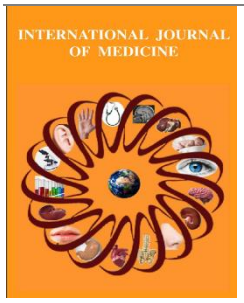
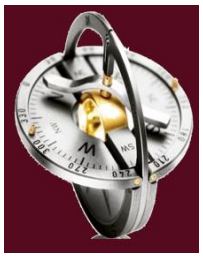
International Journal of Medicine 2025; 7(10): 107-111



International Journal of Medicine

https://www.theinternationalmedicine.com



Research Article

To Study the Association of Vitamin D Deficiency in Cirrhotic Patients in North India: A Case-Control Study

Tanya.[1*], Sunil Kumar Sharma[2], Kusum Bali[3], Sunil Singh Bains[4], Jasmine[5]

[1]Department of Medicine, MBBS, Punjab Institute of Medical Sciences Jalandhar, Punjab, India
[2] Department of Medicine, MD, Punjab Institute of Medical Sciences Jalandhar, Punjab, India
[3] Department of Medicine, MD, Punjab Institute of Medical Sciences Jalandhar, Punjab, India
[4] Department of Medicine, MBBS, Punjab Institute of Medical Sciences Jalandhar, Punjab, India
[5] Department of Medicine, MBBS, Punjab Institute of Medical Sciences Jalandhar, Punjab, India.

Abstract

Background: Globally and in India liver disorders are becoming a notable public health issue, encouraging early screening to detect and assess the disease severity. Liver cirrhosis affects the metabolism and absorption of vitamin D which further affects calcium metabolism. This study aims at evaluating the correlation of 25-hydroxyvitamin D with cirrhosis using Child Pugh score (CTP), model for end-stage liver disease (MELD), MELD 3.0 and MELD-sodium. ***Objectives***: To determine vitamin D deficiency in cirrhotic patients and correlating it with severity of cirrhosis via CTP, MELD, MELD 3.0 and MELD sodium levels. Also, comparing it with a normal population with no comorbidities, serving as controls. ***Material and methods:*** Serum 25-hydrocyvitamin D levels were obtained from both the cases and controls. The deficiency was classified into mild, moderate and severe groups. Furthermore, its relation with Child-Pugh score, model for end-stage liver disease (MELD), MELD 3.0 and MELD sodium was assessed. ***Results***: In the present study comprising 140 participants (70 cirrhotic cases and 70 controls), mean serum vitamin D levels were significantly lower in cases (11.99 ± 13.27 ng/mL) compared to controls (26.51 ± 11.63 ng/mL; $p < 0.01$). Among cirrhotics, only 5.8% had normal vitamin D, while 37.1% showed mild deficiency, 37.1% moderate deficiency, and 20% severe deficiency, indicating a strong inverse association between vitamin D status and liver dysfunction. Most cases were classified as CTP class C (61.4%), followed by class B (37.2%) and class A (1.4%), with mean MELD 3.0, MELD, and MELD-Na scores of 26.66 ± 6.22, 24.59 ± 6.34, and 25.26 ± 6.35, respectively, reflecting advanced disease severity. Vitamin D deficiency correlated significantly with higher CTP and MELD scores ($p < 0.01$), suggesting its potential role as a marker of hepatic dysfunction severity ***Conclusion***: The study reported statistically significant relation between vitamin D deficiency in cirrhotic patients. The dropped level is positively associated with higher stage of liver disease computed via Child-Pugh score, model for end-stage liver disease (MELD), MELD 3.0 and MELD sodium scores.

