Vol.20, No.2, Page 510- 516, 2026 http://dx.doi.org/10.59628/jchm.v20i2.2453 ISSN 2958-7476 JMCH

Sana'a University Journal of Medical and Health Sciences

Hematological Abnormalities in Patients with Chronic Liver Disease Attending Republican Teaching Hospital Authority in Sana'a city, Yemen

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Abstract

Background: Chronic liver disease (CLD) is frequently associated with hematological abnormalities, contributing significantly to patient morbidity and mortality. However, data on this topic are scarce in Yemen.
Objectives: This study aimed to evaluate the spectrum and magnitude of hematological abnormalities in patients with CLD who attended the Republican Teaching Hospital Authority in Sana'a City, Yemen.
Methods: A cross-sectional study was conducted from September 2024 to June 2025, involving 400 patients with CLD diagnosed clinically and by ultrasonography. Three milliliters of venous blood was collected for complete blood count analysis. Data were analyzed using SPSS version 26.
Results: The mean age of the participants was 41.1 ± 14.4 years, with a male predominance (68.8%). Anemia was observed in 60.5% of the patients (27.3% mild, 56.6% moderate, and 16.1% severe). Leukopenia affected 43.0% (87.8% mild, 11.6% moderate, and 0.6% severe) of the patients, whereas leukocytosis was rare (5.5%). Thrombocytopenia was highly prevalent at 65.8% (42.6% mild, 47.1% moderate, and 10.3% severe), with thrombocytosis noted in only 0.5% of patients. Chi-square analysis showed that the distributions of anemia, leukopenia, and thrombocytopenia were statistically significant ($p < 0.001$).
Conclusion: Hematological abnormalities, particularly anemia and thrombocytopenia, are highly prevalent among CLD patients in Sana'a, Yemen, often presenting in moderate to severe forms. Early detection and management of these complications are crucial for improving patient outcomes.

Article Info

Keywords:
Chronic Liver Disease, Hematological Abnormalities, Anemia, Leukopenia, Thrombocytopenia, Yemen.

Article History:
Received: 31-October-2025,
Revised: 20-January-2026,
Accepted: 10-March-2026,
Published: 28 April 2026.

1. INTRODUCTION

The liver is fundamental to maintaining blood homeostasis through several integrated functions. It acts as a key storage site for essential micronutrients, such as iron, vitamin B12, and folic acid, all of which are vital for proper red blood cell (RBC) formation. Although the kidneys are the primary source of erythropoietin, the liver contributes approximately 10% of its continuous production, making it a minor but consistent player in supporting erythropoiesis [1, 2].

In response to inflammation, infection, or sufficient systemic iron levels, the liver produces the regulatory hormone hepcidin, which plays a central role in controlling iron absorption and mobilization. By modulating iron availability, hepcidin indirectly influences RBC production, thus linking hepatic function to systemic erythropoietic activity [3].

Moreover, the liver plays a central role in lipid metabolism, synthesizing and regulating various lipids and cholesterol that are crucial for maintaining the structural integrity and flexibility of RBC membranes, ensuring the deformability and survival of erythrocytes as they navigate the circulatory system, enabling optimal oxygen transport [4]

In chronic liver disease (CLD), leukocytosis often occurs during acute decompensation or infection, driven by systemic inflammation and increased neutrophil production. Although white blood cell (WBC) counts increase, these cells may be functionally impaired, reflecting immune

system dysregulation [5, 6]. In contrast, leukopenia is common in advanced cirrhosis due to hypersplenism, bone marrow suppression from toxins or nutrient deficiencies, and immune-mediated inhibition of blood cell production. This reflects the immunosuppressive state of late-stage liver disease [7–9].

The liver is the primary site of thrombopoietin synthesis, which is the key hormone regulating platelet production in the bone marrow; therefore, chronic liver disease can significantly affect platelet count and platelet-related parameters, contributing to the development of thrombocytopenia [1, 2].

CLD is defined as a persistent deterioration of liver function lasting more than six months, characterized by continuous hepatocellular damage, inflammation, and disorganized regeneration that ultimately leads to fibrosis and cirrhosis. This progressive condition compromises the liver's metabolic and synthetic functions, often leading to systemic complications [10].

