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Research Article

Assesment of Nutritional Status and Sarcopenia in Child Pugh A and B Cirrhosis Patients and Correlating Sarcopenia with Severity of Liver Cirrhosis

Dr Panchalingappa Betageri [1*], Dr Srinivasrao G Shinde [2]

1. *Assistant professor, Department of Gastroenterology, JNMC Belgaum.*
2. *Assistant Professor, Dept of Paediatrics, ESIC Medical College and Hospital, Kalaburagi.*

[*]**Correspondence to**: Dr Panchalingappa Betageri, Assistant professor, Department of Gastroenterology, JNMC Belgaum.

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Introduction

The incidence of hepatitis is increasing and it may become the second important disease [1]. Approximately 50-90% of people with cirrhosis may suffer from malnutrition. Controlling this nutritional deficiency is important to improve clinical outcomes in patients with cirrhosis. Sarcopenia is also associated with functional impairment in patients with cirrhosis [2]. The pathogenesis of sarcopenia is multifactorial. Malnutrition requires treatment through physical therapy and medication to reverse sarcopenia and improve its outcomes [3]. Although it has a positive effect, malnutrition in patients with cirrhosis may pose a diagnostic problem and may be underestimated. In CLD, sarcopenia is the most common and invisible complication that negatively affects quality of life, survival, and response to stressors (e.g., disease and surgery) in patients with cirrhosis [4]. Evaluation of sarcopenia and interventions to improve performance are important in the treatment of patients with cirrhosis. The clinical significance of sarcopenia and its association with liver disease have not been studied in India. It is easier to obtain detailed information about cirrhosis in Child A and Child B, and understanding their nutritional status and severity of liver disease can help guide early intervention and treatment.

Materials And Methods

Materials

This cross-sectional study aimed to evaluate the physical and mental health of adult patients aged 18-65 years with liver cirrhosis, specifically those with Child-Pugh A and B severity. The study population consisted of 100 outpatients and inpatients from King George Hospital, Andhra Medical College, Visakhapatnam.

Inclusion criteria included all adult patients aged 18-65 years evaluated for liver cirrhosis and found to have Child-Pugh A and B severity. Exclusion criteria included liver cirrhosis patients with Child Pugh-C, active comorbid diseases, malignancy, HIV, hepatic encephalopathy, pregnancy, and acute hepatitis.

The study used an anthropometric evaluation method, including measurements of height, weight, mid-arm muscle circumference, mid-arm circumference (MAC), and triceps skinfold thickness (TST). The patient's height was measured using the center of the skin caliper between the acromion and the tip of the olecranon.

Sarcopenia was assessed using a L3 vertebral body level CT scan (PMTH) <16.8 mm/m, which is well correlated with Sarcopenia. Digital CT scan images were accessed from the radiology department, and a single observer analyzed all images.

Muscle strength was measured using a Handgrip dynamometer (HGD), with three readings taken with a gap of >30 seconds. Gait speed was also assessed using a gait speed test, which was performed with any patient able to walk 4 meters.

The study concluded that a gait speed of more than 5 seconds to walk 4 meters (<0.8 m/s) suggests poor muscle performance.

Severity grading of cirrhosis

The severity of cirrhosis was graded as per Child-Turcotte Pugh score [5]

Factor	1 point	2 points	3 points
Total Bilirubin (mg/dL)	< 2	2-3	>3
Serum albumin (mg/dL)	>3.5	2.8-3.5	<2.8
PT INR	<1.7	1.71-2.3	>2.3
Ascites	None	Mild (or suppressed with medication)	Moderate to Severe (or refractory)
Hepatic encephalopathy	None	Grade I-II	Grade III-IV
	Class A	Class B	Class C
Total Points	5-6	7-9	10-15
1-year survival	100%	80%	45%
2-year survival	85%	60%	35%

Table 1 Child Turcotte Pugh Scoring System

The MELD score [68] has also been shown to predict survival in patients with cirrhosis. The estimated 3 month mortality based on MELD score is as follows.

MELD = 3.78×ln[serum bilirubin (mg/dL)] + 11.2×ln[INR] + 9.57×ln[serum creatinine (mg/dL)] + 6.43

Meld Score	Mortality
40	71.3% mortality
30-29	52.6% mortality
20-29	19.6% mortality
10-19	6.0% mortality
10 Or Less	1.9% mortality

Ethical Justification

- Institutional ethics committee approval was taken for the study (Approval no: 184/IEC AMC/DEC/2020).
- This study involved clinical evaluation, routine lab investigations, ultrasound of the abdomen, upper gastrointestinal endoscopy, and CT scan of patients.
- All patients were given the standard of care with no changes in therapy.
- Patients were included in the study after informed consent and had the right to opt- out at any time without giving any reason.
- We conducted this study considering the Helsinki Declaration of Human Rights; the most important factors taken into account were the well-being and safety of patients.