Keywords: 25-hydroxyvitamin D deficiency, Child-Pugh score, Cirrhosis, Bone diseases

Introduction:

Cirrhosis is a condition manifested by the formation of fibrosis and nodules in the liver due to chronic injury, which destroys the normal lobular organization of the liver [1]. The most standard causes of cirrhosis are hepatitis B virus (HBV), hepatitis C virus (HCV) and alcohol-related liver disease (ALD), out of which HCV infection is leading [2,3]. The eloquent clinical impacts of cirrhosis include compromised hepatocyte function, increased intrahepatic resistance leading to portal hypertension, and the potential development of hepatocellular carcinoma (HCC) [4]. Also, there are ongoing findings on the impact of cirrhosis on vitamin D metabolism and absorption. Vitamin D is a secosteroid hormone (fat soluble hormone with a base same as a steroid hormone) primarily acknowledged for its role in maintaining calcium levels, bone metabolism and enormous effects that include cellular proliferation, differentiation, and immune modulation [5,6]. Vitamin D obtained from diet (D2 and D3) is absorbed in the intestine with the help of biliary acids formed by liver and also Vitamin D being synthesised in skin is either stored in fat cells or converted into 25-hydroxyvitamin D3 in hepatocytes. Another step where liver comes into play in vitamin D metabolism is when it is transferred to liver via vitamin-D binding proteins and albumin proteins which are again synthesised by liver. In patients with cirrhosis, up to 93% have insufficient vitamin D levels, with nearly one-third experiencing severe deficiency [7]. Among the Indian population 80% of cirrhosis patients have deficient vitamin d levels. Insufficiency is defined as a 25(OH)D level below 75 nmol/L (30 ng/mL), while deficiency is characterized by levels below 50 nmol/L (20 ng/mL).Vitamin D deficiency is grouped into three levels of severity: mild deficiency is defined as 25-hydroxyvitamin D levels less than 20 ng/mL, moderate deficiency is characterized by levels less than 10 ng/mL, and severe deficiency is indicated by levels less than 5 ng/mL [8]. The correlation between vitamin D and cirrhosis shows considerable promise for clinical application. A review of the literature indicates that there is insufficient research on populations comprising only individuals with cirrhosis. This study aims to explore the analogy between vitamin D deficiency and cirrhosis, with the purpose of using it as a prognostic index, thereby permitting tailored interventions.

Address for Correspondence: Tanya, Department of Medicine, MBBS, Punjab Institute of Medical Sciences Jalandhar, Punjab, India.
Email: tmahajan317@gmail.com

DOI: 10.5455/im.65875612

Materials and Methods

We conducted a prospective case-control study at our tertiary care centre from the medicine ward and ICU in Punjab Institute of Medical Sciences, Jalandhar, Punjab, India for 6 months after acquiring approval from the Ethics Committee of the Institution. A total of 140 patients were included in the study. 70 consenting patients aged >18-80 years male and female diagnosed with cirrhosis, admitted to a tertiary care hospital were included in the study as cases. For controls, patients aged >18-80 years males and females who presented to medicine OPD for routine check-up and didn't have any comorbidities like diabetes, hypertension, hypothyroidism, cirrhosis liver and chronic kidney disease etc, were included in the study after obtaining the consent. The study lasted from October 2024 to December 2024. Exclusion criteria included (a) Patients with a past history of severe chronic illness (diabetes, hypertension, hypothyroidism, cirrhosis liver and chronic kidney disease); (b) Patients with a history of liver transplantation; (c) Patients taking vitamin d or multivitamin supplementation; (d) Patients with other end stage organ failure; (e) Patients with NAFLD; (f) Patients with malabsorptive conditions; (g) Patients on medications affecting vitamin d absorption and metabolism example glucocorticoids; (h) Pregnant and breastfeeding patients; (i) Patients who refused to give consent.

