Assessment of Sarcopenia as an Indicator of Malnutrition in Patients with Liver Cirrhosis

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ABSTRACT
Background: The precise characterization of sarcopenia in cirrhosis is a subject of ongoing debate. It encompasses a decline in both muscular strength and/or function. Cirrhosis is a condition characterized by a state of catabolism, when the breakdown of muscle protein surpasses its synthesis, leading to sarcopenia.
Objective: This work aimed to assess sarcopenia as an indicator of malnutrition in individuals with cirrhotic liver.
Patients and methods: This case-control work was performed on 75 participants, both sexes, diagnosed with liver cirrhosis. All cirrhotic subjects with Child-Pugh score either A, B, or C and hepatocellular carcinoma (HCC). Participants had been split into two groups: Control group (n=15) healthy individuals and group II (cirrhotic group) that was further subdivided into four subgroups: 15 participants Child A, 15 participants Child B, 15 participants Child C, and 15 HCC participants.
Results: a positive correlation was existed among the degree of liver cirrhosis detected by shear wave elastography (SWE) and the degree of sarcopenia (PMTH by CT) (P <0.001). Psoas muscle thickness/height (PMTH) had been substantially elevated in the male group in contrast to the female group (P =0.046). SWE of the liver was substantially various among the five groups (P <0.001). The existence of sarcopenia was significantly various between 4 groups as higher in the HCC group contrasted to Child A, Child B, and Child C (P =0.023). Mid-arm circumference and mid-arm muscle circumference (MAMC) were significantly lower in Child A, Child B, Child C, and HCC group compared to the control group.
Conclusions: Malnutrition frequently coexists with cirrhosis, and sarcopenia can serve as a predictive factor for malnutrition associated with cirrhosis and its consequences. A positive correlation was existed among SWE and the degree of sarcopenia.
Keywords: Sarcopenia, Malnutrition, Liver cirrhosis, PMT , PMTH, MAMC , SWE.

INTRODUCTION

Sarcopenia is a medical disorder that is defined by the reduction of the mass of the muscle as observed using cross-sectional imaging (CT). The precise characterization of sarcopenia in cirrhosis remains a subject of ongoing debate. It encompasses a decline in both muscular strength and/or function [1]. Cirrhosis is a condition characterized by a state of catabolism, when the breakdown of muscle protein exceeds its synthesis, leading to sarcopenia [2].

Shear wave elastography (SWE) is a recently developed technology that utilizes shear waves in diagnostic ultrasonography (US) systems. SWE, similar to transient elastography, utilizes the measurement of the velocity of shear waves to get a quantitative assessment of the stiffness of the tissues[3].

Chronic liver disease patients commonly experience malnutrition and becomes more pronounced as the severity of the liver illness advances. It impacts a maximum of 80% of individuals with decompensated cirrhosis [4].

The recognition of the influence of malnutrition on people's health is growing. Malnutrition amplifies the occurrence and intensity of decompensation manifestations, undermines immunological function, diminishes the mass of muscles, decreases functional status and quality of life, hinders wound healing, and is linked to higher mortality rates [5, 6]. Malnutrition is specifically linked to the occurrence and intensity of hepatic encephalopathy [7].

The majority of papers on malnutrition in cirrhosis utilize varied and diverse classifications. Conventional methods for evaluating nutrition rely on laboratory tests, including prothrombin time, transferrin, albumin, pre-albumin, and creatinine height index [8].

Individuals suffering from cirrhosis experience notable deterioration in their hepatic synthesizing functions, leading to reduced levels of serum albumin, prealbumin, transferrin, and an extended prothrombin time. These values resulted in an overestimation of the overall incidence of malnutrition in those individuals. Anthropometric measurements in individuals with cirrhosis are influenced by changes in fluid levels due to the presence of peripheral edema, ascites, diuretic usage, and salt consumption [9].

The thickness of the skinfold is a measurement of the amount of fat located just beneath the skin. It also includes the measurement of muscle area in the upper arm, known as mid-arm muscle area. Additionally, subjective global assessment (SGA) is a widely recognized tool for evaluating a patient's nutritional status. SGA involves a comprehensive assessment of the participant's medical history and physical examination, using specific clinical criteria for diagnosing malnutrition [10]. The SGA is

recognized as a dependable and accurate technique that forecasts the occurrence of mortality and morbidity linked to malnutrition. This work aimed to assess sarcopenia as an indicator of malnutrition in individuals with cirrhotic liver.

PATIENTS AND METHODS

This case-control work had been performed on 75 subjects (60 participants diagnosed with cirrhotic liver and 15 healthy participants as a control group). Our study included 35 males and 40 females. All cirrhotic participants had Child-Pugh scores of either A and B, or C and hepatocellular carcinoma (HCC).

Our study was done from October 2022 to September 2023 and the patients were referred to the Internal Medicine Department at the Faculty of Medicine, Tanta University, and the Diagnostic Medical Imaging and Intervention Radiology Department at the National Liver Institute, Menoufia University.

Exclusion criteria: Uncontrolled DM, tense ascites, hepatic encephalopathy, hepatorenal, cardiac, chest, and renal patients, and uncontrolled thyroid dysfunction.

Participants had been split into two groups: Group I (control group): (n=15) who do not have any chronic illness and group II (cirrhotic group): (n=60) which furthermore separated into four subgroups: 15 participants with Child-Pugh class A, 15 participants Child B, 15 participants Child C and 15 HCC participants.