Statistical Analysis

- The data were entered into a Microsoft Excel worksheet (Office 2016 Professional for Windows; Microsoft) and IBM Statistical Package for the Social Sciences (SPSS) for Windows [version 20, Professional] (IBM Corp., Armonk, NY, USA) was used for analysis.
- Descriptive statistics are presented in frequency, percentages, mean, standard deviation, median, and quartiles.

- When the data was following the normal distribution, a parametric test like an independent sample t-test was used to compare the means between the two groups.
- Pearson correlation test was used to find the correlation between sarcopenia and severity of the liver disease.
- Results are graphically represented where deemed necessary.
- A p-value of < 0.05 was considered to be statistically significant.

Results

This prospective study included 100 consecutive patients with cirrhosis for 15 months. Specific patient characteristics and outcomes are described below.

Parameter		Result
Age in years, Mean (Range)		47.9(18-65)
Gender %	Male	69
	Female	31
Ascites %	Present	50
	Absent	50

Table 2 General characteristics of patients (n=100)

Note: Since the number of patients is 100, I have refrained from quoting numbers with percentages. As the numbers and percentage, both will be the same wherever appropriate number is mentioned with percentage.

The age of the patients in this study ranged from 18 to 65 years. The mean ± standard deviation age of the patients was 47.9±11.5 years. Most of the 34 patients (34%) were between the ages of 41 and 50. The study was mostly male, with 69 (69%) patients being male and the male/female ratio being 2.2:1. 50% of patients have a history of ascites.

Etiology	Number of patients
Alcohol	51
Hepatitis B	14
Hepatitis C	10
Unknown	12
NASH	10
AIH	3

Table 3 Distribution of patients according to etiology of cirrhosis (n=100)

Causes of cirrhosis are alcohol-related cirrhosis (51%), NASH (10%), hepatitis B-related cirrhosis (14%), hepatitis C cirrhosis (10%), autoimmune hepatitis (3%). No significant relationship was found between chronic liver disease and various causes of sarcopenia (p = 0.655).

Parameter		Number of patients (n=100)	Male n (%)	Female n (%)
CTP class	CTP class A	41	33(80)	8(20)
	CTP class B	59	36(61)	23(39)
MELD score	<15	72	46(64)	26(36)
	>15	28	23(82)	5(18)

Table 4 Severity grading of cirrhosis

The Child-Turcotte-Pugh (CTP) score was child class A in 41% of patients, while Child class B was in 59% of patients. MELD score<15 was seen in 72% of patients. The majority of the males, 23(82%), had MELD score > 15.

Variables	Minimum	Maximum	Mean±SD	Below normal cut-off (%)
Triceps skinfold (mm)	10	22	14.1±2.4	46
MAMC (mm)	11.1	27.3	19.9±3	45
BMI (kg/m2)	15.4	31.3	21.4±3.1	33

Table 5 Anthropometry parameters of patients

Anthropometric indicators, triceps skinfold, mid-arm muscle circumference and body weight were used for nutritional assessment. The mean ± SD of TSF was 14.1 ± 2.4, with a range of 10-22 mm. The MAMC range was 11.1–27.3 mm and the mean ± SD was 19.9 ± 3. BMI range was 15.4–31.3 kg/m2, mean ± SD 21.4 ± 3.1. TSFT was lower than normal in a total of 46 patients. MAMC was below the normal limit in 45 patients. 33 patients had low body mass index.

Nutritional Assessment

Parameter		Triceps skinfold thickness	P-value
		Reduced n=46(%)	
Gender	Male	17(37)	**0.001**
	Female	29(63)	
Ascites	Present	25(54)	0.42
	Absent	21(46)	
CTP	Class A	15(32)	0.11
	Class B	31(68)	
MELD score	<15	38(82)	**0.03**
	>15	8(18)	

Table 6 Association of Triceps skinfold thickness with other parameters

The Association of TSFT with gender, alcohol intake, and MELD score was significant($P<0.05$). In contrast, the association of TSFT with Ascites and CTP score was not significant.

Parameter		MAMC	P-value
		Reduced % n=45	
Gender	Male	34(76)	0.20
	Female	11(24)	
Ascites	Present	17(38)	**0.027**
	Absent	28(62)	
CTP	Class A	22(49)	0.14
	Class B	23(51)	
MELD score	<15	33(73)	0.78
	>15	12(27)	

Table 7 Association of Mid arm muscle circumference with other parameters

The association of MAMC was significant only with ascites (P<0.05), whereas it was not significant with gender, alcohol intake, CTP, and MELD score.

Parameter		BMI	P-value
		Reduced % n=33	
Gender	Male	20(61)	0.20
	Female	13(39)	
Ascites	Present	17(51.5)	0.83
	Absent	16(48.5)	
CTP	Class A	11(33)	0.27
	Class B	22(67)	
MELD score	<15	24(73)	0.9
	>15	9(27)	

Table 8 Association of Body Mass Index with other parameters

The Association of BMI was not significant with any of the above parameters.

Sarcopenia

Sarcopenia was seen in 27/100(27%) patients in the study population.