After applying the necessary criteria, sample size was calculated which is 70 cases and 70 controls. The diagnosis of cirrhosis was made both clinically and radiologically via symptoms of liver failure including fatigue, loss of hair, itchy skin, weight loss, decreased appetite, yellow discoloration of sclera (jaundice), accumulation of fluid in the abdomen (ascites), gastrointestinal bleeding, confusion, drowsiness and slurred speech (hepatic encephalopathy), fluid accumulation in lower limbs (edema), signs such as pallor at lower palpebral conjunctiva, icterus at bulbar conjunctiva, enlargement of parotid gland, spider telangiectasias, liver palms, enlargement of breast known as gynaecomastia, atrophy of testes, thyroid gland examination, blood tests covering complete blood count, liver function tests, renal function tests, PTI/INR, viral makers, 25-hydroxyvitamin D levels and ultrasound of whole abdomen exhibiting shrunken liver with nodular surface, a rough and heterogeneous echotexture, changes in distribution of volume of liver and hypertrophy or atrophy of various sections of lobe, signs of ascites and splenomegaly. CTP, MELD, MELD 3.0 and MELD sodium scores were calculated after noting down the data of each patient into an excel spreadsheet. CTP scoring method was evaluated on the basis of results of serum total bilirubin, albumin, INR, ascites and encephalopathy. MELD score was computed using the values of INR, serum creatinine and total bilirubin while MELD 3.0 was calculated using INR, total bilirubin, serum creatinine, serum sodium, albumin and sex of the patient and the original MELD included the criteria of INR, total bilirubin and serum creatinine for the scores calculation.

Statistical analysis: Data so collected was tabulated in an excel sheet, under the guidance of statistician. The means and standard deviations of the measurements per group were used for statistical analysis (SPSS 22.00 for windows; SPSS inc, Chicago, USA). For each assessment point, data were statistically analyzed using t test and chi square test. The level of significance was set at $p < 0.05$. Pearson correlation test was used to analyse correlation between the two variables..

Results

Table 1: Baseline data among the study groups

Variables	Case		Control		p value
	N=70	%	N=70	%	
Gender					
Male	59	84.3	47	67.1	0.10
Female	11	15.7	23	32.9	
Age in years (Mean±SD)	50.19±12.81		44.37±13.22		0.16
Vitamin d (Mean±SD)	11.99±13.27		26.51±11.63		<0.01*

*: statistically significant

A total of 140 participants were taken in the study, comprising 70 cases and 70 controls. Among the cases, 84.3% were males and 15.7% were females, whereas in the control group, 67.1% were males and 32.9% were females. The difference in gender distribution between the two groups was not statistically significant ($p = 0.10$). The mean age of participants in the case group was 50.19 ± 12.81 years, compared to 44.37 ± 13.22 years in the control group, which was also statistically non-significant ($p = 0.16$). However, the mean serum vitamin D level was significantly lower among cases (11.99 ± 13.27 ng/mL) than among controls (26.51 ± 11.63 ng/mL), indicating a statistically significant difference ($p < 0.01$).

These findings suggest a potential association between lower serum vitamin D levels and the occurrence of the studied condition.

Table 2: Comparison of investigative profile among the study groups

Group		Urea	Creatinine	Sodium	Potassium	Albumin	AST	ALT	ALP	PTI/INR	HB	TLC	PLT
Case	Mean	64.93	2.31	137.43	4.29	2.77	152.47	133.6	184.53	1.74	10.17	10467.59	1.61
	SD	52.49	2.29	7.19	.93	1.01	309.27	368.6	149.06	.58	2.48	5884.57	.94
Control	Mean	33.66	.98	140.73	5.23	4.03	43.90	60.0	109.31	4.34	12.98	8164.52	2.31
	SD	11.86	.26	3.84	4.99	.81	23.19	33.71	36.23	1.15	1.44	2119.06	.55
p value		<0.01*	<0.01*	0.001*	0.12	<0.01*	0.004*	0.098	<0.01*	<0.01*	<0.01*	0.002*	<0.01*

*: statistically significant

A comparison of the biochemical and hematological parameters between the case and control groups revealed significant differences in several variables. The mean serum urea and creatinine levels were markedly higher in cirrhotic patients (64.93 ± 52.49 mg/dL and 2.31 ± 2.29 mg/dL, respectively) compared to controls (33.66 ± 11.86 mg/dL and 0.98 ± 0.26 mg/dL, both $p < 0.01$), indicating impaired renal function among cases. The mean serum sodium level was significantly lower in cases (137.43 ± 7.19 mmol/L) than in controls (140.73 ± 3.84 mmol/L, $p = 0.001$), while the difference in serum potassium was not statistically significant ($p = 0.12$). The mean serum albumin concentration was substantially reduced in cirrhotic patients (2.77 ± 1.01 g/dL) compared to controls (4.03 ± 0.81 g/dL, $p < 0.01$), reflecting compromised hepatic synthetic function.