Each participant had been exposed to comprehensive taking of history, physical examination that included [Waist circumference (WC), hip circumference (HC), mid-arm muscle circumference (MAMC), mid-arm circumference (MAC), triceps skinfold (TSF)], laboratory investigations [full blood picture (CBC), random blood sugar (RBS), liver function tests include (albumin, total bilirubin), coagulation profile test that included (international normalized ratio (INR) and Prothrombin time (PT)), renal function tests, electrolytes included (Serum Ca^{++}, Na^{+}, and K^{+}), thyroid hormones (T3, T4 and TSH) and radiological investigations [Routine Ultrasonography (US) for all patients, Liver shear wave elastography (SWE) for all patients, Computed Tomography (CT) to measure Psoas muscle thickness and Psoas muscle density].

Subjective Global Assessment (SGA):

The gold-standard technique to evalute nutrition is a comprehensive evaluation of the history of the patient and physical examination. It utilizes predefined clinical indicators to detect malnutrition. The modified SGA consists of seven elements and is evaluated using a 5-point Likert-type scale. Elevated scores are indicative of a poorer nutritional status, ranging from A (well-nourished) to C (severely malnourished), with B representing moderate malnourishment. The overall score is divided into three categories: WN (7 - 14), MM (15 - 28), and SM (29 - 35) [11].

All patients were evaluated by the Child-Pugh score:

The Child-Pugh score is a grading system designed to assess the extent of chronic liver illness, including cirrhosis. The purpose was to establish a system that enables practitioners to communicate about the function of the liver in an objective way.

Each patient's liver disease severity was evaluated utilizing 5 clinical characteristics: (1) the level of total bilirubin, (2) serum albumin, (3) prothrombin time (which is currently quantified as the INR), (4) the extent of ascites, and (5) the level of hepatic encephalopathy. The participant's Child-Pugh class was determined based on the total point score [12].

Shear Wave Elastography (SWE):

The patients in the current research had B-mode liver US scanning utilizing ultrasonography equipment (iU22, Philips Medical Systems, Bothell, WA, USA), that was modified to produce shear waves with its ElastPQ features.

The LS was quantitatively assessed utilizing the ElastPQ technique, which utilized a convex transducer C5-1 with a frequency range of (1-5 MHz, C5-1, Philips Healthcare). The 8 liver segments (I-VIII) have been visualized utilizing sub-costal and intercostal scans. A fixed sample box has been employed for simulating each region of interest (ROI). The sample box was placed in a specific area of the liver tissue, avoiding large blood vessels, bile ducts, the heart, diaphragm, liver/kidney interface, and the capsule of the liver. The sample box was positioned at least 1.5-3 cm beneath the Glisson's capsule. We deemed the median values of LS measures, that had been automatically computed, to be dependable if we acquired 10 valid and successful measures of the two hepatic lobes in all participants in the study. The measured values were denoted in meters per second (m/s) or kilopascals (kPa). The mean of these data was subsequently utilized to assess the level of the stiffness of the liver, that was subsequently correlated with an anticipated biopsy METAVIR score for staging of liver fibrosis.

The assessment of fibrosis of the liver utilizing SWE in kPa categorizes the condition into five stages: absence of fibrosis (F0), mild fibrosis (F1), severe fibrosis (F2), substantial fibrosis (F3), and cirrhosis (F4). The US software's automated median value was utilized to determine the elastography grade. Specifically, a value less than 4.6 was classified as F0, a value between 4.6 and 5.6 was classified as F1, a value between 5.7 and 7.0 was classified as F2, a value between 7.1 and 12.0 was classified as F3, and a value greater than 12 was classified as F4 [13].

Computed Tomography (CT):

In our study, a multidetector CT scan on the abdomen and pelvis at the level of the umbilicus (L4) was done to assess iliopsoas muscle thickness and bilateral iliopsoas muscle density. CT images were obtained by using 128-row multidetector CT (Somatom biograph 128, Siemens, Healthineers, Erlangen, Germany). The images have been analysed utilizing a picture archiving and communication system (PACS).

The axial CT scan has been employed to quantify the thickness of the right psoas muscle (PM) at the umbilicus level in both axial and transverse directions. The thickness of axial PM refers to the greatest diameter of the PM when viewed from an axial perspective. The thickness of transversal PM refers to the measurement of the diameter of the PM that is perpendicular to its axial diameter. The measurement of transverse psoas muscle thickness (PMT) was taken and then standardized to the height of the patient by dividing the PMT in millimeters by the height (H) in meters.

The PM thickness/height (PMTH) was readily determined as muscle mass. Accurate height adjustment is essential for evaluating the proportional muscle mass, as there is a direct correlation between skeletal muscle and height. Psoas muscle density (PMD) is quantified using CT by calculating the mean Hounsfield Unit (HU) attenuation of both psoas muscles, then the mean PMD is measured. Lower density reflects higher fat infiltration of muscles.

Ethical approval: After receiving permission from The Ethics Committee of Tanta University Hospitals, Tanta, Egypt. The participants provided a well-informed written consents. Every phase of the study was conducted in accordance with the Helsinki Declaration.

Statistical analysis

The statistical analyses had been performed utilizing SPSS version 27 (IBM©, Chicago, IL, USA). The normality of the data distribution had been analysed utilising the Shapiro-Wilks test and histograms. The quantitative parameters were reported as mean and standard deviation (SD) and had been assessed utilizing an ANOVA (F) test with a post hoc test (Tukey). The quantitative non-parametric data had been reported using the median and interquartile range (IQR). For comparing the various groups, the data had been analysed utilizing Kruskall-Wallis's test with the Mann Whitney-test. The qualitative variables had been presented as frequencies and percentages (%) and had been analysed employing the Chi-square test. A two-tailed P value $\leq$ 0.05 was considered statistically significant.

RESULTS

Age, sex, and height were insignificantly distinct among the five groups. Weight was significantly lower in Child A, Child B, Child C, and HCC groups contrasted to the control group (P <0.005), and in Child B, Child C, and HCC groups contrasted to Child A group (P <0.005).

