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Assessment of Bone Mineral Density in Cirrhotic Patients at Ibn Sina Hospital

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ABSTRACT

Bone diseases are prevalent in patients with liver cirrhosis. Bone mineral density is the most reliable method for detecting osteoporosis, osteopenia, and vulnerability to fractures, with an average prevalence of 35% worldwide. The study aimed to assess the relationship between bone mineral density and liver cirrhosis among Sudanese patients. A cross-sectional study was conducted at Ibn-Sina Specialized Hospital among Sudanese patients from June 2019 to November 2019. The study population consists of 80 patients suffering from liver cirrhosis and reduced bone mineral density. Bone mineral density was measured using DEXA. The diagnosis of osteoporosis and osteopenia was based on the criteria established by the WHO. Further, the severity of liver cirrhosis was assessed using MELD and Child-Pugh Turcott Scores. Ethical approval and written informed consent were obtained. However, data were analyzed using appropriate statistical tests. The analysis revealed that among 80 patients (63.8%) were males and (36.2%) were females, with hepatitis B being the primary cause (61.3%), alcohol consumption (8.8%), and hepatitis C (3.8%). The average MELD score was 15±6. However, abnormal DEXA values were observed in (63.8%) of the patients, with (55%) showing osteopenia and (8.8%) showing osteoporosis. Patients with encephalopathy had a high prevalence of osteoporosis and osteopenia with a significant p-value (p=0.002). Other prominent factors included increased bilirubin (P= 0.000), hypernatremia (p=0.000), advanced Child-pugh score (p= 0.041), and high MELD scoring of liver cirrhosis (p = 0.000), showed statistical significance among these patients. The study showed that patients with liver cirrhosis were more susceptible to reduced bone mineral density, emphasizing the need for timely diagnosis and treatment of bone health issues. However, further research is required to examine the correlation between liver cirrhosis and bone disease in Sudan's population.

INTRODUCTION

The Bone Mineral Density (BMD) test is utilized to measure the amount of calcium and other minerals in bones (Ahmadi *et al.*, 2018). Bones with a higher mineral content tend to be denser, resulting in increased strength and reduced risk of fractures (Burr, 2019). Aging or certain medical conditions can decrease bone density (Aspray & Hill, 2019). In addition, BMD is the most reliable method for diagnosing osteopenia, osteoporosis, and the associated risk of fractures (Choksi *et al.*, 2018; Rossini *et al.*, 2016). Osteoporosis is a condition characterized by the weakening and fragility of bones, which significantly increases the risk of fractures. This condition can be caused by excessive bone resorption (Wilson, 2019). BMD assays are commonly employed for the identification and assessment of osteoporosis (Sözen *et al.*, 2017). The BMD is directly affected by the number of bones present in the skeleton, and stronger bones are associated with higher BMD (Burr, 2019; Nayak *et al.*, 2016). However, genetic factors exert a substantial impact, which may occasionally be modified by external factors and medications (Nayak *et al.*, 2016).

Typically, BMD increases during childhood, reaches the highest point at the age of 25, and subsequently stabilizes for ten years. As people age, both men and women typically lose 0.3 to 0.5% of their BMD after the age of 35 years (Nayak *et al.*, 2016). The Dual-Energy X-ray Absorptiometry (DEXA) screening method is frequently employed to assess BMD in Fragility Fracture Risk Assessment (FRAX) (Haseltine *et al.*, 2021). Social guidelines delineate the populations that are anticipated to benefit from DEXA screening and provide instructions on utilizing the FRAX tool to assist with decisions regarding osteoporosis treatment strategies (Haseltine *et al.*, 2021; Iseri *et al.*, 2020). Additionally, BMD problems can arise in people with chronic liver diseases, such as autoimmune, post-viral cirrhosis, cholestatic disorders, and alcohol consumption (George *et al.*, 2009; Mancell, 2020). This condition is known as Hepatic Osteodystrophy (HO), which is frequently identified in patients with Chronic Liver Disease (CLD) (Ranjan *et al.*, 2021). The cause of the disease is not well understood and is thought to differ depending on the type, severity, and course of liver disease, as well as other factors, such as the ethnicity of the population (Barbu *et al.*, 2017). However, HO can result in the occurrence of spontaneous low-trauma fractures, leading to a substantial negative impact on morbidity, quality of life, and even survival (Karoli *et al.*, 2016). The main symptoms of this are discomfort, deformity, and immobility (Haseltine *et al.*, 2021).