The liver enzyme profile also showed derangements, with AST and ALP levels being significantly higher in the case group ($p = 0.004$ and $p < 0.01$, respectively), while the difference in ALT was not statistically significant ($p = 0.098$). Coagulation parameters, represented by PT/INR, were markedly prolonged among cirrhotic patients (1.74 ± 0.58) compared to controls (4.34 ± 1.15, $p < 0.01$). Hematological indices showed a significant reduction in hemoglobin levels (10.17 ± 2.48 g/dL vs. 12.98 ± 1.44 g/dL, $p < 0.01$), along with lower platelet counts (1.61 ± 0.94 $\times 10^5$/µL vs. 2.31 ± 0.55 $\times 10^5$/µL, $p < 0.01$). The total leukocyte count was also significantly different between the two groups ($p = 0.002$).

These findings collectively indicate that cirrhotic patients exhibited significant hepatic, renal, and hematological abnormalities, consistent with the multisystem impact of advanced liver disease and supporting the observed association between vitamin D deficiency and cirrhosis severity.

Table 3: Comparison of vitamin D among the study groups

Vitamin d	Case		Control		p value
	N=70	%	N=70	%	
Normal	4	5.8	43	61.4	<0.01*
Mild Deficiency	26	37.1	21	30	
Moderate Deficiency	26	37.1	6	8.6	
Severe Deficiency	14	20	0	0	

*: statistically significant

The distribution of serum vitamin D status among the study groups revealed a marked difference between cases and controls. Among the cases with cirrhosis, only 5.8% had normal vitamin D levels, whereas 37.1% had mild deficiency, 37.1% had moderate deficiency, and 20% had severe deficiency. In contrast, among the controls, 61.4% had normal vitamin D levels, 30% had mild deficiency, and only 8.6% showed moderate deficiency, with no participants exhibiting severe deficiency. The difference in the distribution of vitamin D status between the two groups was statistically significant ($p < 0.01$).
These findings demonstrate a strong association between vitamin D deficiency and cirrhosis, suggesting that declining vitamin D levels may correlate with the severity or presence of liver dysfunction.

Table 4: Distribution of CTP and MELD score among the cases

Variables	N=70	%
CTP Score		
A	1	1.4
B	26	37.2
C	43	61.4
MELD 3.0 (Mean±SD)	26.66±6.22	
MELD (Mean±SD)	24.59±6.34	
MELD NA (Mean±SD)	25.26±6.35	

Among the 70 patients with cirrhosis, the distribution of Child–Turcotte–Pugh (CTP) scores showed that 1.4% of patients were classified as CTP class A, 37.2% as class B, and the majority (61.4%) as class C, indicating that most participants presented with advanced liver disease. The mean MELD 3.0 score was 26.66 ± 6.22, the mean MELD score was 24.59 ± 6.34, and the mean MELD-Na score was 25.26 ± 6.35.
These findings suggest that a significant proportion of the study population had severe hepatic dysfunction, reflecting a high disease burden among cirrhotic patients included in the study.

Table 5: Comparison of vitamin D levels according to CTP score among the cases

CTP Score		Vitamin D Category				Total
		Normal	Mild Deficiency	Moderate Deficiency	Severe Deficiency	
A	N	0	1	0	0	1
	%	0.0%	100.0%	0.0%	0.0%	100.0%
B	N	1	10	9	6	26
	%	3.8%	38.5%	34.6%	23.1%	100.0%
C	N	3	15	17	8	43
	%	7.0%	34.9%	39.5%	18.6%	100.0%
p value		<0.01*				

*: statistically significant

The above data presents a comparison of vitamin D levels according to the Child-Turcotte-Pugh (CTP) score among the cases. The distribution of vitamin D categories—normal, mild deficiency, moderate deficiency, and severe deficiency—varies across the different CTP score groups (A, B, and C). In group A, there was only one case, which had severe vitamin D deficiency, representing 100% of that group. Group B comprised 26 cases, with the majority exhibiting mild to moderate deficiency (38.5% and 34.6%, respectively), and 23.1% with severe deficiency. In group C, consisting of 43 cases, vitamin D deficiency was more prevalent, with 34.9% having mild deficiency, 39.5% moderate deficiency, and 18.6% severe deficiency. The statistical analysis revealed a significant difference among the groups ($p < 0.01$), indicating that lower CTP scores are associated with higher levels of vitamin D deficiency.