BMI and WC were significantly lower in Child A, Child B, Child C, and HCC groups contrasted to the control group (P <0.005), in Child C and HCC groups contrasted to Child A group. HC had been substantially higher in Child A, Child B, Child C, and HCC groups in contrast to the control group (P <0.005), in Child C and HCC groups contrasted to Child A group.

MAC had been substantially lower in Child A, Child B, Child C, and HCC groups contrasted to the control group (P<0.001). TSF had been significantly higher in Child A, Child B, Child C, and HCC groups contrasted to control group (P <0.05), in Child B, Child C and HCC groups than in Child A group (P <0.05), in Child C and HCC groups contrasted to Child B group (P=0.034 and <0.001 correspondingly) and in HCC group contrasted to Child C group (P =0.021).

MAMC had been substantially reduced in Child A, Child B, Child C and HCC groups than in control group (P <0.05), in Child B, Child C and HCC group) contrasted to Child A group (P <0.05), in (Child C and HCC group) contrasted to Child B groups (P =0.024 and <0.001 respectively) and in HCC group than in Child C group (P <0.001). SGA and Child-Pugh score had been substantially distinct among the five groups (P <0.001) (Table 1).

Table (1): Patients' characteristics and SGA of the studied groups

		Control group (n=15)	Child A group (n=15)	Child B group (n=15)	Child C group (n=15)	Child HCC group (n=15)	P
Age (years)		50.1±6.54	56 ±7.53	53.3±6.84	57.6±8.12	53.7±7.15	0.063
Sex	**Male**	6(40%)	5(33.33%)	8(53.33%)	10(66.67%)	6(40%)	0.368
	Female	9(60%)	10(66.67%)	7(46.67%)	5(33.33%)	9(60%)	
Weight (kg)		81.2±10.6	70.5±9.23	60.7±10.6	58.7±9.43	52.1±6.43	**<0.001***
	P1		**0.022***	**<0.001***	**<0.001***	**<0.001***	
	P2			**0.043***	**0.008***	**<0.001***	
	P3				0.977	0.096	
	P4					0.304	
Height (m)		1.7±0.06	1.7±0.04	1.7±0.08	1.7±0.08	1.7±0.07	0.183
BMI (kg/m^2)		28.6±4.26	24.6±3.08	21.3±4.28	19.9±3.5	18.9±2.43	**<0.001***
	P1		**0.022***	**<0.001***	**<0.001***	**<0.001***	
	P2			0.105	**0.005***	**<0.001***	
	P3				0.808	0.362	
	P4					0.947	
WC (cm)		95.3±9.25	85.1±8.31	77.1±9.11	67.3±10.07	74.6±11.31	**<0.001***
	P1		**0.04***	**<0.001***	**<0.001***	**<0.001***	
	P2			0.168	**<0.001***	**0.032***	
	P3				0.055	0.956	
	P4					0.249	
HC (cm)		91.6±5.74	100.9±3.92	104.7±4.62	108±4.17	108.4±1.59	**<0.001***
	P1		**<0.001***	**<0.001***	**<0.001***	**<0.001***	
	P2			0.112	**<0.001***	**<0.001***	
	P3				0.226	0.135	
	P4					0.999	
MAC (cm)		35.1±2.7	28.7±3.99	27.2±5.07	26.3±3.37	25.7±3.31	**<0.001***
	P1		**<0.001***	**<0.001***	**<0.001***	**<0.001***	
	P2			0.824	0.445	0.201	
	P3				0.97	0.8	
	P4					0.989	
TSF (mm)		14.1±6.97	19.3±5.39	24.9±4.6	30.2±3.86	35.9±3	**<0.001***
	P1		**0.041***	**<0.001***	**<0.001***	**<0.001***	
	P2			**0.023***	**<0.001***	**<0.001***	
	P3				**0.034***	**<0.001***	
	P4					**0.021***	
MAMC (mm)		29.7±3.41	25.7±3.35	21.7±3.58	18.3±2.32	13.5±2.2	**<0.001***
	P1		**0.004***	**<0.001***	**<0.001***	**<0.001***	
	P2			**0.006***	**<0.001***	**<0.001***	
	P3				**0.024***	**<0.001***	
	P4					**<0.001***	
SGA	**A**	12(80%)	2(13.33%)	0(0%)	0(0%)	0(0%)	**<0.001***
	B	3(20%)	12(80%)	8(53.33%)	5(33.33%)	1(6.67%)	
	C	0(0%)	1(6.67%)	7(46.67%)	10(66.67%)	14(93.33%)	
Child score		5(5-5)	5 (5-6)	5 (5-6)	6 (5-6)	6(6-6)	<0.001*

Data are expressed as mean ± SD or frequency (%). *: Significantly P value ≤ 0.05.BMI: Body mass index. WC: Waist circumference, HC: Hip circumference. TSF: Triceps skinfold, MAC: Mid-arm circumference, MAMC: Mid-arm muscle circumference. P1: P value contrasted to control group, P2: P value contrasted to child A group, P3: P value contrasted to child B group, P4: P value contrasted to HCC group, SGA: Subjective global nutritional assessment.

Right and left PD, mean PD, and PMT had been substantially distinct amongst the five groups (P <0.001). Right, left PD and mean PD were significantly lower in Child A group, Child B group, Child C group, and HCC group than in the control group and in Child B group, Child C group, and HCC group than in Child A group. Right PD was substantially reduced in the HCC group in contrast to Child B group (P =0.005) and was insignificantly distinct among the Child B group, child C group, and HCC group. Left PD and Mean PD were substantially reduced in the HCC group in contrast to Child B group and Child C group (P < 0.005) and were insignificantly different among Child B group and Child C group. PMT and PMTH had been substantially lower in Child A group, Child B group, Child C group and HCC group than in control group and were substantially decreased in Child C group and HCC group contrasted to Child A group and in HCC group than in Child B group and Child C group (P <0.005) and was insignificantly different among Child A group and Child B group and Child B group and child C group (Table 2).