Cirrhosis, a prevalent global health issue, can arise from various factors, including obesity, non-alcoholic fatty liver disease, excessive alcohol consumption, nonalcoholic steatohepatitis, hepatitis B or C infections, autoimmune

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disorders, cholestatic conditions, and imbalances in iron or copper levels (Ginès *et al.*, 2021; Smith *et al.*, 2019). As cirrhosis progresses, there is a prolonged period of inflammation that causes fibrotic and regenerative nodules to replace healthy liver tissue, which raises the risk of portal hypertension (Takahara *et al.*, 2019). Compensated cirrhosis is an asymptomatic phase of the disease that progresses to decompensated cirrhosis (Kumar *et al.*, 2023), a symptomatic phase characterized by frequent hospitalization, a decline in quality of life, and an increased risk of death (D'Amico *et al.*, 2022; Zaccherini *et al.*, 2021). The primary factors contributing to illness outcomes include liver failure, systematic inflammation, and increased hypertension (Costa *et al.*, 2021). Treating the underlying causes of liver cirrhosis and controlling its side effects are the main goals of management; in some circumstances, Liver Transplantation (LT) may be necessary, and it is a gold standard for treatment (Markin *et al.*, 2019; Trebicka *et al.*, 2020). As liver transplantation becomes more common as the primary treatment of end-stage cirrhosis resulting from various causes (Goel *et al.*, 2019), bone disease has become a crucial factor in determining the patient's survival and quality of life (D'Oronzo *et al.*, 2019; George *et al.*, 2009). However, the diagnosis of liver cirrhosis can be accomplished by the utilization of elastography, a technique that assesses liver stiffness, in addition to a variety of blood tests that measure fibrosis scores (Yoshiji *et al.*, 2021).

CLD prevalence in Sudan is unknown, but it is a significant healthcare burden due to diverse etiologies. The 2018 Hepahealth survey found that cirrhosis and CLD prevalence in Europe ranges from 500 to 1100 cases per 100,000 individuals (Traub *et al.*, 2021). The US experienced a 65% rise in mortality associated with cirrhosis between 1999 and 2016, resulting in approximately 44,000 deaths in the US and 2 million worldwide (Pimpin, 2018). Moreover, variability in patient characteristics may account for differences in the reported osteoporosis prevalence among CLD patients (Muhsen *et al.*, 2018). There is inconsistent advice on when to test for BMD in CLD patients (Danford *et al.*, 2020). Latent osteoporosis increases fracture risk, leading to higher hospitalization, morbidity, and mortality (Muhsen *et al.*, 2018). Thus, early diagnosis is crucial for cirrhotic patients to prevent fractures and improve their quality of life (Gokcan *et al.*, 2020). Studies showed that bone diseases are common in cirrhosis patients even after controlling for confounding factors (CHEN *et al.*, 1996; Danford *et al.*, 2020; Lupoli *et al.*, 2016). This occurs due to decreased BMD, and the risk of fractures in cirrhosis is twice as high as that of the general population (Jeong & Kim, 2019; Santos & Romeiro, 2016). Studies on BMD in Sudanese cirrhosis patients are scarce.

Therefore, the study aimed to assess the relationship between bone mineral density and liver cirrhosis among Sudanese patients. The present study provides insights into the incidence, risk factors, signs, prevention, and treatment of BMD in liver cirrhosis patients, defining osteoporosis or osteopenia.

MATERIALS AND METHODS

Study Design and Population

This cross-sectional study was conducted at Ibn-Sina Specialized Hospital among Sudanese patients from June 2019 to November 2019. The study population consists of 80 patients suffering from liver cirrhosis.

Ethical Approval

Ethical approval was obtained from the Sudan Medical Specialization Board (SMSB) and Ibn Sina Hospital's ethical committee. Written informed consent was also obtained from the patients, and the study was carried out in conformity with the 1964 Declaration of Helsinki. The STROBE guidelines were followed, and any subsequent revisions or with comparable ethical standards.

Inclusion and Exclusion Criteria

The study included a clinically suitable participant cohort. The study included patients suffering from liver cirrhosis. Conversely, the exclusion criteria included patients who had renal dysfunction, thyroid and parathyroid disorders, Cushing's syndrome, and diabetes. Similarly, the study excluded patients who had a history of chronic disorders associated with changes in mineral metabolism. Furthermore, patients who received calcium, Vitamin D, and medications influencing bone metabolism such as corticosteroids, hormone replacement therapy, calcitonin, bisphosphonates, cytotoxics, anti-metabolites, anticoagulants, anti-convulsants, thyroxin and interferon were excluded from the study.

Sample Size Calculation

The sample size was calculated using the following formula:

$N = ((z)^2 P (1-P))/(d)^2$

$N = ((1.96)^2 \times 0.05 (1-0.05))/(0.05)^2$

N = 80 Cirrhotic patients

Where;

N = Sample Size

Z = Confidence interval

P = Previous prevalence (5%)

d = marginal error (0.05)

Data Collection

The data was collected through structured questionnaires consisting of 6 components: a) demographic data, b) etiology and complications of liver cirrhosis, c) symptoms of osteoporosis, d) cirrhosis severity by using (CTP and MELD scores), e) lab investigations, and f) DEXA findings.