Table 6: Comparison of vitamin D levels according to MELD score among the cases

Vitamin D Category	Mean MELD 3.0	SD	Mean MELD	SD	Mean MELD NA	SD
Normal	24.31	3.98	24.14	3.19	24.86	3.38
Mild Deficiency	25.43	2.91	25.12	3.06	25.65	3.09
Moderate Deficiency	27.75	3.57	28.15	4.12	28.03	3.01
Severe Deficiency	29.43	3.91	29.58	4.79	29.51	3.37
p value	0.019*		0.012*		0.016*	

*: statistically significant

Table 6 compares vitamin D levels according to MELD scores among the cases. The data show that the mean MELD scores increase progressively with the severity of vitamin D deficiency. Patients with normal vitamin D levels had mean MELD scores of approximately 24.3, while those with mild deficiency had slightly higher scores around 25.4. The increase becomes more pronounced in moderate deficiency, with mean scores of about 27.8, and is highest in severe deficiency, with mean MELD scores around 29.4. The statistical analysis indicates that these differences are significant across the groups (p-values of 0.019, 0.012, and 0.016, respectively), suggesting that lower vitamin D levels are associated with higher MELD scores, reflecting more severe liver disease.

Discussion

In this case control research, we took 70 cases and 70 controls. Out of 70 cases 59 were males and 11 were females. The mean age group of cases was 50.19±12.81 years. The mean age was almost similar to ours in the study by Nilajkar GM et al. (50±9) [9]. In contrast to the study by Patel JK et al., where the number of males and female cases included in the study were 77 and 23 respectively with mean age being 42.92±10.90 years [10]. In the study by Adiri WN et al., 2024 the number of cases taken were 103 with males and females being 76 and 27 in number respectively. The mean age in their study was 46.8±9.2 [11]. Similar to the above studies, our study also showed that the difference in gender distribution between the cases and controls and the mean age of participants is not statistically significant.

In the current study, the mean hemoglobin (Hb) concentration among cirrhotic patients was 10.17 ± 2.48 g/dL, which is higher than the value reported by Sinha et al. (8.08 ± 2.30 g/dL) [12].

Despite this, the presence of anemia remains evident and can be attributed to nutritional deficiencies, hypersplenism, bone marrow suppression, and blood loss secondary to variceal bleeding, as previously observed in similar populations [13]. The mean platelet count was 1.61 ± 0.94 ×10⁵/µL, slightly exceeding the findings of Sinha et al. (1.05 ± 0.75 ×10⁵/µL). The reduction in platelet levels in cirrhotic patients is typically multifactorial, most commonly due to splenic sequestration caused by portal hypertension and decreased thrombopoietin production by the diseased liver [14].

The mean total bilirubin concentration was 4.98 ± 6.01 mg/dL, aligning with the observations of Ahmad et al., who demonstrated a progressive elevation of bilirubin levels with worsening hepatic function [15]. In our study, the mean AST (SGOT) and ALT (SGPT) levels were 152.47 U/L and 133.6 U/L, respectively, showing a predominance of AST over ALT. This pattern, also noted by Sinha et al., may result from reduced hepatic perfusion and the prevalence of alcohol-induced liver injury, which leads to diminished SGPT activity due to pyridoxal phosphate deficiency.

The mean serum albumin level was 2.77 ± 1.01 g/dL, consistent with the findings of Carvalho and Machado, who described a marked decline in albumin synthesis with advancing cirrhosis (2.5–3.0 g/dL), sometimes falling by 60–80% in severe disease [16]. The mean serum creatinine level in our study was 2.31 ± 2.29 mg/dL, reflecting impaired renal function associated with splanchnic vasodilatation, reduced effective arterial volume, and renal hypoperfusion, as outlined by Slack et al. [17]. The mean serum sodium concentration was 137.43 ± 7.19 mEq/L, comparable to the findings of Young et al., who reported 135.36 ± 1.41 mEq/L, demonstrating the tendency toward hyponatremia in advanced cirrhosis [18].

