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ORIGINAL ARTICLE

Prevalence and Pathophysiology of Anemia in Pakistani Patients with Chronic Liver Disease (CLD). A Clinical and Infectious Etiology-Based Study

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ABSTRACT

Background: Anemia is a common but underappreciated complication of chronic liver disease (CLD), contributing to fatigue, impaired immunity, and worse clinical outcomes. In Pakistan, where viral hepatitis and alcohol-related liver injury are prevalent, data on anemia prevalence and underlying mechanisms in CLD are scarce.

Methods: We conducted a cross-sectional study of 90 adult CLD patients recruited consecutively from Pakistan Employees Military Hospital, Rawalpindi, and The University of Lahore Teaching Hospital between January 2022 and April 2023. Demographic and clinical data were recorded, and detailed laboratory tests complete blood count, iron profile, vitamin B12 and folate levels, liver function tests, coagulation profile, and viral serologies were performed. Anemia was classified by red cell indices into microcytic, normocytic, or macrocytic subtypes and graded as mild, moderate, or severe according to WHO criteria. Etiologies of CLD were determined clinically and via imaging, with special focus on hepatitis B, hepatitis C, alcohol-related liver disease, non-alcoholic fatty liver disease (NAFLD), and autoimmune hepatitis.

Results: The cohort's mean age was 52 ± 12 years; 66.7% were male. Hepatitis C (44.4%) and hepatitis B (20.0%) were the most common CLD etiologies. Anemia was present in 100% of patients: microcytic in 45.6%, normocytic in 38.9%, and macrocytic in 15.6%. Moderate anemia predominated (52.2%), followed by mild (26.7%) and severe (21.1%). Microcytic anemia correlated strongly with hepatitis C and NAFLD, while macrocytic anemia was most frequent in alcoholic liver disease ($p < 0.05$).

Conclusions: Anemia affects all CLD patients in this Pakistani cohort, with distinct morphological patterns linked to specific liver disease etiologies. Routine hematologic screening and targeted management iron supplementation, vitamin repletion, and antiviral therapy are essential to improve patient outcomes.

Keywords: Anemia; Chronic liver disease; Cirrhosis; Pathophysiology; Pakistan; Hepatitis C

INTRODUCTION

Chronic liver disease (CLD) is a global health concern associated with significant morbidity and mortality, particularly in low- and middle-income countries such as Pakistan. CLD encompasses a progressive spectrum of hepatic insults that lead to sustained liver inflammation, hepatocyte injury, fibrosis, and ultimately cirrhosis or hepatocellular carcinoma (HCC)[1]. It is typically caused by long-standing liver damage resulting from viral hepatitis (particularly hepatitis B and C), alcohol abuse, autoimmune hepatitis, metabolic liver diseases such as non-alcoholic fatty liver disease (NAFLD), and exposure to hepatotoxic substances. In Pakistan, the burden of CLD is escalating due to the high endemicity of hepatitis B and C viruses, combined with poor vaccination coverage, limited access to early diagnostic facilities, increasing prevalence of metabolic syndrome, and suboptimal healthcare infrastructure[2].

Among the numerous systemic complications of CLD, anemia is one of the most frequently encountered hematological abnormalities, often presenting in early stages and worsening as the disease advances. Anemia is defined as a decrease in the number of red blood cells (RBCs) or hemoglobin concentration below the physiological reference range and has significant clinical implications in CLD patients[3]. It contributes to fatigue, decreased exercise tolerance, impaired immunity, increased susceptibility to infections, worsened hepatic encephalopathy, and a poor overall prognosis. Despite its frequency and impact, anemia in CLD is frequently underdiagnosed and inadequately managed, especially in resource-limited healthcare settings[4].

The pathophysiology of anemia in CLD is complex and multifactorial. It is often the result of a combination of hemodynamic, nutritional, infectious, and hematopoietic disturbances. Hypersplenism, a consequence of portal hypertension in cirrhosis, leads to sequestration and premature destruction of red blood cells, white blood cells, and platelets. Chronic gastrointestinal bleeding, particularly from esophageal varices or portal hypertensive gastropathy, causes iron loss and iron-deficiency anemia[5]. Additionally, nutritional deficiencies including iron, folate, and vitamin B12 are prevalent in CLD patients due to poor dietary intake, malabsorption, and impaired hepatic storage. Bone marrow suppression may occur due to chronic systemic inflammation, infections (such as hepatitis viruses), or alcohol toxicity. Moreover, the anemia of chronic disease, which is characterized by iron sequestration in macrophages, reduced erythropoietin responsiveness, and elevated levels of hepcidin, further exacerbates anemia in these patients. Advanced liver disease also leads to hormonal imbalances and cytokine dysregulation that affect erythropoiesis[6].