Patients with CLD commonly exhibit a wide range of hematological abnormalities arising from multiple factors, including hypersplenism due to portal hypertension, chronic blood loss, bone marrow suppression, dysregulation of hematopoietic growth factors, impaired synthesis of coagulation factors, and altered immune responses, all of which collectively contribute to blood cell imbalances and increased clinical risk [11, 12].

CLD is associated with significant morbidity and mortality rates. Hematological abnormalities are common in CLD but are often underappreciated. This study is particularly important in Yemen because of the lack of previous data on this topic. This study aimed to evaluate hematological abnormalities in patients with CLD attending the Republican Teaching Hospital Authority in Sana'a City, Yemen.

2. SUBJECTS AND METHODS

This cross-sectional study was conducted at the Republican Teaching Hospital Authority in Sana'a, Yemen, from September 2024 to June 2025. The study included both male and female patients aged 18 years and older with a confirmed diagnosis of chronic liver disease (CLD). Diagnosis was established based on the presence of at least one feature persisting for six months or more. These features included abnormal liver biochemistry, such as persistent elevation of alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), total bilirubin, or reduced serum albumin. Structural liver changes detected on imaging, particularly abdominal ultrasound, such as liver surface nodularity, altered echotexture, hepatomegaly or atrophy, splenomegaly, or increased portal vein diameter suggestive of portal hypertension, were also considered diagnostic. Clinical manifestations of CLD, including jaundice, ascites, hepatic encephalopathy, palmar erythema, spider angiomas, or other stigmata of chronic liver injury, were included, as well as histological evidence of chronic liver injury when liver biopsy was available. Patients were included in the study only if they met at least one of these criteria and attended the hospital during the study period.

The exclusion criteria encompassed patients younger than 18 years; those with chronic conditions known to cause anemia, such as sickle cell disease, thalassemia, or chronic kidney disease; individuals with infectious diseases, including HIV/AIDS; and patients taking medications that could affect hematological or coagulation parameters. Additionally, patients with acute hepatitis, drug-induced liver injury, acute liver failure, malignancy, jaundice secondary to seasonal viral infections, or those who were unable to provide informed consent were excluded from the study.

A total of 400 participants were enrolled, with the sample size calculated using the OpenEpi program (version 2.3.1), assuming a 95% confidence level, an expected anemia frequency of 50% among CLD patients, a design effect of 1, and a statistical power of 80%. Three milliliters of venous blood was drawn from each participant into EDTA tubes for complete blood count (CBC) analysis.

Socio-demographic data, including age and sex, were collected using a standardized questionnaire. The CBC tests were performed using a Sysmex automated analyzer. Anemia was classified according to hemoglobin (HGB) concentration: in adult males, mild (11.0–12.9 g/dl), moderate (8.0–10.9 g/dl), and severe (<8.0 g/dl); in non-pregnant females, mild (11.0–11.9 g/dl), moderate (8.0–10.9 g/dl), and severe (<8.0 g/dl); and in pregnant women, mild (10.0–10.9 g/dl), moderate (7.0–9.9 g/dl), and severe (<7.0 g/dl) [13]. Leukopenia was classified as mild (2.0–3.9 × 10^9/L), moderate (1.0–1.9 × 10^9/L), or severe (<1.0 × 10^9/L) [14], while leukocytosis was defined as a WBC count above 11 × 10^9/L [15]. Thrombocytopenia was defined based on platelet count levels and classified according to severity. Mild thrombocytopenia was considered when the platelet count ranged from 100 to less than 150 × 10^9/L, moderate thrombocytopenia when the platelet count ranged from 50 to less than 100 × 10^9/L, and severe thrombocytopenia when the platelet count was less than 50 × 10^9/L [16], whereas thrombocytosis was defined as a platelet count exceeding 450 × 10^9/L [17].