Table (2): CT findings of the groups under the study

	Control group (n=15)	Child A group (n=15)	Child B group (n=15)	Child C group (n=15)	HCC group (n=15)	P
Right PD (HFU)	64.1±9.05	55.9±8.83	47.9±7.81	42.9±6.55	37.9±5.32	**<0.001***
	P1	**0.033***	**<0.001***	**<0.001***	**<0.001***	
		P2	**0.045***	**<0.001***	**<0.001***	
			P3	0.373	**0.005***	
			P4		0.4	
Left PD (HFU)	58.7±5.71	51.6±5.26	44.7±5.16	40.3±9.15	33.3±7.38	**<0.001***
	P1	**0.038***	**<0.001***	**<0.001***	**<0.001***	
		P2	**0.047***	**<0.001***	**<0.001***	
			P3	0.385	**<0.001***	
			P4		**0.047***	
Mean PD (HFU)	59.5±7.48	52.2±7.36	44.9±5.45	41.2±6.13	34.5±4.15	**<0.001***
	P1	**0.017***	**<0.001***	**<0.001***	**<0.001***	
		P2	**0.017***	**<0.001***	**<0.001***	
			P3	0.471	**<0.001***	
			P4		**0.038***	
PMT (Mm)	34.1±7.1	26.7±8.41	23.5±8.28	19.7±5.18	12.5±3.57	**<0.001***
	P1	**0.031***	**<0.001***	**<0.001***	**<0.001***	
		P2	0.71	**0.048***	**<0.001***	
			P3	0.563	**<0.001***	
			P4		**0.038***	
PMTH	20.2 ± 4.33	15.7 ± 4.88	13.9 ± 4.76	11.5 ± 3.11	7.5 ± 2.07	**<0.001***
	P1	**0.023***	**<0.001***	**<0.001***	**<0.001***	
		P2	0.7	**0.036***	**<0.001***	
			P3	0.48	**<0.001***	
			P4		**0.05***	

Data are expressed as mean ± SD. *: Significantly P value ≤ 0.05. P1: P value contrasted to control group, P2: P value contrasted to child A group, P3: P value contrasted to child B group, P4: P value contrasted to HCC group. CT: computed tomography. PD: Psoas muscle density, PMT: Psoas muscle thickness.

CBC, liver function tests, creatinine, serum Ca, Na, K, and thyroid function tests of the studied groups were shown in table (3).

Table (3): CBC, liver function tests, creatinine, serum Ca, Na, K, and thyroid function tests of the studied groups

	Control group (n=15)	Child A group (n=15)	Child B group (n=15)	Child C group (n=15)	HCC group (n=15)	P
Hemoglobin (g/dl)	13.4±0.89	12.8±0.72	12.4±0.88	11.2±0.73	11±0.67	**<0.001***
	P1	0.253	**0.008***	**<0.001***	**<0.001***	
	P2		0.631	**<0.001***	**<0.001***	
	P3			**<0.001***	**<0.001***	
	P4				0.956	
Platelets (10^9/L)	320.7±31.52	272.5 ± 43.81	217.5±41.89	223.4±55.81	203.8±50.62	**<0.001***
	P1	**0.046***	**<0.001***	**<0.001***	**<0.001***	
	P2		**0.015***	**0.04***	**0.001***	
	P3			0.997	0.929	
	P4				0.778	
WBCs (10^9/L)	9±2.06	6.8±1.88	6.5±1.63	6.8±1.70	5.8±2	**<0.001***
	P1	**0.026***	**0.011***	**0.026***	**<0.001***	
	P2		0.998	**<0.001***	0.723	
	P3			0.998	0.883	
	P4				0.723	
Albumin (g/dl)	4.7±0.64	3.9±0.69	3.2±0.63	2.5±0.45	1.9±0.46	**<0.001***
	P1	**0.006***	**<0.001***	**<0.001***	**<0.001***	
	P2		**0.005***	**<0.001***	**<0.001***	
	P3			**0.02***	**<0.001***	
	P4				**0.047***	
Bilirubin (g/dl)	0.5±0.11	0.8±0.18	1.1±0.22	1.3±0.31	1.4±0.32	**<0.001***
	P1	**0.007***	**<0.001***	**<0.001***	**<0.001***	
	P2		**0.032***	**<0.001***	**<0.001***	
	P3			0.432	**0.032***	
	P4				0.721	
Prothrombin time (sec)	10.6±1.18	12.6±1.5	13.5±1.55	15.3±1.87	16.7±2.09	**<0.001***
	P1	**0.013***	**<0.001***	**<0.001***	**<0.001***	
	P2		0.615	**<0.001***	**<0.001***	
	P3			**0.034***	**<0.001***	
	P4				0.125	
INR	1.3±0.2	1.5±0.23	1.6±0.22	1.7±0.18	1.9±0.16	**<0.001***
	P1	**0.043***	**<0.001***	**<0.001***	**<0.001***	
	P2		0.698	**0.012***	**<0.001***	
	P3			0.263	**<0.001***	
	P4				0.155	
Creatinine (mg/dl)	1±0.2	1.2±0.18	1.3±0.26	1.4±0.23	1.5±0.16	**<0.001***
	P1	**0.048***	**0.015***	**<0.001***	**<0.001***	
	P2		0.992	0.227	**0.03***	
	P3			0.458	0.091	
	P4				0.903	
Serum Ca (mg/dl)	9.5±0.59	8.9±0.7	8.7±0.51	8.2±0.5	8±0.48	**<0.001***
	P1	**0.026***	**0.006***	**<0.001***	**<0.001***	
	P2		0.985	**0.018***	**<0.001***	
	P3			0.071	**0.003***	
	P4				0.805	
Serum Na (mEq/L)	139.9±2.97	136.5±2.33	135±2.9	133.5±3.16	130.7±3.6	**<0.001***
	P1	**0.028***	**<0.001***	**<0.001***	**<0.001***	
	P2		0.636	0.061	**<0.001***	
	P3			0.674	**0.002***	
	P4				0.081	
Serum K (mEq/L)	4.7 ± 0.52	4.1 ± 0.72	4 ± 0.62	3.7 ± 0.45	3.5 ± 0.46	**<0.001***
	P1	**0.028***	**<0.001***	**<0.001***	**<0.001***	
	P2		0.636	0.061	**<0.001***	
	P3			0.674	**0.002***	
	P4				0.081	
TSH (mIU/L)	1.9±0.47	2.2±0.54	2.3±0.56	2.7±0.66	2.8±0.52	**0.069**
T3 (ng/l)	167.9±33.62	164.1±37.57	157.3±32.01	143.4±35.34	135.9±33.21	**0.067**
T4 (ng/l)	165.4± 38.84	157.9±27.08	159.1±33.17	152.3±37.66	138.1±34.31	**0.271**