Clinical Procedure

Bone mineral density was assessed in the patient's heel using the Furuno CM-200 light ultrasound bone densitometer, a compact and portable device manufactured by Furuno Electric Co. LTD in Japan. During the procedure, the patient placed their bare feet, right and left, in designated spaces within the machine while a lubrication gel was applied. Subsequently, the system adapts to accurately

interpret the score. The results were interpreted according to the criteria of WHO:

- T-score of -1.0 or above = normal bone density
- T-score between -1.0 and -2.5 = low bone density or osteopenia
- T-score of -2.5 or lower = osteoporosis

Data Analysis

The data was analyzed using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 21.0. Descriptive statistics were calculated, which included frequencies and percentages, whereas the Chi-square (χ^2) test was employed to analyze categorical data. The P-value of < 0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

The results section displays data analysis and statistical interpretations based on data collection. A total of 80 patients were included in the study, with a majority of male (63.8%) patients and female patients accounting for (36.2%). With a mean age of 49.6±13.9 years (31.3%), patients between the ages of 51 and 60. However, the majority of patients with cirrhosis were from the Sudan Central region (35%), followed by Khartoum (26.3%) and West (21.3%), as shown in Table 1.

Table 1: Demographic characteristics (N= 80)

Characteristics	Frequency	Percentage
Gender		
Male	51	63.8%
Female	29	36.2%
Age (Years); mean ± SD 49.6±13.9		
< 20	2	2.5%
20-30	7	8.8%
31-40	16	20%
41-50	15	18.8%
51-60	25	31.3%
> 60	15	18.8%
Origin		
Khartoum	21	26.3%
Central	28	35%
West	17	21.3%
North	11	13.8%
East	3	3.8%

Figure 1 revealed that Hepatitis B (HBV) accounts for (61.3%) of liver cirrhosis cases, while alcohol addiction accounts for (22.5%). The prevalence rates of autoimmune diseases, unknown etiology cases, and Hepatitis C virus were (8.8%), (3.8%), and (3.8%), respectively. This analysis suggested a need for further investigation into potential risk factors.

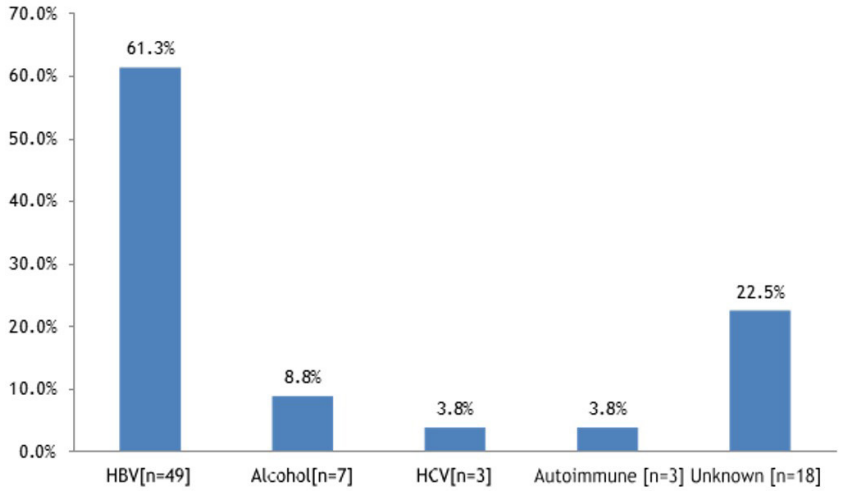

Figure 1: Etiologies of liver cirrhosis (N= 80)

Table 2 presents the distribution symptoms of osteoporosis, patients' performance, ascites, and encephalopathy among cirrhotic patients.

Encephalopathy and ascites indicate severe liver disease, classifying cirrhosis based on their quantity and intensity, which can significantly impact medical treatment for cirrhosis patients. The analysis revealed that a significant proportion experienced diminished energy (52.5%), while (35%) and (12.8%) experienced back or body aches. Furthermore, cirrhosis was characterized by ascites in (37.5%) of cases, with (92%) of patients reporting no encephalopathy.