Variable	Sarcopenia Present n=27	Sarcopenia Absent N=73
Age in years, Mean ±SD	52.77±9.86	46.24±11.75

Table 9 Association of age with sarcopenia

The mean age of patients with sarcopenia was 52.77±9.86 years and this was significant;p =0.012

Variables	Mean±SD	Min	Max	% abnormal of total patients
Handgrip strength (kg)	25.8±6.3	11.6	36	31
Gait Speed (m/sec)	0.87±0.19	0.6	1.3	26
CT PMTH (mm/m)	17±2.2	13.2	22.1	44

Table 10 Sarcopenia Assessment parameters

Grip strength was abnormal in 31/100 (31%) patients. Speed was decreased in 26/100 (26%) patients, and CT PMTH was abnormal in 44 patients. Mean grip strength was 25.8 ± 6.3 kg, mean walking speed was 0.87 ± 0.19 m/s, and mean CT PMTH was 17 ± 2.2 mm/m.

Gender	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
Females	9 (33.3)	22(30.1)
Males	18(66.7)	51(69.9)

Table 11 Association of gender with sarcopenia

In females, sarcopenia was present in 9/31(33.3%) patients, while in males, sarcopenia was seen in 18/69(66.7%) patients, with no significant association between gender and sarcopenia with p= 0.759.

Etiology	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
Alcohol	16(59.3)	35(47.9)
Hepatitis B virus	2(7.4)	12(16.4)
Hepatitis C virus	3(11.1)	7(9.6)
Autoimmune hepatitis	0	3(4.1)
NASH	2(7.4)	8(11)
Unknown	4(14.8)	8(11)

Table 12 Association of etiology with sarcopenia

The percentage of sarcopenia in patients who consume alcohol is 16 (59.3%), 2 (7.4%) have HBV+, 3 (11.1%) have HCV+ and 2 (7.4%) have NASH, the cause is unknown. The number of patients was 4 (14.8%). None of the AIH patients developed sarcopenia.

Ascites	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
Present	21(77.8)	29(39.7)
Absent	6(22.2)	44(60.3)

Table 13 Association of ascites with sarcopenia

In patients with ascites, 21(77.8%) patients had sarcopenia. In patients without ascites, sarcopenia was seen in 6(22.2%) patients. Presence of ascites was significantly associated with sarcopenia with p=0.001.

CTP	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
A	4(14.8)	27(50.7)
B	23(85.2)	36(49.3)

Table 14 Association of Child-Turcotte-Pugh class with sarcopenia

In CTP class A, 4(14.8%) patients had sarcopenia. In CTP class B, sarcopenia was seen in 23(85.2%) patients. There was a significant association seen between Child- Turcotte-Pugh class and sarcopenia with p=0.001.

MELD Score	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
< 15	15(55.6)	57(78.1)
> 15	12(44.4)	16(21.9)

Table 15 Association of MELD Score with sarcopenia

In patients with a MELD score of <15, sarcopenia was seen in 15(55.6%) patients, and 12(44.4%) patients had sarcopenia with MELD >15. There was a significant association seen between MELD score and sarcopenia with p = 0.026.

HGS grading	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
Reduced	27(100)	4(5.5)
Normal	0	69(94.5)

Table 16 Association of Handgrip Strength grading with sarcopenia

The handgrip strength was reduced in 27(100%) patients with sarcopenia. Handgrip strength was significantly associated with sarcopenia p=0.001.

ROC of Handgrip Strength grading with sarcopenia

The ROC curve of handgrip strength for predicting sarcopenia had an area under the curve of 0.85 (excellent) with a cut-off of 27kg. It showed a sensitivity of 64% and a specificity of 100%.

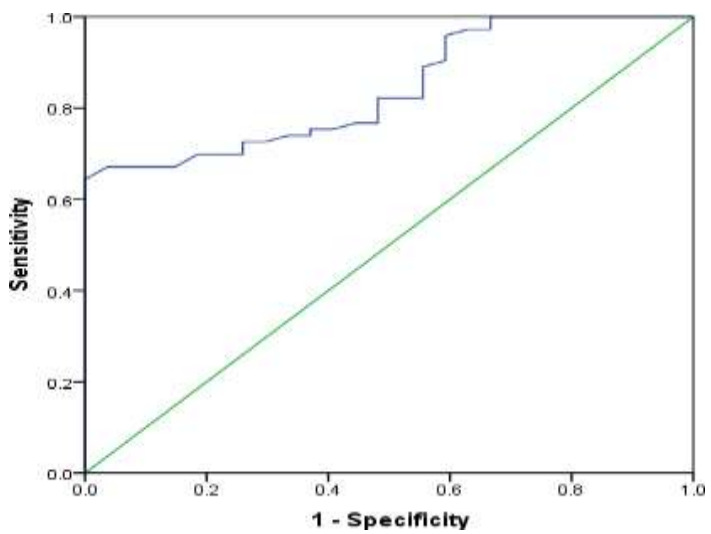

Fig 1 ROC curve of handgrip strength for predicting sarcopenia

CTP	HGS n (%) Reduced	HGS n (%) Normal
A	5(16.1)	36(52.2)
B	26(83.9)	33(47.8)

Table 17 Association of Child-Turcotte-Pugh class with Handgrip strength

The handgrip strength was reduced in 5(16.1%) patients of CTP class A and 26(83.9%) patients with CTP class B. There was a significant association between Child-Turcotte-Pugh class and handgrip strength in chronic liver disease patients with p=0.001.