Data are expressed as mean ± SD.*: Significantly P value ≤ 0.05. P1: P value contrasted to control group, P2: P value contrasted to child A group, P3: P value contrasted to child B group, P4: P value contrasted to HCC group. PD: Psoas muscle density, PMT: Psoas muscle thickness, WBCs: White blood cells, INR: International normalized ratio, T3: Triiodothyronine, TSH: Thyroid stimulating hormone, T4: Thyroxine.

Shear wave elastography of the liver was substantially distinct among the five groups (P <0.001). The existence of sarcopenia was substantially distinct among the 4 groups as higher in the HCC group than in Child A, child B, and Child C groups (P =0.023) (Table 4).

Table (4): Shear wave elastography(SWE) of the liver and the presence of sarcopenia among the studied groups

		Control group (n=15)	Child A group (n=15)	Child B group (n=15)	Child C group (n=15)	HCC group (n=15)	P
Shear wave elastography	**F0**	15(100%)	3(20%)	0(0%)	0(0%)	0(0%)	<0.001*
	F1	0(0%)	12(80%)	10(66.67%)	0(0%)	0(0%)	
	F2	0(0%)	0(0%)	3(20.0%)	4 (26.67%)	0(0%)	
	F3	0(0%)	0(0%)	1(6.67%)	2 (13.33%)	5 (33.33%)	
	F4	0(0%)	0(0%)	1(6.67%)	9(60%)	10(66.67%)	
Presence of sarcopenia		--	3(20%)	5 (33.33%)	6(40%)	1(73.33%)	**0.023***

Data are expressed as mean ± SD. *: Significantly P value ≤ 0.05. according to METAVIR Score for staging of liver fibrosis, F0: <4.6, F1:4.6-5.6, F2:5.7-7, F3:7.1-12, F4: >12.

A positive correlation was existed among shear wave elastography(SWE) of the liver and the degree of sarcopenia (P <0.001) (Table 5).

Table (5): Correlation between the degree of liver fibrosis by shear wave elastography (SWE) of the liver and degree of sarcopenia

		Shear wave elastography (n=60)
Degree of sarcopenia	**r**	0.437
	P	**<0.001***

r: Pearson coefficients, *: Significantly P value ≤ 0.05.

PMTH was substantially elevated in the male group in contrast to the female group (P =0.046). Sarcopenia was present in 11 (37.9%) males and 14 (45.16%) females. The presence of sarcopenia was insignificantly different between both sexes.Table 6.

Table (6): Relation between (PMTH and presence of sarcopenia) and sex among studied patients

	Male (n=29)	Female(n=31)	P
PMTH	13.35 ± 4.42	10.86 ± 4.97	**0.046***
Presence of sarcopenia	11 (37.9%)	14 (45.16%)	0.609

