 0.066). In contrast, BCM did not differ according to liver disease severity. Mean BCM was 30.02 ± 4.27 kg in Child–Pugh A, 29.52 ± 4.88 kg in Child–Pugh B, and 29.43 ± 4.79 kg in Child–Pugh C, with no significant between-group difference (ANOVA p = 0.900; Welch p = 0.884).

Multivariable linear regression results are presented in Table 4. In the full model, BCM was independently associated with SGA C (B = -4.058, p = 0.002), age (B = -0.136, p < 0.001), and male sex (B = 5.647, p = 0.002), whereas SGA B, CCI score, NIS score, Child–Pugh score, disease duration, and alcohol-related etiology were not significantly associated with BCM. After backward elimination, the final model retained SGA C, age, and sex. In this model, SGA C remained independently associated with lower BCM compared with SGA A (B = -3.296, 95% CI -5.396 to -1.196; p = 0.002), while age remained negatively associated with BCM (B = -0.144, p < 0.001) and male sex was positively associated with BCM (B = 4.828, p < 0.001). The final model showed acceptable explanatory performance (R^2 = 0.348; adjusted R^2 = 0.333). No evidence of problematic multicollinearity was observed, with all VIF values below 3.

Table 3. *Body cell mass according to nutritional status and Child–Pugh class (n = 133)*

Classification	BCM, kg	*p by ANOVA test*	*p by Welch test*
SGA category			
SGA A (n = 40)	30.56 ± 4.12		
SGA B (n = 78)	29.55 ± 4.78	0.038	0.066
SGA C (n = 15)	26.91 ± 5.30		
Child–Pugh class			
Child A (n = 18)	30.02 ± 4.27		
Child B (n = 65)	29.52 ± 4.88	0.900	0.884
Child C (n = 50)	29.43 ± 4.79		

Data are presented as mean ± standard deviation (SD). One-way analysis of variance (ANOVA) and Welch's robust test were used to compare body cell mass (BCM) across Subjective Global Assessment (SGA) categories and Child–Pugh classes. SGA, Subjective Global Assessment; BCM, body cell mass.

Table 4. *Multivariable linear regression models for factors associated with BCM (kg) (N = 133)*

Variable	β (SE)[a]	β[b]	p-value	95% CI	VIF
Full model (Model 1)					
Constant	33.915 (3.003)	–	<0.001	27.97 to 39.859	–
SGA B	-0.754 (0.836)	-0.079	0.369	-2.409 to 0.900	1.492
SGA C	-4.058 (1.308)	-0.272	0.002	-6.648 to -1.468	1.508

Variable	β (SE)[a]	β[b]	p-value	95% CI	VIF
Age	-0.136 (0.035)	-0.325	<0.001	-0.205 to -0.066	1.386
Sex	5.647 (1.808)	0.367	0.002	2.068 to 9.227	2.711
CCI score	-0.773 (0.573)	-0.104	0.179	-1.907 to 0.361	1.157
NIS score	-0.160 (0.173)	-0.069	0.357	-0.501 to 0.182	1.074
Child–Pugh score	0.148 (0.175)	0.071	0.398	-0.198 to 0.493	1.356
Disease duration (months)	0.000 (0.007)	0.002	0.982	-0.014 to 0.015	1.144
Alcohol-related etiology	-0.892 (1.423)	-0.072	0.532	-3.708 to 1.923	2.547
Final model)					
Constant	33.963 (2.569)	–	<0.001	28.880 to 39.046	–
SGA C	-3.296 (1.061)	-0.221	0.002	-5.396 to -1.196	1.002
Age	-0.144 (0.033)	-0.345	<0.001	-0.209 to -0.079	1.213
Sex	4.828 (1.205)	0.314	<0.001	2.444 to 7.212	1.215

[a] Unstandardized regression coefficient; [b] Standardized regression coefficient.
BCM (kg); CI, confidence interval; VIF, variance inflation factor; BCM, body cell mass; CCI, Charlson Comorbidity Index; NIS, Nutritional Impact Symptoms score; SGA, Subjective Global Assessment. SGA A was used as the reference category. Sex was coded as a binary variable (0 = female, 1 = male). The full model (Model 1) included 9 candidate predictors and yielded R = 0.610, R^2 = 0.372, adjusted R^2 = 0.326. The final model retained 3 predictors and yielded R = 0.590, R^2 = 0.348, adjusted R^2 = 0.333, with a Durbin–Watson statistic of 1.973. Multicollinearity was assessed using VIF.

IV. DISCUSSION

Main findings

In this study of 133 patients with cirrhosis, several important findings were identified. First, malnutrition was highly prevalent, with nearly 70% of patients classified as SGA B or C. Second, BCM decreased progressively across worsening nutritional status, and severe malnutrition (SGA C) remained independently associated with lower BCM in the final multivariable model. Third, age and sex were also independent predictors of BCM. Finally, BCM did not differ significantly across Child–Pugh classes, and liver disease severity was not associated with BCM in multivariable analysis, suggesting that BCM reflects nutritional and body composition status rather than hepatic functional severity alone.

