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Assessment of Sarcopenia by Computed Tomography and Its Prognostic Significance in Cirrhosis

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ABSTRACT

Background: Loss of skeletal muscle mass is increasingly recognized as a major determinant of adverse outcomes in patients with cirrhosis. Although the Child–Pugh and Model for End-stage Liver Disease (MELD) scores are routinely used to assess hepatic dysfunction, they do not evaluate muscle depletion. This study investigated the prevalence of computed tomography (CT)-based sarcopenia and its relationship with disease severity, cirrhosis-related complications, and mortality.

Methods: In this prospective observational study, 100 adults with confirmed cirrhosis underwent abdominal CT evaluation. Skeletal muscle index (SMI) was calculated from the cross-sectional muscle area at the third lumbar vertebral level (L3) and normalized for height. Sex-specific SMI thresholds were used to diagnose sarcopenia. Clinical features, biochemical parameters, liver disease severity scores, complications, and survival outcomes were compared between patients with and without sarcopenia.

Results: CT-defined sarcopenia was identified in 58% of participants. Patients with sarcopenia had significantly higher MELD scores, lower serum albumin concentrations, and lower platelet counts than those without sarcopenia. Decompensating events, including ascites, esophageal varices, hepatic encephalopathy, and spontaneous bacterial peritonitis, occurred more frequently in the sarcopenic group. Overall mortality was 16%, with a significantly greater risk among sarcopenic patients (22.4% vs. 7.1%). Multivariable analysis demonstrated that both sarcopenia and MELD score independently predicted mortality.

Conclusion: CT-based assessment of skeletal muscle provides valuable prognostic information in cirrhosis. Incorporating sarcopenia evaluation into routine abdominal CT interpretation may improve risk stratification and facilitate timely therapeutic interventions for high-risk patients.

Key-words: Cirrhosis; sarcopenia; Computed tomography; Skeletal muscle index; MELD; Prognosis

INTRODUCTION

Cirrhosis is the sequela of chronic liver disease and carries with it a significant burden of morbidity and mortality globally.

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As hepatic fibrosis progresses, it leads to portal hypertension, hepatic insufficiency, and several systemic complications that significantly increase morbidity and mortality. Several prognostic scores, such as the Child–Pugh classification and the Model for End-stage Liver Disease (MELD) score, are currently used to assess liver disease severity; however, they do not adequately predict nutritional status or changes in body composition, both of which have important prognostic implications. [1-3]

Loss of skeletal muscle mass and function, referred to as sarcopenia, is increasingly recognized as an important

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feature of cirrhosis and a key component of liver frailty. Protein-energy malnutrition, chronic inflammation, hypermetabolism, hormonal disturbances, reduced physical activity, endocrine abnormalities, and impaired ammonia metabolism all contribute to the development of sarcopenia. Skeletal muscle also plays an important role in ammonia detoxification,[4-6] and its depletion contributes to hyperammonemia and hepatic encephalopathy. [7]

Numerous studies have demonstrated that sarcopenia is associated with advanced liver disease, a higher risk of hepatic decompensation, prolonged hospitalization, reduced health-related quality of life, and increased mortality, independent of conventional prognostic scores. [8-11] Therefore, assessment of skeletal muscle has become an important component in evaluating the prognosis of patients with cirrhosis.

CT is considered the reference standard for assessing skeletal muscle mass. Cross-sectional measurement of skeletal muscle area at the third lumbar vertebral (L3) level correlates well with whole-body skeletal muscle mass and provides an objective and reproducible method for diagnosing sarcopenia. [12-14] Patients with cirrhosis frequently undergo abdominal CT for evaluation of portal hypertension, hepatocellular carcinoma surveillance, and pre-transplant assessment, allowing opportunistic measurement of skeletal muscle without additional radiation exposure or cost.

Although CT-based muscle assessment has demonstrated significant prognostic value, it remains underutilized in routine clinical practice, particularly in resource-limited settings. Therefore, this prospective observational study evaluated the prevalence of CT-defined sarcopenia in patients with cirrhosis and its association with disease severity, hepatic decompensation, and mortality during a 24-month follow-up period. [15]

MATERIALS AND METHODS

Study Design and Participants- This prospective observational study was conducted jointly by the Departments of Radiodiagnosis and Gastroenterology at a tertiary care teaching hospital over a period of two years.

Inclusion and Exclusion Criteria- A total of 100 consecutive adult patients (≥18 years) with clinically and radiologically confirmed cirrhosis who underwent contrast-enhanced CT of the abdomen were included in the study.

Patients with hepatocellular carcinoma (HCC) or other active malignancies, previous liver transplantation, chronic neuromuscular disorders, recent major trauma or abdominal surgery, and poor-quality CT images unsuitable for muscle assessment were excluded.

Clinical and Laboratory Evaluation- Demographic characteristics, body mass index (BMI), etiology of cirrhosis, and clinical features of hepatic decompensation were recorded. Disease severity was assessed using the Child–Pugh classification and MELD score. During follow-up, clinical outcomes including ascites, esophageal varices, hepatic encephalopathy, spontaneous bacterial peritonitis (SBP), and all-cause mortality were documented. Laboratory parameters included serum bilirubin, albumin, creatinine, international normalized ratio (INR), platelet count, and liver function tests.