Table 2: Distribution of Clinical Characteristics

Characteristics	Frequency	Percentage
Symptoms of osteoporosis		
Fatigability	42	52.5%
Back pain	28	35%
Bone pain	10	12.5%
Patient performance		
Freely mobile	64	80%
Mobile at home	10	12.5%
Bedridden	6	7.5%
Assessment Indicators		
Ascites		
Absent	30	37.5%
Slight	34	42.5%
Moderate	16	20%
Encephalopathy		
Absent	74	92.5%
Grade1-2	6	7.5%
Grade3-4	0	0%

Table 3 shows blood chemical composition, coagulation status, and liver functionality in study patients. A severe deficiency of albumin in the blood was observed, with (31.3%) of serum albumin values below 2.8g/Dl. Bilirubin levels were also low, with (70%) of patients below 2 mg/dL. The International Normalized Ratio (INR) was used to assess coagulation status, with (85%) of patients showing an INR value < 1.7. Most patients had sodium levels over 130 mmol/L (85%), and (30%) had elevated creatinine levels.

Table 3: Laboratory investigations of cirrhotic patients (N= 80)

Investigations	Frequency	Percentage
Albumin (g/dl)		
< 2.8	25	31.3%
2.8-3.5	30	37.5%
> 3.5	25	31.3%
Bilirubin (mg/dl)		
< 2	56	70%
2-3	18	22.5%
> 3	6	7.5%
INR		
< 1.7	68	85%
1.7-2.2	9	11.3%
> 2.2	3	3.8%
Sodium (mmol/L)		
< 130	12	15%
≥ 130	68	85%
Creatinine (mg/dl)		

< 1	56	70%
> 1	24	30%

Figure 2 illustrates the 3 categories of cirrhosis patients based on their Child-Turcotte-Pugh (CTP) scores. The results revealed that (49%) of patients had moderate cirrhosis (CTP-B), indicating moderate liver dysfunction. Whereas, (35%) showed mild cirrhosis (CTP-A), suggesting some liver function was intact and a favorable prognosis. Only (16%) had severe cirrhosis (CTP-C), indicating severe liver disease.

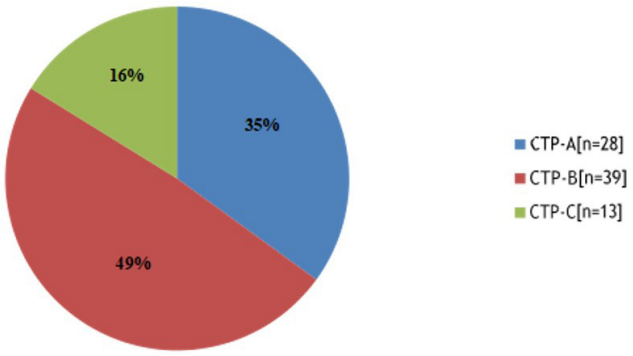

Figure 2: Child-Pugh classification (N= 80)

Figure 3 shows the Model for End-Stage Liver Disease (MELD) scores. These scores were based on laboratory findings like serum bilirubin, creatinine, and INR. MELD score among study patients was 15±6, and (77.5%) of patients fell within the MELD score range of 10-19, indicating a (6%) mortality rate (in 3 months).

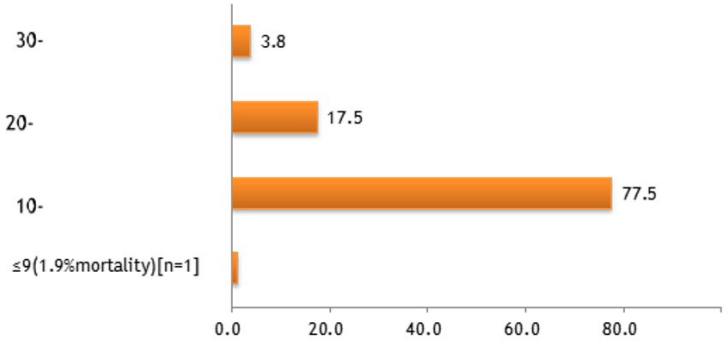

Figure 3: MELD score of cirrhotic patients (N= 80)

The DEXA scan results indicated that (36.2%) of patients had normal bone mineral density, with a mean DEXA score of 0.14. Additionally, (55%) of patients had osteopenia, with a mean DEXA score of -1.5, while (8.8%) of patients had osteoporosis, with a mean DEXA score of -2.8, as shown in Figure 4. This analysis showed that a significant proportion of patients had moderate or severe cirrhosis.