Data were analyzed using SPSS version 27 (SPSS Inc., Chicago IL, USA). Descriptive statistics, including frequencies, percentages, means, standard deviations, and medians with ranges were calculated. Differences between males and females were analyzed using the independent-samples t-test for normally distributed data and the Mann–Whitney U test for non-normally distributed variables. Categorical data were compared using the chi-square test, and statistical significance was

Table[1]: Demographic Characteristics of Study Participants with CLD

Variable	Number (Percentage)
Age (Mean ± SD)	41.1 ± 14.4 years
18–28 years	87 (21.8)
29–39 years	108 (27.0)
40–50 years	111 (27.8)
51–61 years	57 (14.2)
62–72 years	29 (7.2)
> 72 years	8 (2.0)
Sex n(%)	
Male	275 (68.8)
Female	125 (31.2)

set at $p < 0.05$.

Ethical approval was obtained from the Committee on Postgraduate Studies and Scientific Research of the Faculty of Medicine and Health Sciences. Written informed consent was obtained from all participants after they were informed of the study objectives and procedures.

3. RESULTS

A total of 400 study participants were diagnosed with CLD. The mean age of the participants was 41.1±14.4 years. Regarding sex distribution, the majority of patients were male (68.8%), while female patients comprised 31.2% of the total sample (Table 1).

Patients with CLD showed no significant differences between males and females in HGB levels (11.7 ± 2.8 g/dL vs. 11.4 ± 2.3 g/dL, p value = 0.232), RBCs count (4.4 ± 0.9 $\times 10^6/\mu$L vs. 4.4 ± 0.8 $\times 10^6/\mu$L, p value = 0.532), PCV (35.9 ± 7.9 % vs. 35.3 ± 6.5 %, p value = 0.397), MCV (81.6 ± 10.8 fL vs. 81.2 ± 9.9 fL, p value = 0.732), MCH (26.6 ± 4.4 pg vs. 26.2 ± 3.8 pg, p value = 0.352), MCHC (32.6 ± 2.1 g/dL vs. 32.3 ± 1.7 g/dL, p value = 0.099), and RDW-CV (17.4 ± 3.6 % vs. 17.2 ± 3.2 %, p value = 0.562) (Table 2).

Patients with CLD showed no significant differences between males and females in WBCs count expressed as median and IQR (4.3 (IQR 3.15) vs. 4.3 (IQR 2.83), p = 0.805), neutrophil count (2.4 (IQR 2.12) vs. 2.4 (IQR 1.62), p = 0.994), basophil count (0.02 (IQR 0.03) vs. 0.03 (IQR 0.03), p = 0.444), MPV (10.3 ± 1.1 fL vs. 10.3 ± 1.3 fL, p = 0.845), PDW (15.4 ± 3.6 % vs. 14.9 ± 4.1 %, p = 0.291), and P-LCR (34.2 ± 9.3 % vs. 33.4 ± 10.4 %, p = 0.466). However, significant differences were observed in lymphocyte count expressed as median and IQR (1.0 (IQR 1.02) vs. 1.2 (IQR 1.41), p = 0.025), monocyte count (0.4 (IQR 0.33) vs. 0.3 (IQR 0.26), p = 0.001), eosinophil count (0.1 (IQR 0.19) vs. 0.1 (IQR 0.12), p = 0.016), platelet count expressed as median and IQR (108.0 (IQR 99.0) vs. 124.0 (IQR 118.5), p = 0.027), and PCT (0.14 ± 0.1 % vs. 0.15 ± 0.1 %, p = 0.044) (Table 3).

A comparison of anemia between male and female patients with CLD is presented in Table (4). Anemia was present in 63.3% of males and 54.4% of females, with no statistically significant difference between the sexes (p = 0.092).

The severity of the hematological abnormalities in patients with CLD is summarized in Table (5). Anemia was the most common abnormality, observed in 242 patients (60.5% of the total). Regarding severity, 27.3% of the cases were mild, 56.6% were moderate, and 16.1% were severe.

Regarding WBC abnormalities, leukopenia was identified in 172 patients (43.0%), whereas leukocytosis was less common, affecting 22 patients (5.5%). Among those with leukopenia, 87.8% had mild leukopenia, 11.6% had moderate leukopenia, and only 0.6% had severe leukopenia. Thrombocytopenia was another highly prevalent abnormality, affecting 263 (65.8%) patients. Of these, 42.6%, 47.1%, and 10.3% had mild, moderate, and severe disease, respectively. In contrast, thrombocytosis was rare, being reported in only two cases (0.5%).