In our study the cases with cirrhosis, only 5.8% had normal vitamin D levels, whereas 37.1% had mild deficiency, 37.1% had moderate deficiency, and 20% had severe deficiency. In contrast, among the controls, 61.4% had normal vitamin D levels, 30% had mild deficiency, and only 8.6% showed moderate deficiency, with no participants exhibiting severe deficiency. In the study by Patel JK et al., 1% of cases had normal vitamin D levels, 21% had insufficient levels, majority had vitamin D deficiency (56%), and 22 % cases suffered from severe deficiency. Among controls 49% individuals had subnormal vitamin D level. The mean vitamin D level in control group was higher (30.12±6.60) than cases (15.97±7.45). Similarly in our study the mean serum vitamin D level was significantly lower among cases (11.99 ± 13.27 ng/mL) than among controls (26.51 ± 11.63 ng/mL), indicating a statistically significant difference. In the study by Adiri WN et al., cases with liver cirrhosis were distributed as 36.9% with vitamin D deficiency, 31.1% had vitamin D insufficiency while 32.0% had sufficient serum levels. The Endocrine Society Clinical Practice Guideline (ESCPG) [19] recommend screening for vitamin D deficiency in individuals at high risk for cirrhosis, including those with hepatic failure, and recommends vitamin D supplementation in cases of deficiency. There are many other studies which had shown high prevalence of vitamin D deficiency among liver cirrhosis patients [20,21,22].

Our findings demonstrate a significant association between the severity of liver disease, as classified by the Child-Pugh score, and the degree of vitamin D deficiency. Specifically, in our study,1.4% of patients were classified as CTP class A, 37.2% as class B, and the majority (61.4%) as class C. Patients with Child-Pugh class A showed only mild deficiency, while more advanced disease (classes B and C) had higher deficiency rates. In group B (26 cases), 38.5% had mild, 34.6% moderate, and 23.1% severe deficiency. In group C (43 cases), 34.9% had mild, 39.5% moderate, and 18.6% severe deficiency, indicating increased deficiency with disease progression. This trend underscores the impact of liver dysfunction on vitamin D metabolism, likely due to impaired synthesis, hydroxylation, and storage functions of the liver. This observation aligns with the research the study by Kim et al. (2020), where the deficiency of vitamin D increases with CTP score of cases [23]. Similar findings were found in many studies [11,12,24,25].

This study clearly represents that an inverse relation is present between vitamin D deficiency and CTP and MELD scoring systems. In the current study, the mean MELD 3.0, MELD, and MELD-Na scores among cirrhotic patients were 26.66 ± 6.22, 24.59 ± 6.34, and 25.26 ± 6.35, respectively. When categorized according to vitamin D status, there was a clear upward trend in all three indices with increasing severity of deficiency. Individuals with normal vitamin D levels had mean MELD 3.0, MELD, and MELD-Na scores of 24.31 ± 3.98, 24.14 ± 3.19, and 24.86 ± 3.38, while those with severe deficiency recorded significantly higher values (29.43 ± 3.91, 29.58 ± 4.79, and 29.51 ± 3.37; $p < 0.05$). These findings demonstrate a significant association between vitamin D deficiency and greater hepatic dysfunction, indicating its potential role as a marker of disease severity in cirrhosis.

Comparable observations were reported by Ayoub et al. (2025), who identified a strong inverse correlation between serum 25(OH)D and MELD score as well as liver stiffness, irrespective of disease etiology [26]. Nilajkar et al. (2024) also noted that declining vitamin D levels were significantly linked with higher Child–Pugh and MELD scores, reinforcing its prognostic relevance in chronic liver disease [27].