		MELD	TSFT	MAMC	BMI	Gait speed	CTPMTH
HGS	R-value	-0.170	-0.188	0.260**	0.373	0.561	0.843
	P value	0.091	0.062	0.009	0.000	0.000	0.000

Table 18 Correlation of Hand Grip Strength with MELD score, triceps skinfold thickness, mid-arm muscle circumference, Body Mass Index, Gait Speed, and Psoas Muscle thickness per height Measured with Computed Tomography

A significant correlation was seen between Handgrip strength and MAMC, BMI, Gait Speed, and CT PMTH ($p<0.05$)

Gait Speed

Gait speed (m/sec)	Sarcopenia Present, n (%)	Sarcopenia Absent, n (%)
< 0.8	18(66.7)	8(11)
> 0.8	9(33.3)	65(89)

Table 19 Association of Gait speed with sarcopenia

Gait speed was reduced in 18(66.7%) patients with sarcopenia. Gait Speed was significantly associated with sarcopenia p=0.001.

ROC of GS grade with sarcopenia

The ROC curve of gait speed for predicting sarcopenia had an area under the curve of 0.75 (acceptable) with a cut-off of 0.75 m/sec and showed a sensitivity of 89% and specificity of 67%.

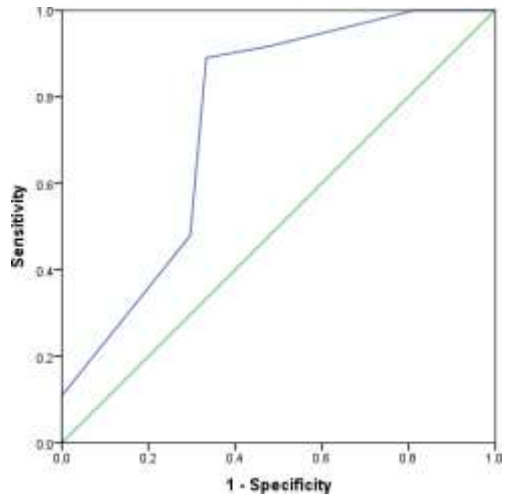

Fig 2 ROC curve of gait speed grade for predicting sarcopenia

CTP	Gait speed, n (%) Reduced	Gait speed, n (%) Normal
A	6(23.1)	35(47.3)
B	20(76.9)	39(52.7)

Table 20 Association of Child-Turcotte-Pugh class with Gait Speed

Gait speed was reduced in 6(23.1%) patients of CTP class A and 20(76.9%) patients with CTP class B. There was a significant association between Child-Turcotte-Pugh class and gait speed in chronic liver disease patients with p=0.031.

		MELD	TSFT	MAMC	BMI	HGS	CT PMTH
GAITSPEED	R- value	-0.222	-0.142	0.245	0.222	0.561	0.497
	P value	0.027	0.160	0.014	0.027	0.000	0.000

Table 21 Correlation of Gait Speed with MELD score, triceps skinfold thickness, mid-arm muscle circumference, Body Mass Index, handgrip strength, and Psoas Muscle thickness per height Measured with Computed Tomography

A significant correlation was seen between Gait speed and MELD score, MAMC, BMI, HGS, and CT PMTH ($p<0.05$).

CT PMTH

CT PMTH	**Sarcopenia Present, n (%)**	**Sarcopenia Absent, n (%)**
<16.8mm	27(100)	17(23.3)
>16.8mm	0	56(76.7)

Table 22 Association of CT psoas muscle thickness per height with sarcopenia

CT PMTH was reduced in 27(100%) patients with sarcopenia. There was a significant association between psoas muscle thickness per height and sarcopenia with p=0.001.

ROC of CT PMTH with Sarcopenia

The ROC curve of psoas muscle thickness per height measured with CT for predicting sarcopenia had an area under the curve of 0.89 (excellent) with a cut-off of 16.52mm. It showed a sensitivity of 75% and a specificity of 100%.