4. DISCUSSION

In the present study, among the 400 patients diagnosed with CLD, 68.8% were men and 31.2% were women. This male predominance is consistent with the findings of Chintala and Saadvi [18], who reported that males comprised 66.6% of their study population, compared to 33.3% females. Similarly, Inkalagi and Katti [19] found that 80% of their patients with CLD were male. Behera

Table[2]: Comparison of HGB and RBCs indices among between Male and Female of CLD

Parameters	Male (Mean ± SD)	Female (Mean ± SD)	*p*-value
HGB (g/dl)	11.7 ± 2.8	11.4 ± 2.3	0.232
RBCs ($\times 10^6$/µL)	4.4 ± 0.9	4.4 ± 0.8	0.532
PCV (%)	35.9 ± 7.9	35.3 ± 6.5	0.397
MCV (fL)	81.6 ± 10.8	81.2 ± 9.9	0.732
MCH (pg)	26.6 ± 4.4	26.2 ± 3.8	0.352
MCHC (g/dl)	32.6 ± 2.1	32.3 ± 1.7	0.099
RDW-CV (%)	17.4 ± 3.6	17.2 ± 3.2	0.562

Comparison performed by independent sample t-test, data are mean ±SD, **SD**; standard deviation, **HGB**: Hemoglobin, **RBCs**: Red Blood Cells **PCV**: Packed Cell Volume, **MCV**: Mean Cell Volume, **MCH**: Mean Cell Hemoglobin, **MCHC**: Mean Cell Hemoglobin Concentration, **RDW-CV**: Red Cell Distribution Width Coefficient of Variation.

Table[3]: Comparison of WBCs and platelets indices between Male and Female of CLD

Parameters	Male (Mean ± SD) or median (IQR)	Female (Mean ± SD) or median (IQR)	*p*-value
WBCs ($\times 10^3$/µL)	4.3 (3.15)	4.3 (2.83)	0.805
Neutrophils count ($\times 10^3$/µL)	2.4 (2.12)	2.4 (1.62)	0.994
Lymphocytes count ($\times 10^3$/µL)	1.0 (1.02)	1.2 (1.41)	0.025*
Monocytes count ($\times 10^3$/µL)	0.4 (0.33)	0.3 (0.26)	0.001*
Eosinophils count ($\times 10^3$/µL)	0.1 (0.19)	0.1 (0.12)	0.016*
Basophils count ($\times 10^3$/µL)	0.02 (0.03)	0.03 (0.03)	0.444
Platelets ($\times 10^3$/µL)	108.0 (99.0)	124.0 (118.5)	0.027*
PCT (%)	0.14 ± 0.1	0.15 ± 0.1	0.044*
MPV (fL)	10.3 ± 1.1	10.3 ± 1.3	0.845
PDW (%)	15.4 ± 3.6	14.9 ± 4.1	0.291
P-LCR (%)	34.2 ± 9.3	33.4 ± 10.4	0.466

Comparison performed by independent sample t-test and Mann-Whitney test, data are mean ±SD or median(IQR), * p<0.05 is statistically significant, **SD**: standard deviation, **IQR;** Interquartile Range , **WBCs**; White Blood Cells, **PCT**: Plateletcrit, **MPV**: Mean Platelet Volume, **PDW**: Platelet Distribution Width, and **P-LCR**: Platelet-Large Cell Ratio.

Table[4]: Comparison of Anemia between Male and Female of CLD

Parameters		Male (n%)	Female (n%)	*p*-value
Anemia	Yes	174 (63.3%)	68 (54.4%)	0.092
	No	101 (36.7%)	57 (45.6%)	

Comparison was performed using the chi-square test, and data are presented as frequency and percentage, n: number of individuals.