Recent studies assessing the MELD 3.0 system have yielded mixed insights. Di Napoli et al. (2025) reported that despite incorporating sex and albumin adjustments, MELD 3.0 did not reduce sex-based disparities in transplant waitlist survival and, in some cases, worsened overall outcomes, suggesting that demographic differences are multifactorial [28]. Conversely, Putri et al. (2025) demonstrated that MELD 3.0 improved mortality prediction and patient reclassification accuracy compared to the traditional MELD model in a German liver transplant cohort [29]. Our study supports this latter observation, as MELD 3.0 showed enhanced sensitivity to disease progression in patients with vitamin D deficiency.

Taken together, these findings emphasize that while MELD 3.0 refines prognostic accuracy, incorporating metabolic parameters such as vitamin D may provide additional insight into patient outcomes and improve individualized management strategies in chronic liver disease. In contrast to our study Anty R et al., described that vitamin D levels are independent of these scoring systems [30].

Conclusion

In our study vitamin D deprivation is shown in cirrhotic patients in addition to it, the correlation with severity of cirrhosis is also revealed. Thus, higher the severity, lower the vitamin D levels and increased the risk of infections. So, to decrease the morbidity and mortality in chronic liver disease, it's important to get routine serum 25-hydroxyvitamin D levels checked to provide early intervention via supplements.

References

1. Sharma B, John S. Hepatic Cirrhosis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan– [updated 2022 Oct 31].
2. Huang DQ, Terrault NA, Tacke F, Gluud LL, Arrese M, Bugianesi E, et al. Global epidemiology of cirrhosis — aetiology, trends and predictions. Nat Rev Gastroenterol Hepatol. 2023;20(5):388–98. doi:10.1038/s41575-023-00723-1.
3. Gonzalez-Chagolla A, Olivas-Martinez A, Ruiz-Manriquez J, et al. Cirrhosis etiology trends in developing countries: transition from infectious to metabolic conditions. Lancet Reg Health Am. 2021;7:100151. doi:10.1016/j.lana.2021.100151.
4. Schuppan D, Afdhal NH. Liver cirrhosis. Lancet. 2008;371(9615):838–51. doi:10.1016/S0140-6736(08)60383-9.
5. Konstantakis C, Tselekouni P, Kalafateli M, Triantos C. Vitamin D deficiency in patients with liver cirrhosis. Ann Gastroenterol. 2016;29(3):297–306. doi:10.20524/aog.2016.0037.
6. Kitson MT, Roberts SK. D-livering the message: the importance of vitamin D status in chronic liver disease. J Hepatol. 2012;57(4):897–909. doi:10.1016/j.jhep.2012.04.033.
7. Iruzubieta P, Terán Á, Crespo J, Fábrega E. Vitamin D deficiency in chronic liver disease. World J Hepatol. 2014;6(12):901–15. doi:10.4254/wjh.v6.i12.901.
8. Kumar R, Kumar P, Saxena KN, Mishra M, Mishra V, Kumari A, et al. Vitamin D status in patients with cirrhosis of the liver and their relatives: a case control study from North India. Indian J Gastroenterol. 2017;36(1):40–45. doi:10.1007/s12664-017-0727-7.
9. Nilajkar GM, Kolwalkar RJ, Prithvi KA. Hepatic decompensation in patients with chronic liver disease: exploring the role of vitamin D deficiency as a prognostic marker. J Assoc Physicians India. 2024;72(3):82–6. doi:10.59556/japi.72.0352.