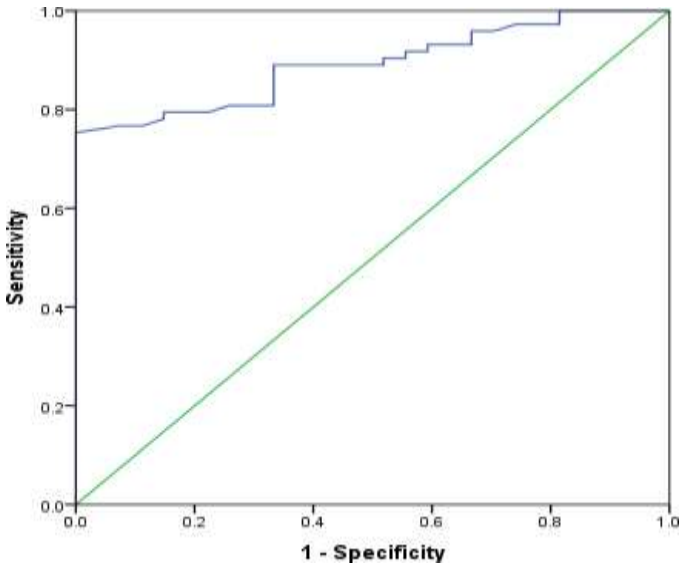

Fig 3 ROC curve of psoas muscle thickness per height measured with CT for predicting sarcopenia

CTP	PMTH n (%) Reduced	PMTH n (%) Normal
A	9(20.5)	32(57.1)
B	35(79.5)	24(42.9)

Table 23 Association of CTP class with CT psoas muscle thickness per height

PMTH was reduced in 9(20.5%) of CTP class A and 35(79.5%) with CTP class B. There was a significant association seen between Child-Turcotte-Pugh class and CT psoas muscle thickness per height in chronic liver disease patients with p=0.001.

		MELD	TSFT	MAMC	BMI	HGS	Gait speed
CTPMTH	R-value	-0.191	-0.222*	0.238*	0.412**	0.843**	0.497**
	P value	0.056	0.026	0.017	0.000	0.000	0.000

Table 24 Correlation of Psoas Muscle thickness per height Measured with Computed Tomography with MELD score, triceps skinfold thickness, mid-arm muscle circumference, Body Mass Index, handgrip strength, and Gait Speed

There was a significant correlation of CT PMTH with TSFT, MAMC, BMI, HGS, and Gait Speed ($p<0.05$).

Discussion

Sarcopenia is defined as a decrease in skeletal muscle strength, function and efficiency and is common in patients with cirrhosis [6]. It is associated with increased mortality, more complications, and poor prognosis in patients with hepatocellular carcinoma. We also investigated the prevalence of sarcopenia in patients with Child-Pugh type A and B cirrhosis and the association of sarcopenia with severe cirrhosis.

General characteristics of patients

The results were examined. The average age of the patients participating in the study was 47.9 ± 11.5 years and ranged from 18-65 years. Most of the 34 patients (34%) were between the ages of 41 and 50. This means that the groups most affected are the groups that are best off. The majority of the study participants were male, with 69 (69%) patients being male and the male/female ratio being 2.2:1. The mean ± SD of BMI was 21.4 ± 3.1 kg/m2. The results are almost identical to those seen worldwide.

Study	Mean age (years)	Males
Dae Hoe Gu et al., 2018 [41]	53.6	76.4%
Tae Yeob Kim et al., 2014 [70]	55	63.1%
Hari et al, 2019 [71]	63	52%
Durand et al, 2014 [65]	53	80.9%
Hou et al., 2020 [72]	62.6	51.4%
Present study	47.9	69%

Table 25 Demographic characteristics of different studies

Distribution of patients concerning etiology of cirrhosis

Behavior-related cirrhosis is the cause of cirrhosis in 51% of patients with NASH. Cirrhosis due to Hepatitis B occurs in 14% of patients. Hepatitis C virus cirrhosis occurs in 10%. Autoimmune sexual hepatitis accounts for 3%. By comparison, approximately 12% of patients remain unknown. No significant relationship was found between chronic liver disease and various causes of sarcopenia (p = 0.655).

Study	Patient Population	Etiology
Dae Hoe Gu et al., 2018 [41]	Cirrhotic	49.9% Alcoholic liver disease 41% Chronic viral hepatitis
Tae Yeob Kim et al., 2014 [70]	Cirrhotic	Cirrhosis 56.9% alcohol 26.1% viral 9.3% mixed 7.7% other
Hari et al., 2019 [71]	Cirrhotic	67% alcohol 15% NAFLD 18% other
Durand et al., 2014 [65]	End-stage liver disease	42% alcohol 15% HBV, 30% HCV 5% biliary disease 8% others
Hou et al., 2020 [72]	Cirrhotic	38.3% viral 15.9% alcohol 8.4% autoimmune 37.5% other
Present study	Cirrhotic	51% Alcohol 24% Viral 10% NASH 3% Autoimmune 12% Unknown

Table 26 Etiology of patient population across different studies

Severity grading of cirrhosis

CTP and MELD scores are widely used as indicators of liver disease in all studies. Child-Turcotte-Pugh (CTP) score was Child A in 41% of patients and Child B in 59%. 72% of the patients had a MELD score <15. The majority of men (23 (82%)) had a MELD score >15.