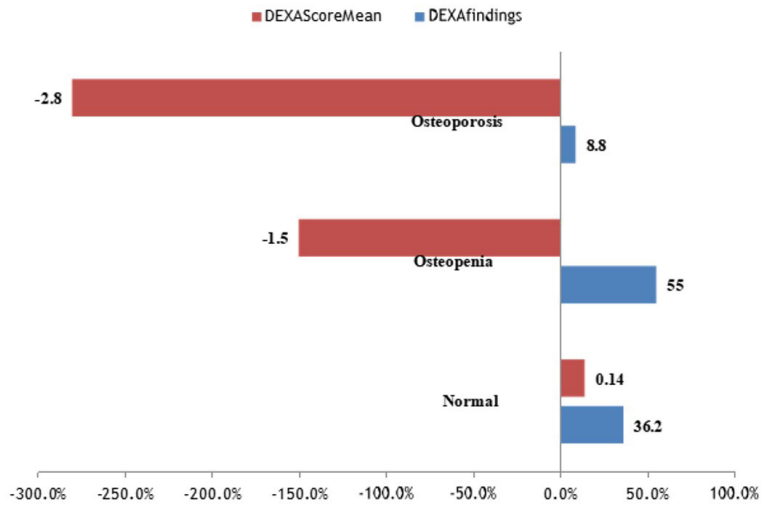

Figure 4: Bone mineral density by DEXA (N= 80)

Table 4 presents the correlation between the demographic characteristics of patients with cirrhosis and the results of Dual-Energy X-ray Absorptiometry (DEXA). The analysis showed that males had a higher prevalence of osteopenia (49%) than females (65.5%), while both genders had a comparable proportion of osteoporosis (9.8%) and (6.9%), respectively. Osteoporosis had a higher prevalence (16%) among patients aged 51-60, while osteopenia was more prevalent (73.3%) among those aged 41-50. Moreover, the East region exhibited a higher prevalence of osteoporosis (33.3%), while the West region had a higher frequency (70.6%). The p-values showed a significant association between DEXA findings and demographic characteristics of cirrhotic patients.

Table 4: Association between DEXA findings and demographics (N= 80)

Characteristics	Normal	Osteopenia	Osteoporosis	P. value
Gender				
Male	21	25	5	0.361
	41.2%	49.0%	9.8%	
Female	8	19	2	
	27.6%	65.5%	6.9%	
Age (Years)				
< 20	1	1	0	0.606
	50.0%	50.0%	0.0%	
20-30	4	3	0	
	57.1%	42.9%	0.0%	
31-40	8	7	1	
	50.0%	43.8%	6.3%	
41-50	4	11	0	
	26.7%	73.3%	0.0%	
51-60	7	14	4	
	28.0%	56.0%	16.0%	
> 60	5	8	2	
	33.3%	53.3%	13.3%	
Origin				
Khartoum	12	9	0	0.072
	57.1%	42.9%	0.0%	
Central	7	17	4	
	25.0%	60.7%	14.3%	
West	5	12	0	
	29.4%	70.6%	0.0%	
East	2	0	1	
	66.7%	0.0%	33.3%	
North	3	6	2	
	27.3%	54.5%	18.2%	

Table 5 analyzes the relationship between liver cirrhosis causes and DEXA findings. It showed that patients with cirrhosis associated with HCV had a higher incidence of osteopenia (66.7%) and autoimmune causes (42.9%). The p-value (0.854) showed no significant correlation between DEXA findings and cirrhosis causes among patients.

Table 5: Association between DEXA findings and cirrhosis causes (N= 80)

Liver cirrhosis causes	Normal	Osteopenia	Osteoporosis	P. value
HBV	19	25	5	
	38.8%	51.0%	10.2%	
HCV	1	2	0	
	33.3%	66.7%	0.0%	
Alcohol	0	3	0	

	0.0%	100.0%	0.0%	0.854
Autoimmune	3	3	1	
	42.9%	42.9%	14.3%	
Unidentified diagnosis	6	11	1	
	33.3%	61.1%	5.6%	

Table 6 shows a correlation between DEXA findings and osteoporosis symptoms. Patients with osteoporosis often report symptoms, indicating a higher prevalence rate. A significant association was observed between osteoporosis and bone pain symptoms (p = 0.000), highlighting the correlation between bone pain and reduced bone density. Although there was no significant association between fatigability and back pain and DEXA findings, these patterns suggest increased sensitivity to osteoporosis. The p-value <0.05 indicated a significant association between osteoporosis and back pain.

Table 6: Association between DEXA findings and symptoms of osteoporosis (N= 80)

Symptoms of osteoporosis	Normal	Osteopenia	Osteoporosis	P. value
Fatigability				
Yes	18	24	6	0.283
	37.5%	50.0%	12.5%	
No	11	20	1	
	34.4%	62.5%	3.1%	
Back pain				
Yes	9	15	4	0.422
	32.1%	53.6%	14.3%	
No	20	29	3	
	38.5%	55.8%	5.8%	
Bone pain				
Yes	2	8	0	0.000*
	20.0%	80.0%	0.0%	
No	27	36	7	
	38.6%	51.4%	10.0%	

Table 7 examines the relationship between DEXA findings and patients with cirrhosis, focusing on their mobility. The results showed no significant correlation (p = 0.662). However, there were notable trends, such as a s higher prevalence of osteoporosis among home-mobile patients and a greater proportion of the disease among bedridden patients.