10. Patel JK, Mahur HK, Jat SS, Singh DP. A study of the correlation of serum vitamin D levels to Child-Pugh and MELD-Na scoring system in cirrhosis of the liver. Int J Res Med Sci. 2020;9(1):210–14. doi:10.18203/2320-6012.ijrms20205846.
11. Adiri WN, Basil B, Onyia CP, Asogwa P, Ugwuanyi OJ, Obienu O, et al. Association between serum vitamin D status and severity of liver cirrhosis: implications for therapeutic targeting in Nigerian patients. BMC Gastroenterol. 2024;24(1):259. doi:10.1186/s12876-024-03353-1.
12. Sinha S, Chaudhary SC, Usman K, Sawlani KK. To compare between CTP, MELD, MELD-Na, MELD + HDLc, RDW, and RDW to platelet ratio as a predictor of short-term mortality in cirrhosis of liver. J Clin Diagn Res. 2025;73(9):P37–42.
13. Manrai M, Dawra S, Kapoor R, et al. Anemia in cirrhosis: an underestimated entity. World J Clin Cases. 2022;10(3):777–89.
14. Peck-Radosavljevic M. Hypersplenism. Eur J Gastroenterol Hepatol. 2001;13(4):317–23.
15. Cohen JA, Kaplan MM. The SGOT/SGPT ratio—an indicator of alcoholic liver disease. Dig Dis Sci. 1979;24:835–38.
16. Carvalho JR, Machado MV. New insights about albumin and liver disease. Ann Hepatol. 2018;17(4):547–60.
17. Slack A, Yeoman A, Wendon J. Renal dysfunction in chronic liver disease. Crit Care. 2010;14(2):214.
18. Young S, Rostambeigi N, Golzarian J, et al. MELD or sodium MELD: a comparison of the ability of two scoring systems to predict outcomes after transjugular intrahepatic portosystemic shunt placement. AJR Am J Roentgenol. 2020;215(1):215–22.
19. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2011;96(7):1911–30.
20. Putz-Bankuti C, Pilz S, Stojakovic T, Scharnagl H, Pieber TR, Trauner M, et al. Association of 25-hydroxyvitamin D levels with liver dysfunction and mortality in chronic liver disease. Liver Int. 2012;32(5):845–51.
21. Ciardullo S, Muraca E, Cannistraci R, Perra S, Lattuada G, Perseghin G. Low 25(OH) vitamin D levels are associated with increased prevalence of nonalcoholic fatty liver disease and significant liver fibrosis. Diabetes Metab Res Rev. 2023;39(5):e3628.
22. Khan D, Alam F, Khan JD. Vitamin D deficiency in patients with chronic liver disease. Med Forum Mon. 2022;33(1).
23. Kim TH, Yun SG, Choi J, Goh HG, Lee HA, Yim SY, et al. Differential impact of serum 25-hydroxyvitamin D3 levels on the prognosis of patients with liver cirrhosis according to MELD and Child-Pugh scores. J Korean Med Sci. 2020;35(19):e129. doi:10.3346/jkms.2020.35.e129.
24. Trépo E, Ouziel R, Pradat P, Momozawa Y, Quertinmont E, Gervy C, et al. Marked 25-hydroxyvitamin D deficiency is associated with poor prognosis in patients with alcoholic liver disease. J Hepatol. 2013;59(2):344–50.
25. Stokes CS, Krawczyk M, Reichel C, Lammert F, Grünhage F. Vitamin D deficiency is associated with mortality in patients with advanced liver cirrhosis. Eur J Clin Invest. 2014;44(2):176–83.
26. Ayoub S, Sheikh A, Raina Y, Mahmood K. The impact of vitamin D deficiency on CTP and MELD scores in chronic liver disease. J Cardiovasc Dis Res. 2025;16(2):90–96.
27. Nilajkar GM, Kolwalkar RJ, Prithvi KA. Hepatic decompensation in patients with chronic liver disease: exploring the role of vitamin D deficiency as a prognostic marker. J Assoc Physicians India. 2024;72(3):82–86.
28. Di Napoli M, Nydam T, Baimas-George M, Choudhury R, Kaplan B, Malamon J. The sex-based survival disparity persists in liver transplantation: MELD 3.0 fails to improve upon the disadvantage for waitlisted women. Am J Transplant. 2025;25(Suppl 1).
29. Putri AJ, Uluk D, Czigany Z, Michalski C, Lurje G, Husen P. Validation of MELD 3.0 scoring system: a single-center analysis from Germany. Am J Transplant. 2025;25(Suppl 1).
30. Anty R, Tonohouan M, Ferrari-Panaia P, Piche T, Pariente A, Anstee QM, et al. Low levels of 25-hydroxy vitamin D are independently associated with the risk of bacterial infection in cirrhotic patients. Clin Transl Gastroenterol. 2014;5(5):e56.