Table[5]: Severity of Hematological Abnormalities in CLD Patients

Variable	No. (%)	Severity No. (%)			*p*-value
		Mild	Moderate	Severe	
HGB					
Anemia	242 (60.5)	66 (27.3)	137 (56.6)	39 (16.1)	$< 0.001^*$
WBCs					
Leukopenia	172 (43.0)	151 (87.8)	20 (11.6)	1 (0.6)	$< 0.001^*$
Leukocytosis	22 (5.5)				
Platelets					
Thrombocytopenia	263 (65.8)	112 (42.6)	124 (47.1)	27 (10.3)	$< 0.001^*$
Thrombocytosis	2 (0.5)				

Comparison was performed using chi-square test; data are frequency and percentage; n: number of individuals; * p value < 0.05.

and Dash [20] also documented a pronounced male dominance, with 85.51% of the participants being male, resulting in a male-to-female ratio of 5.9:1. Similarly, Kaur *et al*. [1] noted that 86.6% of their patient group was male. These consistent observations across multiple studies indicate a higher prevalence of CLD among men, likely due to increased exposure to risk factors such as alcohol use, viral hepatitis, and occupational hazards, which are more commonly associated with males.

Regarding age distribution, the average age in our study was 41.1 ± 14.4 years, which aligns with findings reported in the literature. Inkalagi and Katti [19] recorded a patient age range spanning from 18 years to over 70, with most cases falling between 31 and 40 years (30%), which corresponds to our observation that the most represented age groups were in their 30s and 40s. Similarly, Selvamani and Thomas [21] found the majority of patients to be middle-aged. Behera and Dash [20] reported a mean age of 49.8 ± 13.19 years, and Chandra *et al*. [22] found that most patients were between 31 and 50 years old. However, Khare *et al*. [23] reported a slightly older mean age of 47.56 ± 13.77 years, with mean ages for males and females at 48.708 ± 12.36 and 44.607 ± 16.74 years, respectively. Solomen *et al*. [24] also found a comparable pattern, with an average patient age of 48 years and 70% of their cohort aged between 40 and 60 years. This recurring trend across various studies reinforces the fact that CLD predominantly affects individuals in middle age, highlighting the importance of early screening, timely diagnosis, and targeted interventions for this age group to prevent disease progression and mitigate complications.

This study examined several hematological parameters in CLD patients and found a notable prevalence of abnormalities, particularly anemia, leukopenia, and thrombocytopenia. These findings contribute to the broader understanding of hematologic involvement in CLD. Anemia was highly prevalent among the patients, with a notable proportion experiencing moderate to severe forms, highlighting the importance of assessment and management in this population. These outcomes are comparable to other studies. Inkalagi and Katti [19] reported severe anemia (<6 g/dL) in 9.33% of cases, with a range of severity across other levels. Chandra *et al*. [22] observed anemia in 88% of patients, including 24% with severe anemia. Likewise, Selvamani and Thomas [21] found anemia in 88 of 100 patients, with 32 cases classified as severe (<8 g/dL). Behera and Dash [20] recorded a mean HGB of 7.99 ± 2.18 g/dL, with 89.85% of patients having HGB levels below 11 g/dL, and 53.62% with HGB $\leq$ 8 g/dL, indicating a significant burden of severe anemia. Kaur *et al*. [1] also reported a mean HGB of 8.8 g/dL, with 43.3% of their patients presenting with severe anemia.

Awasthi *et al*.[25] found a mean HGB level of 10.215 ± 3.339 g/dL, with anemia (<11 g/dL) detected in 75% of their subjects. Our findings are also in line with Chintala and Saadvi [18], who reported a mean HGB of 10.7 g/dL, with mild anemia in 18.6%, moderate in 17.3%, and severe in 10.6% of cases. Tomar *et al*. [26] observed anemia in 71% of their patients, further highlighting the frequent occurrence of anemia in CLD. The high rate and varying severity of anemia in CLD are likely multifactorial, involving reduced erythropoiesis, gastrointestinal (GI) blood loss, hypersplenism, and nutritional deficiencies [27, 28].

The mean WBC count in our cohort was 5.09 ± 3.18 × $10^3/\mu$L. Leukopenia was identified in 43.0% of patients, with most cases being mild (87.8%), followed by moderate (11.6%) and severe (0.6%) (p =0.001). Leukocytosis was less frequent, seen in only 5.5% of cases. Inkalagi and Katti [19] reported WBC counts between 2000–4000/μL in 26.6% of patients, and less than 2000/μL in 6.67%, indicating severe leukopenia. Selvamani and Thomas [21] found leukocytosis in 22% of patients and leukopenia in 6%. Chintala and Saadvi [18] observed leukopenia (WBC count between 2000–4000/μL) in 64% of cases and severe leukopenia (<2000/μL) in 9.3%. Tomar *et al*. [26] noted leukopenia in 21% of patients. These findings reflect the variability in WBC abnormalities among CLD patients, which may be influenced by disease cause, coexisting infections, hypersplenism, and bone marrow suppression [29].