Study	CTP	MELD (Mean)
Dae Hoe Gu et al., 2018 [41]	-	11.4
Tae Yeob Kim et al., 2014 [70]	CP A 4.6 CP B 56.9 CP C 38.5	12
Hari et al., 2019 [71]	Mean 8±2	15 (Meld Na)
Durand et al., 2014 [65]	-	20 (Meld Na)
Hou et al., 2020 [72]	CP A 41.4 CP B 44.2 CP C 14.3	11.1
Kang SH et al., 2018 [55]	CP A 47.6 CP B 44.2 CP C 8.2	9
Present study	CP A 41 CP B 59	13.03

Table 27 Severity grading of cirrhosis (CTP and MELD) across different studies

Anthropometry parameters

For nutritional assessment, we used anthropometric measurements, namely triceps skinfold thickness, mid-arm muscle circumference, and body weight. The TSFT range was 10-22 mm and the mean ± SD was 14.1 ± 2.4. The MAMC range was 11.1–27.3 mm and the mean ± SD was 19.9 ± 3. BMI range was 15.4–31.3 kg/m2, mean ± SD 21.4 ± 3.1. In a total of 46 patients, TSFT was below normal (TSFT <12.5 mm in men and <18 mm in women was considered abnormal). Forty-five patients had MAMC below the normal limit [MAMC values <21.1cm in men and <19.2cm in women were considered abnormal and patients were diagnosed with no food to eat]. 33% of patients had low BMI [BMI values <18.5 kg/m2 were considered abnormal]. On the

other hand, the correlation of TSFT with ascites and CTP score was not significant. MAMC was only associated with acid (P<0.05), but not with gender, alcohol consumption, CTP, and MELD scores. In contrast, the correlation between BMI and any of the above indicators is not significant. 4]. In a recent 2018 study in northern India, the authors examined malnutrition in patients with liver disease. Patients with cirrhosis (n=352), patients with chronic liver disease (n=189) and healthy controls (n=159) were included in this study. Eating disorders were diagnosed according to global scale (SGA) scores. According to SGA, 24% of patients with chronic liver disease and 56% of patients with cirrhosis were malnourished (P = 0.001). The prevalence of malnutrition in patients with chronic liver disease was 12% by MAMC and 31% by TST [73]. In 2017, [74] used anthropometry to examine nutritional assessment in patients with lung disease. There were 130 chronic lung disease patients (80 men) ranging in age from 22 to 89 years (mean, 60 years). Alcohol is the most common cause of cirrhosis (45%). Hospitalized patients were more severely ill (P<0.001) and had poorer nutritional status as measured by BMI (P=0.002), mean upper arm circumference (P<0.001), mid-arm muscle circumference (P<0.001), and triceps. skinfold (P) definition. The third represented inadequate/weak comprehension. Alcohol consumption (P = 0.03) and diet, BMI (P = 0.03), mid-arm circumference (P = 0.001), triceps skinfold (P = 0.06), and mid-arm muscle circumference (P = 0, 02) was found. severe lung disease. The authors concluded that triceps skinfold was the most useful anthropometric parameter and was associated with mortality. In 2012, [75] investigated the nutritional status of patients with cirrhosis. In a series of 176 patients treated for cirrhosis in hospital, 114 (65%) of the men were diagnosed with alcohol, the most common cause of liver disease in 98 (56%) patients with a mean age of 52 years. Malnutrition is associated with serious liver disease. 88% of patients with mild to moderate pain have child B, and more than 58% have a bacterial cause. 22% of these patients were using alcohol and 11% had a Child score of C (p < 0.01). In the severely malnourished group, 43% had alcoholism and 31% were in the Children C category (p<0.01). According to the Child Score, triceps skinfold thickness (mm) and mid-arm circumference (cm) were significantly reduced.

Sarcopenia parameters

Sarcopenia occurs in approximately 50% of patients with cirrhosis and is also present in alcohol-related liver disease, ascites, and brain disease. This study tries to measure this fact. Patients with cirrhosis underwent abdominal computed tomography (CT) scans, which measured psoas transversus muscle thickness per unit height and included L3 and umbilical levels.

Study	No of patients	Mean age	Body Composition Methods	Outcomes
Tae Yeob Kim et al., 2014 [70]	562	55	CT, L4, TPMT/height	Mortality with TPMT/height ≥14 mm/m was higher than TPMT/height <14 mm/m (HR = 5.4, p < 0.001)
Durand et al., 2014 [65]	65	53	CT at the level of umbilicus, TPMT/height	TPMT/height was an independent predictive factor of waiting list mortality (HR = 0.87, p = 0.001)

Table 28 Body Composition methods and outcomes of cirrhosis across different studies

In this study, 27/100 (27%) patients developed sarcopenia. The mean age of sarcopenia patients was 52.7 ± 9.8 years. In a study conducted in South Korea, Bae EJ et al. In 2017, the incidence of sarcopenia increased with age (19.2%, 29.1% and 42.3% in the 20-39, 40-64 and 65+ age groups, respectively). The incidence of sarcopenia is higher in men in the 20-39 age group. The incidence of sarcopenia is higher in women in the 40-64 age group. The overall estimate of the prevalence of sarcopenia in the general population is 10% (95% CI: 8-12%) for men and 10% (95% CI: 8-13%) for women. In previous studies, the prevalence of sarcopenia in cirrhosis varies between 30% and 70% depending on the diagnostic tool used and the liver disease, with the prevalence being higher in men (61.6%) than in women (36%).