Data are expressed as mean ± SD. *: Significantly P value ≤ 0.05. PMT: Psoas muscle thickness.
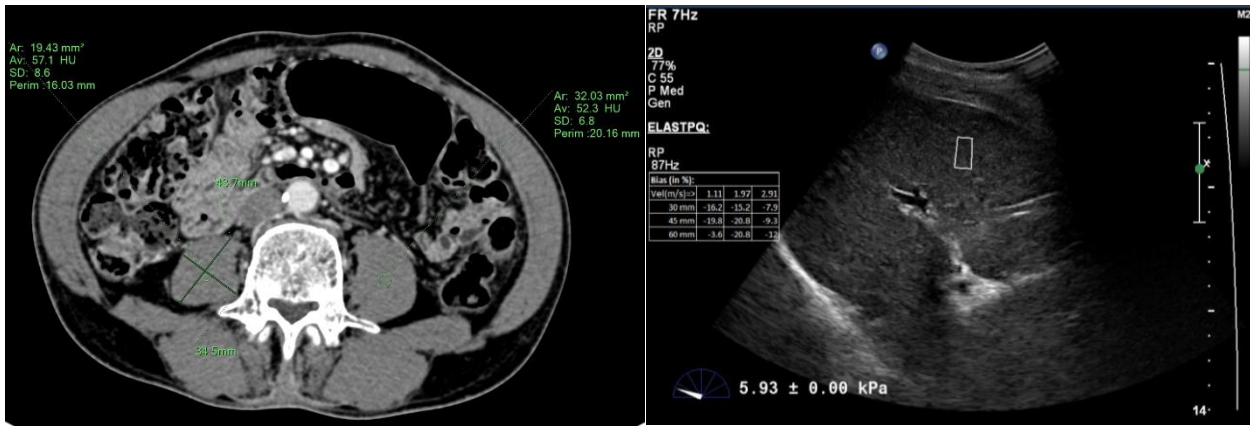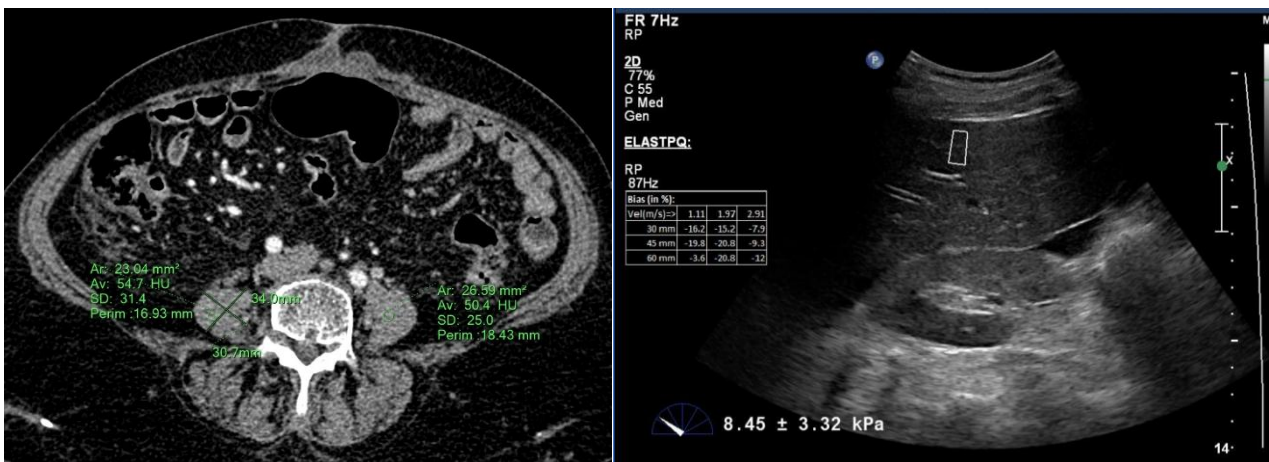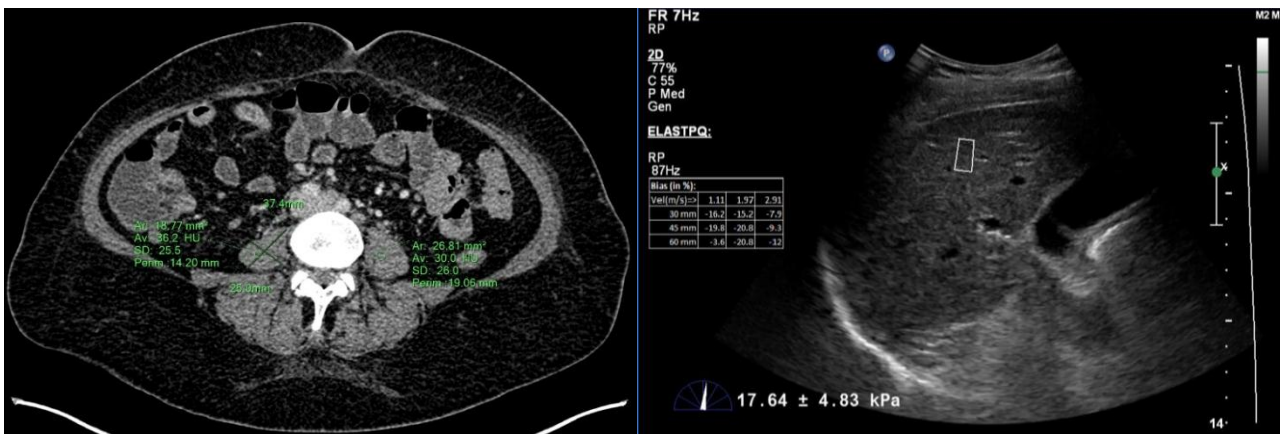
Fig (a)   **Fig (b)**

Case (1): Fig a and b: A male patient 51 years old with Child-Paugh class A and SGA grade A, (a) axial Ct scan pelvis at the umbilicus level showed PMT (transverse axial diameter in mm) = 34.5 mm and PMTH (transverse axial diameter in mm /height in M) =20.1mm/M. Rt-sided PMD =57.1 HU, Lt-sided PMD =52.3 HU with mean PMD =54.3 HU. (b) Elast PQ SWE to measure the elasticity of the liver through intercostal access with the sample box positioned in the upper part of the right lobe showing an elasticity index of 5.93 ± 0.00 KPa (F2).

Fig (a)   **Fig (b)**

Case (2): Fig a and b: A female patient 57 years old with Child-Paugh class B and SGA grade B, (a) axial Ct scan pelvis at the umbilicus level showed PMT (transverse axial diameter in mm) = 30.7 mm and PMTH (transverse axial diameter in mm/height in M) =19.1mm/M. Rt-sided PMD =54.7 HU, Lt-sided PMD =50.4 HU with mean PMD =52.5 HU. (b) Elast PQ SWE to measure the elasticity of the liver through intercostal access with the sample box positioned in the upper part of the right lobe showing an elasticity index of 8.45 ± 3.32 KPa (F3).