Table 8 shows a significant correlation between ascites, encephalopathy and bone density. The p-value of ascites (p=0.496) showed no statistical significance, whereas encephalopathy had a significant association (p=0.002*) with osteoporosis, particularly in patients with Grade 1-2 encephalopathy.

Table 7: Association between DEXA findings and patient physical performance (N= 80)

Patient performance	Normal	Osteopenia	Osteoporosis	P. value
Bedridden	2	4	0	0.662
	33.3%	66.7%	0.0%	
Mobile at home	3	5	2	
	30.0%	50.0%	20.0%	
	24	35	5	
Freely mobile	37.5%	54.7%	7.8%	

Table 8: Association of DEXA findings with ascites and encephalopathy (N=80)

Indicators	Normal	Osteopenia	Osteoporosis	P. value
Ascites				
Absent	13	16	1	

	43.3%	53.3%	3.3%	
Slight	10	19	5	
	29.4%	55.9%	14.7%	0.496
Moderate	6	9	1	
	37.5%	56.3%	6.3%	
Encephalopathy				
Absent	29	40	5	
	39.2%	54%	6.8%	0.002*
Grade1-2	0	4	2	
	0.0%	66.7%	33.3%	

Table 9 indicates a correlation between laboratory tests and DEXA findings. Patients with osteoporosis had elevated bilirubin levels (p=0.000*), with a significant proportion (77.2%) falling within 2-3 mg/dL. Similarly, low sodium levels (<130 mmol/L) were significantly associated with osteoporosis (p=0.000*), suggesting an electrolyte imbalance and reduced bone density. Albumin levels were approaching statistical significance (p=0.386), indicating a positive trend in bone health.

Table 9: Association between DEXA findings and laboratory investigations (N=80)

Lab Analysis	Normal	Osteopenia	Osteoporosis	P. value
Albumin (g/dL)				
< 2.8	7	14	4	
	28.0%	56.0%	16.0%	
2.8-3.5	10	18	2	0.386
	33.3%	60.0%	6.7%	
> 3.5	12	12	1	
	48.0%	48.0%	4.0%	
Bilirubin (mg/dL)				
< 2	27	28	1	
	48.2%	50%	1.8%	
2-3	2	14	2	0.000*
	11.1%	77.2%	11.1%	
> 3	0	2	4	
	0.0%	33.3%	66.7%	
INR				
< 1.7	26	38	4	
	38.2%	55.9%	5.9%	
1.7-2.2	2	4	3	0.093
	22.2%	44.4%	33.3%	
> 2.2	1	2	0	
	33.3%	66.7%	0.0%	
Sodium (mmol/L)				
< 130	0	8	4	
	0.0%	66.7%	33.3%	0.000*
≥ 130	29	36	3	
	42.7%	52.9%	4.4%	
Creatinine (mg/dL)				
< 1	23	27	6	0.167
	41.1%	48.2%	10.7%	
> 1	6	17	1	
	25.0%	70.8%	4.2%	

Table 10 presents a significant correlation between the Child-Pugh classification and DEXA findings. Patients with severe cirrhosis, specifically (CTP-C) had a higher prevalence of osteoporosis (23.1%) while (CTP-A) showed a reduced occurrence of osteoporosis (3.6%). The p-value < 0.05 indicated a statistical significance.

Table 10: Association between DEXA findings and Child-Pugh classification (N=80)

Child-Pugh class	Normal	Osteopenia	Osteoporosis	P. value
CTP-A	15	12	1	0.041*
	53.6%	42.9%	3.6%	
CTP-B	10	26	3	
	25.6%	66.7%	7.7%	
CTP-C	4	6	3	
	30.8%	46.2%	23.1%	

Table 11 reveals a correlation between MELD scores and DEXA findings among cirrhosis patients. Greater MELD scores indicated severe liver disease and an increased mortality risk. Osteoporosis prevalence was high (71.4%0 in patients with MELD scores 20-29, with a 19.6% mortality risk. Patients with MELD scores 30-39 had a 52.6% mortality rate, and lower MELD scores showed regular bone density and a reduced death rate.