CT Acquisition and Image Analysis- Contrast-enhanced abdominal CT examinations were performed using a 128-slice multidetector CT scanner following a standardized imaging protocol. Images were acquired approximately 70 seconds after intravenous administration of nonionic iodinated contrast medium using a tube voltage of 120 kVp with automatic tube current modulation. Images were reconstructed with a slice thickness of 5 mm and a reconstruction interval of 3 mm.

A single axial image at the third L3 level was used to assess skeletal muscle mass, as it closely correlates with whole-body skeletal muscle mass.[12–14] The skeletal muscles analyzed included the bilateral psoas, erector spinae, quadratus lumborum, rectus abdominis, transversus abdominis, and internal and external oblique muscles. Skeletal muscle area was identified using attenuation thresholds of −29 to +150 Hounsfield units (HU) and normalized for height squared to calculate the skeletal muscle index (SMI).

SMI (cm^2/m^2) = Skeletal muscle area (cm^2) / height^2 (m^2)

Sarcopenia was defined using validated sex-specific cut-off values of <50 cm^2/m^2 for men and <39 cm^2/m^2 for women. [8,12]

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Outcome Measures- The primary outcome was the prevalence of CT-defined sarcopenia among patients with cirrhosis. Secondary outcomes included the association of sarcopenia with disease severity (Child–Pugh class and MELD score), cirrhosis-related complications (ascites, esophageal varices, hepatic encephalopathy, and SBP), and all-cause mortality.

Statistical Analysis- Statistical analysis was performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons between sarcopenic and non-sarcopenic groups were performed using the independent Student's *t*-test or Mann–Whitney *U* test for continuous variables and the Chi-square or Fisher's exact test for categorical variables, as appropriate. Variables showing statistical significance in univariate analysis were entered into a multivariable logistic regression model to identify independent predictors of mortality. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A two-tailed p value <0.05 was considered statistically significant.

Ethical Approval- The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants before enrolment in the study.

RESULTS

Study enrollees were 100 patients who were acutely hospitalized for cirrhosis. The age of the study population was 54.2 years on average (SD 10.6 years), and there was a higher proportion of males (68%) than females (32%) that were studied. The most common causes of cirrhosis were alcoholic liver disease (36%), viral hepatitis (28%), non-alcoholic fatty liver disease (22%), autoimmune liver disease (8%) and other causes (6%). Baseline demographic and clinical characteristics of the study population are shown in Table 1 and etiology of cirrhosis in Table 2.

Table 1: Baseline demographic and clinical characteristics of the study population

Characteristics	Value
Total patients	100
Age (years), mean ± SD	54.2 ± 10.6
Male, n (%)	68 (68%)
Female, n (%)	32 (32%)

Table 2: Etiology of cirrhosis

Etiology	n (%)
Alcoholic liver disease	36 (36%)
Viral hepatitis	28 (28%)
NAFLD	22 (22%)
Autoimmune liver disease	8 (8%)
Others	6 (6%)

CT-based assessment demonstrated sarcopenia in 58 (58%) patients, while 42 (42%) patients had preserved skeletal muscle mass as shown in Table 3.

Table 3: Prevalence of CT-defined sarcopenia

Variable	n (%)
Sarcopenia	58 (58%)
No sarcopenia	42 (42%)

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Patients with sarcopenia had significantly more advanced liver disease than those without sarcopenia. The mean MELD score was significantly higher in the sarcopenia group (18.6 ± 5.1 vs. 12.8 ± 4.3; p < 0.001). Child–Pugh Class C was also more frequent among sarcopenic patients (53.4% vs. 21.4%; p = 0.002). In addition, sarcopenic patients had significantly lower serum albumin and platelet counts (Table 4).

Table 4: Comparison of disease severity between patients with and without sarcopenia

Variable	Sarcopenia (n=58)	No Sarcopenia (n=42)	*p* value
MELD score	18.6 ± 5.1	12.8 ± 4.3	<0.001
Child–Pugh Class C, n (%)	31 (53.4%)	9 (21.4%)	0.002
Serum albumin (g/dL)	2.7 ± 0.6	3.3 ± 0.5	<0.001
Platelet count (/mm³)	96,000 ± 28,000	128,000 ± 34,000	0.001

Patients with sarcopenia had significantly higher rates of cirrhosis-related complications than those without sarcopenia. Ascites, esophageal varices, hepatic encephalopathy, and spontaneous bacterial peritonitis were all significantly more frequent in the sarcopenia group. During the follow-up period, the overall mortality rate was 16%, with significantly higher mortality observed among patients with sarcopenia compared to those without sarcopenia (22.4% vs. 7.1%; p = 0.030), as shown in Table 5.