Fig (a)   **Fig (b)**

Case (3): Fig a and b: A male patient 63 years old with Child-Paugh class B and SGA grade C, (a) axial Ct scan pelvis at the umbilicus level showed PMT (transverse axial diameter in mm) = 25 mm and PMTH (transverse axial diameter in mm/height in M) =14.2mm/M. Rt-sided PMD =36 HU, Lt-sided PMD =30 HU with mean PMD =33 HU. (b) Elast PQ SWE to measure the elasticity of the liver through intercostal access with the sample box positioned in the upper part of the right lobe showing an elasticity index of 17.64 ± 4.83 KPa (F4).
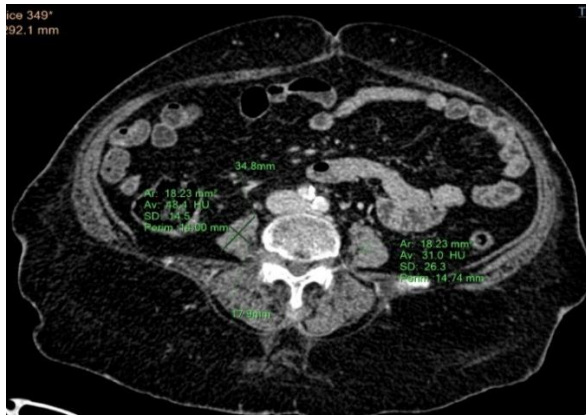
| **Fig (a)** | **Fig (b)** |

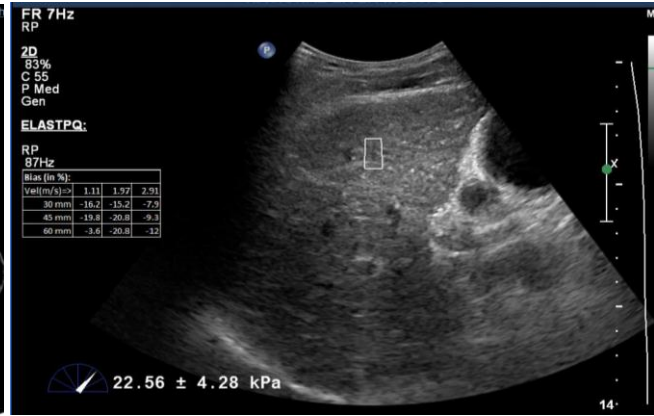**Case (4): Fig a and b:** A male patient 59 years had a left lobe segment III HCC lesion with Child-Paugh class C and SGA grade C, (a) axial Ct scan pelvis at the umbilicus level showed PMT (transverse axial diameter in mm) = 17.9 mm and PMTH (transverse axial diameter in mm/height in M) =10.8mm/M. Rt-sided PMD =48.4 HU, Lt-sided PMD =31 HU with mean PMD =39.7 HU. (b) Elast PQ SWE to measure the elasticity of the liver through intercostal access with the sample box positioned in the upper part of the right lobe showing an elasticity index of 22.56 ± 4.28 KPa (F4).

DISCUSSION

Cirrhosis is the ultimate stage of various chronic liver disorders, marked by the degradation and regeneration of liver cells, along with the development of fibrosis and nodular formations [14].

Regarding sarcopenia in relation to anthropometric measures, we revealed that TSF was significantly higher in Child A group, Child B group, Child C group, and HCC group contrasted to the control group, in Child B group, Child C group and HCC group than in Child A group, in Child C group and HCC group than in Child B group and HCC group than in Child C. Another study by **Elkholy et al.** [15] reported that TSF is a good estimate of the fat composition of the body, but does not reflect the muscle bulk or strength that could be measured by other methods such as HGS.

In our study, we found that MAMC was significantly lower in Child A group, Child B group, Child C group and HCC group than in control group, in Child B group, Child C group and HCC group than in Child A group, in Child C group and HCC group than in Child B group and HCC group than in Child C group. MAMC exhibits a robust correlation with lean muscle mass and body fat, demonstrates reliable consistency among different observers, and has been proven to be a reliable predictor of mortality [16]. Although muscle mass is important, muscular strength plays a more prominent role in identifying physical function [17]. HGS has demonstrated superior predictive ability for unfavorable clinical outcomes when contrasted with CT assessments of muscle mass and the Model for End-Stage Liver Disease (MELD). Even slight enhancements in HGS, as minimal as 1 kg, indicated a noteworthy decrease in mortality [18]. **Vulcano et al.** [19] observed that anthropometric measures such as MAMC are rather precise, even in the presence of retention of salt and water, unlike body weight. This is owing to that edema tends to develop to a smaller degree in the upper extremities.

In our study, we found that SGA was significantly decreased, while child score was significantly increased among the five groups. The findings of **Mei-Ling et al.** [20] were consistent with this study, showing that individuals with compensated cirrhosis had a greater prevalence of poor nutritional status (SGA grade C) in Child-Pugh C cirrhotic individuals in contrast to Child-Pugh B cirrhotic individuals.

In our research, we observed that the right and the left PD and mean PD were substantially reduced in the Child A group, Child B group, Child C group, and HCC group in contrast to the control group. Additionally, the Child B group, Child C group, and HCC group had substantially reduced right and left PD and mean PD compared to the Child A group. Currently, CT combined with image analysis systems is being more often utilized to evaluate skeletal muscle mass. Performing an abdominal CT scan only for the purpose of measuring muscle mass would be challenging to justify due to the high expenses involved and the potential risks of exposure to radiation. Nevertheless, since the majority of individuals with cirrhotic liver get regular surveillance scans to identify focal liver lesions [21], there was no requirement for further CT scans to assess muscle mass. In line with our findings, **Paternostro et al.** [22] determined that there is a high prevalence of decreased muscle mass among the group of individuals with cirrhosis that we studied.

In our results, we revealed that PMT and PMTH were significantly lower in Child A group, Child B group, Child C group, and HCC group than in control group and were substantially reduced in Child C group and HCC group than in Child A group and in HCC group than in Child B group and Child C group. Similarly, **Khattab et al.** [23] revealed that a statistically substantial variations were existed among participants with sarcopenia and individuals without it as regards mean PM density and PMT.