Table 11: Association between DEXA findings and MELD score (N=80)

MELD Score	Normal	Osteopenia	Osteoporosis	P. value
≤9 (1.9% mortality)	1	0	0	0.000*
	100.0%	0.0%	0.0%	
10-19 (6.0% mortality)	27	34	1	
	43.5%	54.8%	1.6%	
20-29 (19.6% mortality)	1	10	3	
	7.1%	71.4%	21.4%	
30-39 (52.6% mortality)	0	0	3	
	0.0%	0.0%	100.0%	

Discussion

Chronic liver disease impacts almost 1.5 billion individuals globally, with Alcoholic Liver Disease (ALD) accounting for (2%), Hepatitis B Virus (HBV) accounting for (29%), Hepatitis C Virus (HCV) accounting for 9%, and Non-Alcoholic Fatty Liver Disease (NAFLD) accounting for (60%) (Moon *et al.*, 2020; Traub *et al.*, 2021; Ye *et al.*, 2020). The median prevalence of cirrhosis in European countries was 833 cases per 100,000. The Global Burden of Disease study revealed a (13%) growth in the age-standardized incidence rate of CLD and cirrhosis in 2015 (Asrani *et al.*, 2019). In Europe, the prevalence of cirrhosis is 26.0 cases per 100,000 individuals (Moon *et al.*, 2020). Cirrhosis is the 11th most common cause of death globally and the 15th leading cause of morbidity (Cheemerla & Balakrishnan, 2021). West Europe and South Sub Suharan Africa had the fourth to sixth lowest age-standardized death rates of cirrhosis in 2017, with alcohol-related liver disease and hepatitis C being the primary cause (Ye *et al.*, 2022; Younossi *et al.*, 2023). North Africa and the Middle East had modest rates of age-standardized death and prevalence rates due to cirrhosis driven by hepatitis B and C (Huang *et al.*, 2023; Mokdad *et al.*, 2014). In contrast, Sudan is among the countries with high hepatitis B virus seroprevalence, with exposure ranging from (47%) to (78%) (Elsheikh *et al.*, 2016; Mudawi, 2008). It is the common cause of CLD and hepatocellular carcinoma, and the second common cause of acute liver failure in Sudan (Konyn *et al.*, 2021; Lan *et al.*, 2023; Mohammed *et al.*, 2015; Moses, 2021).

Liver Cirrhosis can be diagnosed by various techniques and a definitive method for diagnosing cirrhosis is liver biopsy (Jain *et al.*, 2021). However, if clinical, laboratory, and radiologic findings indicate cirrhosis, a biopsy is unnecessary. Cirrhosis increases the susceptibility to complications from liver biopsy (Chowdhury & Mehta, 2023). The most reliable indicators of cirrhosis include ascites, a platelet count below 160,000/mm3, spider angiomata, and a Bonacini cirrhosis discriminant score (Sharma, 2022). Ultrasound is also used for assessing liver cirrhosis, but other methods include transient elastography, acoustic radiation force impulse imaging, supersonic shear imaging, magnetic resonance elastography, and endoscopy (Ahmed, 2022; Cui *et al.*, 2022). Elastography offers painless sampling and examination of a broader area as compared to biopsy. While abdominal Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) are also used under specific conditions for diagnosis (Nadarevic *et al.*, 2021). Decompensated cirrhosis anagement should focus on preventing progression rather than treating complications. Treatment targets liver pathological

alterations, suppressing inflammation, fibrosis regression, and normalizing cell function.

The present study analyzed bone mineral density in liver cirrhotic patients and examined the rate of osteoporosis, osteopenia, and risks of fractures. The results revealed that most patients were males, with an average age of 49.6±13.9 years. The male (63.8%) to female (36.2%) ratio was 1.8:1 with a higher proportion from Sudan Central region (35%). Based on the etiological findings, alcohol consumption was found to be the second most prevalent factor contributing to liver cirrhosis (22.5%), followed by HBV which accounts for (61.3%) of cases. The prevalence rates of HCV, autoimmune diseases, and unknown etiology were (3.8%, 3.8%, and 8.8%), respectively. Notably, a significant proportion of patients (52.5%) experienced reduced energy levels, while (37.5%) exhibited ascites, a typical indicator of severe livere disease. Encephalopathy, a sign of nuerological problems, was observed in (7.5%) of the patients. Moreover, laboratory investigations demonstrated significant abnormalities in liver functions. A total of (13%) of the patients exhibited a significant deficiency of albumin, with levels below 2.8g/dL, indicating poor synthetic liver function. The patients' bilirubin levels (70%) were below 2mg/Dl. INR showed that (85%) of the patients had normal coagulation levels. the child-pugh score system was employed to categorize liver dysfunction into various stages. Among 80 patients, (49%) exhibited moderate cirrhosis (CTP-B), (35%) showed mild cirrhosis (CTP-A), and (16%) showed severe cirrhosis (CTP-C). Furthermore, (75%) of patients with cirrhosis had a mean score of 15±6, indicating a high risk of mortality. The DEXA scan revealed that (35.2%) had normal bone density, (55.5%) had osteopenia, and (8.8%) had osteoporosis. The DEXA findings showed a significant correlation with child-pugh scores, MELD scores, and bone diseases. A notable association was also observed between the intensity of encephalopathy and DEXA findings.