Sarcopenia and etiology

The severity and cause of liver disease, age, chronic disease, and comorbidities influence the severity of sarcopenia [7]. Sarcopenia is a well-known complication of cirrhosis and can increase liver function, from liver fibrosis to NASH and NAFLD cirrhosis [8]. In this study, the rate of sarcopenia in alcoholic patients was 16 (59.3%), 2 (7.4%) in HBV+ patients, 3 (11.1%) in HCV+ patients, and 2 (7.4%) in NASH patients. The etiology of 4 patients (14.8%) is unknown. None of the AIH patients developed sarcopenia.

Study	No of patients	Males	Prevalence	Predictors
Cruz et al [78]	234	157 (67)	70% (men 76%)	-
DiMartini et al [79]	338	223 (66)	68% (men 76%, women 51%)	80% prevalence in alcoholic liver disease vs 31%-71% in other diseases 80% prevalence in normal-weight vs 62% in obese
Hanai et al [80]	130	76 (58)	68% (men 82%, women 50%)	Male gender and BMI were independent predictors of sarcopenia
Montano- Loza et al [81]	112	78 (70)	40% (men 50%, women 18%)	Sarcopenia was more frequent in men and patients with a low BMI
Montano- Loza et al [82]	248	169 (68)	5% (men 52%, women 30%)	Sarcopenia was more common in men, patients with ascites, patients with low BMI, and patients with higher CTP scores and MELD scores
Tandon et al [83]	142	85 (60)	41% (men 54%, women 21%)	Male sex, CTP class C, and BMI were independent predictors of sarcopenia.

Table 29 Prevalence of sarcopenia in cirrhosis across different studies

In our study, among patients with ascites, 21(77.8%) patients had sarcopenia. In patients without ascites, sarcopenia was seen in 6 (22.2%) patients. There was a significant association between the presence of ascites and sarcopenia with p=0.001.

Association of Child-Turcotte-Pugh and MELD with sarcopenia

In CTP A stage, 4 (14.8%) patients had sarcopenia. In CTP stage B, sarcopenia developed in 23 (85.2%) patients. There is a significant relationship between Child-Turcotte-Pugh level and sarcopenia, p=0.001. Sarcopenia developed in 15 (55.6%) of the patients with MELD score <15, and sarcopenia developed in 12 (44.4%) of the patients with MELD>15. There was a positive relationship between MELD score and sarcopenia, p = 0.026. Review. However, assessing the nutritional status of patients with cirrhosis is difficult due to fluid retention due to insufficient protein synthesis (84). Therefore, an objective evaluation of the nutritional status of patients with cirrhosis is required.These findings suggest that sarcopenia is the best prognostic factor for physical development in patients with cirrhosis. However, Tandon et al stated that the effect of sarcopenia was significant in patients with low MELD scores (<15; P = 0.02) but not in patients with high MELD scores (<15; P = 0.59). . These results are consistent with data from Merli et al., who showed that muscle wasting predicted mortality in patients with CTP class A and CTP B, but not in patients with CTP class C cirrhosis [85]. Overall, these results suggest that further validation is required. If possible, a clinical trial is warranted to investigate whether transplantation would be more effective in sarcopenic patients with low MELD scores. There is no correlation between the presence or absence of sarcopenia. Montano-Loza AJ et al [81] examined 112 consecutive patients with cirrhosis for liver transplantation and selected patients with CT scans of the third lumbar vertebra (L3). The relationship between sarcopenia and MELD and CTP and between sarcopenia was investigated. A negative correlation was found between sarcopenia and MELD score (r = 0.04, P < 0.7) and Child-Pugh score (r = 0.01, P < 0.9). Additionally, sarcopenia was negatively correlated with serum albumin (r = -0.02, P < 0.9) and serum sodium (r = -0.11, P < 0.2).

Association of Handgrip Strength with sarcopenia and its correlation with other parameters

Twenty-seven (100%) patients with sarcopenia had decreased grip strength (<27 kg in men, <16 kg in women). Grip strength was associated with sarcopenia, p = 0.001. The area under the holding power ROC curve for predicting sarcopenia was 0.85 (very good) with a cutoff of 27 kg. It has 64% sensitivity and 100% accuracy. -Correlation between Turcotte-Pugh level and grip strength, p = 0.001. There was a positive correlation between grip strength and MAMC, BMI, walking speed, and CT PMTH (p < 0.05). The peak on the curve is 0.82 (95% confidence interval (CI) 0.78–0.86, P = 0.001). The authors concluded that hand pressure is the best tool for bedside assessment of nutritional status in hypertensive patients and, like other anthropometric measurements such as MAMC and TST, has the highest diagnostic accuracy [9].