In the present study, PMTH ≤ 16mm/m was reliable indicator of sarcopenia so, our results revealed that sarcopenia was diagnosed in 25 out of 60 patients (41.6%), out of which 11 (18.3%) were males, 14 (23.3%) were females. Sarcopenia was diagnosed in 3 (5%), 5 (8.3%), 6 (10%), and 11 (18.3%) in Child A, Child B, Child C and HCC groups respectively.

Regarding the relation between PMTH and the presence of sarcopenia and sex, we found that PMTH was substantially elevated in the male group in contrast to the female group (P value=0.046). Sarcopenia was present in 11 (37.9%) males and 14 (45.16%) females. The presence of sarcopenia was insignificantly different between both genders. A study by **Khattab et al.** [23] suggested that the PMTH at 16 mm/m is a reliable indicator of sarcopenia. Sarcopenia was observed in 50% of all patients, regardless of their sex, according to the mean of PMTH across each group of participants. However, when using the mean PMTH values particular to each sex, with PMTH > 17.6 for males and PMTH > 11.56 for females, it was discovered that 52.5% of these individuals have sarcopenia.

In our work, we found that albumin was significantly lower in Child A group, Child B group, Child C group, and HCC group than in Control group, in Child B group, Child C group and HCC group than in Child A group, in Child C group and HCC group than in Child B group and in HCC group than in Child C group. **Gad et al.** [24] did a cross-sectional investigation on 150 individuals with cirrhotic liver to evaluate the muscular status and sarcopenia. The study also examined the relationship between patient physical activity, food history, and progressing liver disease. Sarcopenic individuals exhibited notable hyperbilirubinemia, hypoalbuminemia, and an increase in blood creatinine levels compared to nonsarcopenic individuals. The logistic regression analysis identified several independent predicted indicators of sarcopenia, including advancing age, reduced BMI, inadequate intake of proteins, and hypoalbuminemia.

In our results, we found that INR was substantially elevated in HCC group in contrast to the control group, Child B group and Child C group and was insignificantly distinct among the Child C group and Child B group and HCC group. In line with our findings, **GadAllah et al.** [25] revealed that INR had been substantially reduced in control group contrasted to HCC and CLD groups with no substantial variation among HCC and CLD groups.

In this study, we revealed that bilirubin was substantially greater in Child B group, Child C group and HCC group contrasted to in Child A group, in HCC group contrasted to in Child C group, and was insignificantly distinct among Child C group and Child B group and HCC group. Supporting our findings, **GadAllah et al.** [25] showed that bilirubin was substantially reduced in the control group in contrast to HCC and CLD groups with no substantial variation among HCC and CLD groups.

In our study, we found that PT was substantially greater in Child C group and HCC group than in Child A group and Child B group and was insignificantly different among Child A group and Child B group and among Child C group and HCC group. Prothrombin time and INR were significantly higher in Child A group, Child B group, Child C group and HCC group than in the control group. Supporting our findings, **GadAllah et al.** [25] showed that PT had been substantially reduced in the control group in contrast to HCC and CLD groups with no substantial variation among HCC and CLD groups.

In this work, we found that Creatinine was significantly greater in (Child A group, Child B group, Child C group, and HCC group) than in control group and in HCC group than in Child A group and was insignificantly different among Child B group and Child C group and Child A group and between Child C group and (Child B group and HCC group). **Yoo et al.** [26] discovered that the actual kidney function in individuals with cirrhosis is prone to be overestimated when utilizing a creatinine-based algorithm for measurement. Female gender, hepatic dysfunction, and reduced muscle mass had been determined as risk factors for overestimation. In line with our findings, **GadAllah et al.** [25] revealed that creatinine was substantially lower in the control group than in HCC and CLD groups with no substantial variation among HCC and CLD groups.

In our study, serum Ca, Na, and K in our results were significantly lower in Child A group, Child B group, Child C group and HCC group contrasted to in the control group, in HCC group than in Child A group, and were insignificantly different between Child B group and Child A group and Child C group and between Child C group and HCC group. In line with our findings, **Hessien et al.** [27] showed that the hemostatic abnormalities in PT and calcium deteriorated simultaneously with the progressive decline of the liver's fundamental function.

Regarding sarcopenia in relation to shear wave elastography in the present study, we found that shear wave elastography was significantly different among the five groups. A positive correlation was existed among SWE and the degree of sarcopenia. Lately, innovative approaches relying on US have been assessed as additional instruments in the diagnosis of sarcopenia. Initial data indicates a potential involvement of SWE, a technique utilized to evaluate the stiffness of tissues, in the evaluation of the quality as well as quantity of muscles. The velocities of SWE contractions have been found to be substantially reduced among individuals with sarcopenia, and there is a favorable correlation between these velocities and grip strength [28]. These findings may be associated with the rearrangements in muscle structure that occur among individuals with sarcopenia, characterized by increased accumulation of adipose tissue and fibrosis.

Limitations of the present research was the relatively limited sample size. The study was conducted at a solitary center. Anthropometry is a reliable and established method. By ensuring that well-trained individuals use standardized measurement techniques, the chances of systematic errors are greatly reduced. Furthermore, there were no universally accepted and scientifically verified standards to precisely characterize malnutrition in individuals with cirrhosis. Another limitation was the wide range of situations where sarcopenia can accurately predict malnutrition in cirrhotic patients. This is because there was a disproportionately high prevalence of renal impairment, which is a common co-existing illness in this group of patients.

CONCLUSIONS

Malnutrition frequently coexists with cirrhosis, and sarcopenia could serve as a predictive factor for malnutrition associated with cirrhosis and its consequences. A positive correlation was existed among SWE and the degree of sarcopenia.

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