Comparison with previous studies

Malnutrition is a well-recognized and frequent complication of cirrhosis. Previous studies have reported that 20–60% of patients with cirrhosis exhibit malnutrition, depending on disease stage and assessment method [1]. Current clinical guidelines emphasize that nutritional impairment may develop early in chronic liver disease and progressively worsen over time [2]. The high

prevalence of malnutrition observed in the present cohort is therefore consistent with existing literature and underscores the importance of systematic nutritional screening in cirrhosis.

A key finding of this study is the independent association between severe malnutrition (SGA C) and reduced BCM. BCM represents the metabolically active component of fat-free mass and reflects cellular mass and protein reserves. In our cohort, BCM decreased markedly from SGA A to SGA C, and this association remained significant after adjustment for clinical variables. This finding supports the validity of SGA as a clinically relevant tool for identifying patients with significant depletion of metabolically active tissue. Previous studies have similarly demonstrated that SGA correlates with body composition abnormalities and adverse clinical outcomes in cirrhosis [1, 8].

Age was independently associated with BCM in our analysis, with older patients exhibiting lower BCM. This finding is consistent with established evidence showing age-related decline in lean body mass and body cell mass. Physiological aging is associated with progressive loss of skeletal muscle, reduced anabolic signaling, and increased catabolic activity. In patients with cirrhosis, these processes may be further exacerbated by reduced dietary intake, chronic inflammation, hormonal disturbances, and decreased physical activity. Therefore, the inverse association between age and BCM observed in this study is biologically plausible and consistent with previous body composition research [10].

Sex differences in BCM were also evident. Male patients had significantly higher BCM than female patients, independent of other variables. This is expected, as men generally have greater lean mass and intracellular mass than women across age groups. Importantly, the persistence of sex as an independent predictor suggests that differences in body composition extend beyond simple anthropometric measures and should be considered when interpreting BCM values in clinical practice.

An important observation in this study is the lack of association between BCM and Child–Pugh class. BCM values were similar across Child–Pugh A, B, and C groups, and liver disease severity was not retained in the final regression model. While advanced liver disease is often associated with malnutrition, previous studies suggest that alterations in body composition may occur early and independently of hepatic functional decline. For example, Figueiredo et al. demonstrated significant BCM depletion even in patients with compensated cirrhosis [11]. Our findings therefore support the concept that nutritional impairment and hepatic functional reserve represent distinct but complementary dimensions in cirrhosis.

The very strong correlations observed between BCM and body water compartments (TBW, ECW, and especially ICW) are physiologically expected. BCM is closely related to intracellular water, which represents the water content of metabolically active cells. Previous studies using bioelectrical impedance analysis have similarly reported strong associations between BCM and body water distribution in cirrhotic patients [3]. However, these relationships largely reflect the structural basis of BCM measurement and should be interpreted accordingly.

Clinical implications

The findings of this study have several important clinical implications. First, the high prevalence of malnutrition highlights the need for routine nutritional assessment in patients with cirrhosis. Second, SGA, particularly the identification of severe malnutrition (SGA C), may serve as a simple and effective bedside tool to identify patients with significant depletion of metabolically active body mass. Third, BCM provides additional insight into cellular and metabolic status beyond conventional liver severity scores such as Child–Pugh classification.

Taken together, these findings support a multidimensional approach to patient assessment, combining clinical nutritional evaluation with body composition analysis to improve risk stratification and guide nutritional interventions.

Strengths and limitations

This study has several strengths. It provides a comprehensive evaluation of BCM in a well-characterized cohort of patients with cirrhosis and integrates clinical, nutritional, and body composition data within a multivariable analytical framework. In addition, multicollinearity was formally assessed, and no evidence of problematic collinearity was observed, supporting the robustness of the regression model.

However, several limitations should be acknowledged. First, the cross-sectional design precludes causal inference. Second, BCM in this study was estimated using bioelectrical impedance analysis rather than measured by a reference method such as total body potassium counting. As a result, BCM should be interpreted as an indirect, device-dependent estimate rather than a direct gold-standard measurement. Moreover, bioelectrical impedance analysis may be affected by hydration abnormalities and fluid retention, which are common in cirrhosis, although efforts were made to minimize this effect. Third, the relatively small number of patients in the SGA C group may have limited statistical power for subgroup comparisons. Finally, the study was conducted at a single center, which may limit generalizability.

V. CONCLUSION

In patients with cirrhosis, body cell mass (BCM) was independently associated with severe malnutrition, older age, and sex, whereas Child–Pugh class was not independently associated with BCM. These findings suggest that BCM reflects nutritional and body composition status rather than liver functional severity alone. Severe malnutrition identified by SGA was accompanied by significant depletion of metabolically active body mass, underscoring the clinical relevance of nutritional assessment in cirrhosis. The combined use of bedside nutritional assessment tools such as SGA and body composition analysis may improve the identification of patients with substantial cellular mass depletion and support earlier, more targeted nutritional intervention. Further longitudinal studies are warranted to determine whether BCM has prognostic value for clinical outcomes and survival in cirrhosis, and to clarify its role in guiding nutritional and metabolic management.

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