Association of gait speed with sarcopenia and its correlation with other parameters

We quickly examined muscle tone and found that velocity was reduced in 18 (66.7%) patients with sarcopenia. Fasting was associated with sarcopenia, p = 0.001. The area under the curve of the walking speed ROC curve for predicting sarcopenia is 0.75 (accepted), the cut-off point is 0.75 m/s, the sensitivity is 89%, and the specificity is 67%. There were 20 (23.1%) patients with CTP grade A and 20 (76.9%) patients with CTP grade B. There was a positive relationship between increasing speed and MELD score, MAMC, BMI, HGS and CT PMTH ($p < 0.05$). It is a harbinger of disability, morbidity, mortality and loss in various diseases and in the elderly [10, 11]. ACSM guidelines recommend this as a simple test run before starting work. The average walking speed is 0.95 m/s, and every 0.1 m/s decrease in walking speed is associated with a 22% increase in hospital days and significant costs. Gait speeds less than 0.6 m/s to less than 0.8 m/s are associated with poor prognosis in adults [12].

Association of CT PMTH with sarcopenia and its correlation with other parameters

CT PMTH decreased in 27 (100%) patients with sarcopenia [PMTH cut-off for sarcopenia <16.8 mm/m2]. There was a positive association between psoas muscle thickness per unit height and sarcopenia, p = 0.001. The area under the curve of the ROC curve for psoas muscle thickness per unit height measured by CT for predicting sarcopenia was 0.89 (very good) and the cut-off value was 16.52 mm. It showed 75% sensitivity and 100% specificity. Pugh level and CT psoas unit height thickness, p = 0.001. CT was correlated with PMTH, TSFT, BMI, HGS, and rapid movement ($p < 0.05$). We also found that muscle area measured by CT analysis correlated with anthropometric MAMC. It has the advantage of being easy to use as it does not require special software. Durand et al. [13] also found a significant association between height-normalized transversus lumborum thickness and mortality on the liver transplant waiting list, regardless of MELD. CT scan identifies sarcopenia, which is most common in cirrhosis. CT scanning is the first technique that can measure the central nervous system, which may be less affected by gender, physical activity and water retention. It is important to note that high cost, potential equipment limitations, and concerns about radiation exposure may limit the use of this technology in practice unless patients require a CT scan for other purposes. A prospective study including 653 patients with cirrhosis investigated the clinical significance of psoas muscle thickness for the diagnosis of sarcopenia [14]. The mean age was 53.6 ± 10.2 years and 499 patients (76.4%) were male. PMTH was correlated with SMI in both men and women ($P<0.001$). 241 (36.9%) patients met SMI-sarcopenia criteria. The best PMTH cutoff values for predicting sarcopenia in SMI are 17.3 mm/m in men and 10.4 mm/m in women, and these values are interpreted as sex-specific for PMTH (SsPMTH). 230 (35.2%) patients were

diagnosed with SsPMTH-sarcopenia and 280 (44.4%) patients were diagnosed with SnPMTH-sarcopenia [15]. Sarcopenia is frequently observed in patients. There was a significant relationship between sarcopenia and grip strength, speed, and psoas muscle thickness per unit height measured by computed tomography. Sarcopenia is an important prognostic factor in patients with cirrhosis and may predict advanced disease. Therefore, it is important to investigate interventions to improve sarcopenia in patients with cirrhosis in well-controlled studies.

Strengths and Limitations

Strengths

1. This is a prospective observational study with a large number of cases.

2. We assessed all possible parameters of anthropometry, including BMI, triceps skinfold thickness, mid-arm circumference, and mid-arm muscle circumference, to look for nutritional assessment.

3. Muscle strength is the measure of age-related muscle change. To assess this, we did a CT scan on all patients. In addition to this, we studied Handgrip Strength, Gait Speed, and Psoas Muscle thickness height measured with Computed Tomography.

Limitations

1. The study results are from a single-center, with a noncomparative study design; hence, the findings cannot be generalized.

2. Being a tertiary referral center, the study includes a selected subset of referred patients; thereby, an element of referral bias might exist, the results of which may not be generalizable outside of this environment.

3. There were no interventions and follow-ups due to the limited time frame available during the study tenure. Treatment was not part of the study, so further improvement could not be assessed.

4. Quality of Life was not assessed.

5. The results perhaps would have improved if we could identify the dietary habits of these patients.

6. Nevertheless, we believe that the decent results obtained from this study add to the current pool of existing knowledge for future studies in India and across the world.

Conclusion

It has been researched that sarcopenia occurs in patients with cirrhosis, which causes less activity and an increased risk of falling. It is most commonly seen in middle-aged men. The most common cause of sarcopenic cirrhosis is alcohol. There was a significant relationship between sarcopenia and grip strength, speed, and psoas muscle thickness measured by computed tomography. The finding of a significant relationship between Child-Turcotte-Pugh class (Grade A and B) and sarcopenia in our study shows that these patients may need early routine care and treatment to prevent future risks.

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