A study by Zheng *et al.* 2018 evaluated (20.3%) cases of osteoporosis in liver cirrhotic patients and observed that it resulted from alcohol consumption and hepatitis virus. Notably, individuals with a lower BMI and higher fibroscan scores exhibited a greater occurrence of osteoporosis (Zheng *et al.*, 2018). The occurrence of osteoporosis in individuals with CLD varied from (13%) to (55%) in Western countries (Chinnaratha *et al.*, 2015; Collier, 2007). Another study conducted by Meena *et al.* 2018 analyzed patients aged 20-65, with varying degrees of liver cirrhosis severity. Elderly patients had a poorer prognosis and reduced quality of life compared to younger patients, with a significant difference observed (p=0.0003) (Meena *et al.*, 2018). A study by Younossi *et al.* revealed comparable results indicating that the age of cirrhosis patients had a detrimental effect on their quality of life (Younossi *et al.*, 2001). In contrast, the finding of the study by Marchesini *et al.* demonstrated that younger patients with cirrhosis experienced a more severe decline in Health Related Quality of Life (HRQL) compared to older patients (Marchesini *et al.*, 2001).

Furthermore, a study by Shukla *et al.* 2023 found that (34.3%) of the patients had liver cirrhosis attributable to alcohol consumption. Among 70 patients, (25.7%) had HBV, while (20%) had cryptogenic cirrhosis and HCV. The combined prevalence of osteoporosis and and osteopenia was found to be 22.9%, respectively (Shukla *et al.*, 2023). Similarly, Soylu *et al.* examined the prevalence of osteoporosis was (1.9%) and osteopenia was (20%) (Soylu *et al.*, 2012). Ninkovic *et al.* found a higher prevalence of (48.8%) for osteopenia and (36.6%) for osteoporosis among cirrhotic patients (Ninkovic *et al.*, 2001). Sokhi *et al.* demonstrated that (11.5%) of the patients had osteoporosis, while (34.6%) had osteopenia (Sokhi *et al.*, 2004). Other (Danford *et al.*, 2020; Mantovani *et al.*, 2019; Shukla *et al.*, 2023). Moschen *et al.* reported (37.8%) osteopenia and (12.8%) osteoporosis (Moschen *et al.*, 2005).

However, numerous studies showed a statistical significance and a positive correlation was between bone mineral density and liver cirrhosis. The prevalence of osteoporosis, osteopenia, and fractures were found to be 45% to 47% on average among chronic liver disease patients (Goral *et al.*, 2010; Luxon, 2011; Turkeli *et al.*, 2008; Vargas *et al.*, 2012). In order to increase bone density, correct vitamin D levels, calcium supplements, regular physical activity, a balanced diet, and an individualized approach to health care are recommended (Rondanelli *et al.*, 2021).

CONCLUSION

In conclusion, the study findings revealed that bone diseases were a prevalent consequence in Sudanese patients with liver cirrhosis. The majority of cases were related to osteoporosis and osteopenia. Bone diseases such as osteopenia and osteoporosis were significantly associated with encephalopathy, higher bilirubin levels, hypernatremia, high MELD scores and severe liver disease (CTP-B and CTP-C). However, HBV was found to be the primary cause of liver cirrhosis, followed by alcohol consumption. Patients with severe cirrhosis had a higher prevalence of osteoporosis, which was linked to low sodium levels and elevated bilirubin levels. In contrast, osteopenia was more prevalent than osteoporosis among patients. Furthermore, the study emphasized the importance of early detection and treatment of bone health problems in patients with liver cirrhosis.

LIMITATIONS AND STRENGTHS

- The limitations of the study may include the generalizability due to a single-center trial with 80 patients and a cross-sectional design.
- However, the study is crucial for determining healthcare accessibility for patients with cirrhosis.
- This study offers insights into the complex relationship between liver cirrhosis and bone health, providing the way for further examination and clinical therapy.

RECOMMENDATIONS

- Cirrhotic patients often experience bone pain and fractures due to bone disease, and orthopedic care is often

neglected. Regular bone mineral density assessments are recommended for all patients with liver cirrhosis.

• Patients with severe stages of cirrhosis should be advised to receive anti-osteoporotic treatment due to the increased risk of bone disease.

• Larger prospective studies or longitudinal studies with frequent clinical evaluations and more accurate biochemical or laboratory assessments are needed to determine the effect of liver disease stage on bone mineral density.

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