Table 5: Cirrhosis-related Complications and Mortality According to Sarcopenia Status

Variable	Sarcopenia (n = 58)	No Sarcopenia (n = 42)	*p* value
Ascites	44 (75.9%)	18 (42.9%)	0.002
Esophageal varices	47 (81.0%)	24 (57.1%)	0.010
Hepatic encephalopathy	27 (46.5%)	8 (19.0%)	0.004
Spontaneous bacterial peritonitis	14 (24.1%)	4 (9.5%)	0.040
Mortality	13 (22.4%)	3 (7.1%)	0.030

Multivariable logistic regression analysis identified sarcopenia and MELD score as independent predictors of mortality, whereas higher serum albumin was associated with a lower risk of death (Table 6).

Table 6: Multivariable logistic regression analysis for predictors of mortality

Variable	Odds Ratio	95% Confidence Interval	*p* value
MELD score	1.34	1.12–1.67	0.002
Sarcopenia	2.91	1.21–6.84	0.010
Serum albumin	0.64	0.42–0.88	0.030

DISCUSSION

In this prospective observational study, CT-defined sarcopenia was identified in 58% of patients with cirrhosis, highlighting its high prevalence in chronic liver disease. Furthermore, sarcopenia was significantly associated with advanced hepatic dysfunction, increased hepatic decompensation, and higher mortality, supporting its role as an important prognostic biomarker. [13-15]

The prevalence observed in our study is consistent with previous reports, where sarcopenia has been documented in 30–70% of patients with cirrhosis, depending on differences in study populations, disease severity, ethnicity, and diagnostic criteria. Higher rates have been reported among patients with end-stage liver disease awaiting liver transplantation, and several studies have demonstrated that sarcopenia

independently predicts adverse clinical outcomes beyond conventional prognostic scores.[13,16]

Patients with sarcopenia had significantly higher MELD scores and a greater proportion of Child–Pugh Class C disease than those without sarcopenia. Similar findings have been reported by Cruz-Jentoft *et al*. [17], Cui *et al*. [18], and Englesbe *et al*. [19], who demonstrated that progressive muscle wasting is closely associated with worsening hepatic function and poor prognosis [17]. These findings suggest that sarcopenia reflects disease severity rather than age-related muscle loss alone.

Sarcopenic patients also had significantly lower serum albumin levels and platelet counts, indicating impaired hepatic synthetic function, poor nutritional status, and more severe portal hypertension. Progressive muscle loss in cirrhosis is multifactorial and is driven by chronic inflammation, hypermetabolism, insulin resistance, hormonal disturbances, and hyperammonemia. [20]

Our study further demonstrated a significantly higher frequency of hepatic decompensation, including ascites, esophageal varices, hepatic encephalopathy, and spontaneous bacterial peritonitis, among patients with sarcopenia. Previous studies have similarly reported that sarcopenia is associated with increased portal hypertension-related complications, prolonged hospitalization, poorer quality of life, and worse clinical outcomes. [13,21] Loss of skeletal muscle reduces extrahepatic ammonia metabolism, thereby contributing to hyperammonemia and hepatic encephalopathy.

Mortality was significantly higher among patients with sarcopenia (22.4% vs. 7.1%), and multivariable logistic regression confirmed sarcopenia as an independent predictor of mortality after adjustment for MELD score and serum albumin. These findings are consistent with previous prospective studies and meta-analyses demonstrating that sarcopenia independently predicts mortality, liver-related complications, and adverse outcomes following liver transplantation. [13,16,22]

Computed tomography remains the reference standard for body composition assessment because skeletal muscle area measured at the L3 vertebral level strongly correlates with whole-body muscle mass and provides highly reproducible measurements. As abdominal CT is routinely performed in patients with cirrhosis for hepatocellular carcinoma surveillance, assessment of portal hypertension, and pre-transplant evaluation, opportunistic assessment of skeletal muscle can be performed without additional radiation exposure or cost.[20]

The strengths of this study include its prospective design, standardized CT-based assessment of skeletal muscle using validated diagnostic criteria, and evaluation of clinically meaningful outcomes, including hepatic decompensation and mortality. CT-derived skeletal muscle index provides an objective and reproducible assessment that can be readily incorporated into routine abdominal CT interpretation.

This study has several limitations. It was conducted at a single tertiary care center with a relatively small sample size, which may limit the generalizability of the findings. In addition, muscle strength and physical performance, as recommended by the EWGSOP2 criteria, were not assessed. Serial assessment of skeletal muscle during follow-up was also not performed, preventing evaluation of temporal changes in muscle mass and their impact on clinical outcomes [20].

Overall, our findings add to the growing evidence that CT-defined sarcopenia is a valuable imaging biomarker in cirrhosis. Incorporating routine assessment of skeletal muscle mass into abdominal CT reporting, alongside conventional prognostic models such as the Child–Pugh and MELD scores, may improve risk stratification, facilitate early nutritional and rehabilitation interventions, and support timely referral for liver transplantation. [13,22]

CONTRIBUTION OF AUTHORS

Research concept- Dr. Priyam Agarwal, Akash Marade
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