Thrombocytopenia was another major hematologic issue, found in 68.0% of the cases. Among these patients, 42.6%, 47.1%, and 10.3% had mild, moderate, and severe thrombocytopenia, respectively (p =0.001). Thrombocytosis was rare, occurring in only 0.5% of patients. The mean platelet count was 142.49 ± 89.46 × $10^3/\mu$L. These results are consistent with those of prior research. Inkalagi and Katti [19] reported mild thrombocytopenia in 25.3%, moderate in 6.6%, and severe in 1.3% of the patients. Selvamani and Thomas [21] noted thrombocytopenia in 46% of their sample, with severe thrombocytopenia (<50,000/μL) strongly associated with splenomegaly and a history of major hematemesis. Behera and Dash [20] found reduced platelet counts in 68.12% of patients, with 33.33% having counts below 100,000/μL. In the study by Solomen *et al*. [24], thrombocytopenia (<100,000/μL) was observed in 50% of the patients. Among those with upper GI bleeding, only three had normal platelet counts, whereas the rest had significantly low levels. The average platelet count in patients with GI bleeding was 92,000 /μL, compared to 120,000 /μL in those without bleeding.

Chintala and Saadvi [18] reported mild thrombocytopenia in 14.6%, moderate in 13.3%, and severe in 12%, attributing the condition to factors such as reduced thrombopoietin production, hypersplenism, consumptive coagulopathy, and bone marrow suppression [28]. Similarly, Tomar *et al*. [26] observed thrombocytopenia in 56% of cases. These findings further confirm that thrombocytopenia is a hallmark hematological manifestation of CLD,

often reflecting underlying portal hypertension, splenic sequestration, and impaired platelet synthesis [29].

The high prevalence of hematological abnormalities observed in this study may be influenced by several local factors that are specific to the Yemeni context. Yemen has a relatively high prevalence of parasitic infections, such as schistosomiasis, which can contribute to portal hypertension and hypersplenism, thereby exacerbating cytopenias, particularly anemia and thrombocytopenia. Furthermore, prolonged conflict and socioeconomic instability have resulted in widespread food insecurity and malnutrition, leading to deficiencies in essential nutrients, such as iron, folate, and vitamin B12, which are critical for normal hematopoiesis. Limited access to healthcare services, delayed presentation to medical facilities, and inadequate management of chronic liver disease may also contribute to the advanced disease stages at which many patients are diagnosed, thereby increasing the severity of hematological abnormalities. These local factors may partly explain the high prevalence and predominance of moderate-to-severe anemia and thrombocytopenia observed in the present study, underscoring the need for context-specific preventive and therapeutic strategies.

5. CONCLUSIONS

This study highlights the substantial burden of hematological abnormalities in patients with chronic liver disease (CLD) who attended the Republican Teaching Hospital Authority in Sana'a, Yemen. Anemia was the most prevalent abnormality, affecting more than half of the patients, with a considerable proportion presenting with moderate-to-severe forms. Thrombocytopenia was also highly prevalent, observed in nearly two-thirds of the study population, with moderate and severe thrombocytopenia comprising the majority of cases. Leukopenia was frequently identified, predominantly in its mild form, whereas leukocytosis was relatively uncommon.

The predominance of moderate-to-severe anemia and thrombocytopenia represents the most clinically significant finding of this study, underscoring the profound impact of CLD on hematopoietic function and the associated risk of bleeding, infection, and disease-related complications. These findings emphasize the importance of routine hematological monitoring and early intervention in patients with CLD.

Future research should focus on investigating the specific etiologies and underlying mechanisms of anemia and thrombocytopenia in CLD, including nutritional deficiencies, bone marrow suppression, hypersplenism, and chronic blood loss. Longitudinal multicenter studies are also recommended to assess disease progression, treatment response, and outcomes, thereby improving the clinical management and prognosis of patients with chronic liver disease.

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