The situation in Pakistan is further complicated by the high prevalence of infectious etiologies of CLD, particularly hepatitis B and C, which are known to exert direct effects on bone marrow function and immune-mediated hemolysis. Hepatitis C virus (HCV), for example, has been linked to aplastic anemia, myelodysplastic syndrome-like changes, and autoimmune hemolytic anemia[7]. In such patients, anemia may also be aggravated by antiviral therapies such as ribavirin, which causes hemolytic anemia. Hepatitis B virus (HBV) infection, similarly, has been associated with immune thrombocytopenia and various forms of anemia secondary to chronic inflammation or antiviral therapy. In addition to viral hepatitis, bacterial infections, tuberculosis, and intestinal parasitic infestations which remain endemic in many regions of Pakistan also contribute to the development and progression of anemia in CLD patients[8].

Despite the clinical importance of anemia in the setting of chronic liver disease, there remains a paucity of comprehensive, multicenter studies in Pakistan evaluating its true burden, underlying etiologies, and clinical correlations. Most published data

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are either limited to hematological profiling without etiological breakdown or are based on international populations with different disease patterns and healthcare access. In the Pakistani context, unique socio-demographic factors, healthcare disparities, and the overlapping burden of infectious diseases necessitate a more localized understanding of the anemia-CLD relationship. Additionally, there is a need to differentiate between various types of anemia including microcytic, normocytic, and macrocytic subtypes and their correlation with the stage and etiology of liver disease, particularly in the backdrop of cirrhosis and decompensation[9,10].

This study is designed to fill this critical knowledge gap by assessing the prevalence and pathophysiological mechanisms of anemia in a cohort of Pakistani patients with chronic liver disease, with particular emphasis on clinical presentation and infectious etiologies[11]. By incorporating a detailed clinical, biochemical, and hematological evaluation of patients attending two tertiary care hospitals in Pakistan, this study aims to classify the types of anemia observed, identify contributing etiologies, and correlate anemia severity with the type of liver disease and degree of hepatic dysfunction. A special focus will be placed on identifying the influence of viral hepatitis, alcohol use, NAFLD, and autoimmune hepatitis on hematological profiles, as well as the impact of anemia on patient outcomes. The findings of this study are expected to aid clinicians in early identification, stratification, and appropriate management of anemia in CLD patients, ultimately improving quality of life and long-term prognosis.Overall, this clinical and infectious etiology-based study aims to provide an in-depth analysis of the burden, patterns, and pathophysiological underpinnings of anemia in chronic liver disease among the Pakistani population, contributing valuable evidence for clinical decision-making and targeted interventions in hepatology practice[12].

MATERIALS AND METHODS

This descriptive cross-sectional study was carried out at two major tertiary care hospitals in Pakistan: Pakistan Employees Military Hospital (PEMH), Rawalpindi and The University of Lahore Teaching Hospital, Lahore. The study was conducted over a period of sixteen months, from January 2022 to April 2023. These two centers were selected due to their high patient turnover of chronic liver disease (CLD) cases, enabling a representative sample of the Pakistani population to be studied.

A total of 90 patients diagnosed with chronic liver disease were enrolled in this study using a non-probability consecutive sampling technique. All patients included were aged 18 years or older, belonged to both genders, and had a confirmed diagnosis of CLD based on clinical evaluation, laboratory investigations, and ultrasonographic evidence of chronic hepatic insult. Patients were included after obtaining informed written consent, and participation was entirely voluntary. The inclusion criteria specifically required adult patients with a known diagnosis of CLD due to any etiology. Patients were excluded if they had hematologic malignancies, were currently receiving chemotherapy or radiotherapy, were pregnant, had a history of chronic kidney disease, or were already diagnosed with primary hematological disorders such as autoimmune hemolytic anemia.

Data collection was performed using a structured proforma designed for the study. Demographic details such as age, gender, and occupation were recorded, along with detailed medical history including presenting complaints, duration and progression of liver disease, history of gastrointestinal bleeding, dietary patterns, alcohol intake, and any previous diagnosis or treatment of anemia. Special focus was given to infectious etiologies of liver disease, particularly hepatitis B virus (HBV) and hepatitis C virus (HCV). These were diagnosed using ELISA testing for HBsAg and anti-HCV antibodies, with polymerase chain reaction (PCR) confirmation where applicable.

Each patient underwent comprehensive laboratory evaluation, including complete blood count (CBC) with red blood cell indices (MCV, MCH, MCHC), reticulocyte count, and peripheral blood smear examination. Serum iron profile was obtained, including serum iron, serum ferritin, total iron-binding capacity (TIBC), and transferrin saturation. In addition, serum vitamin B12 and folate levels were measured to detect nutritional deficiencies. Liver function tests (ALT, AST, ALP, total and direct bilirubin, serum albumin), coagulation profile (prothrombin time, INR), and renal function tests were also performed. Abdominal ultrasound imaging was used to assess liver size, echotexture, presence of ascites, splenomegaly, and signs of portal hypertension.

The type of anemia in each patient was classified based on peripheral smear morphology and red cell indices into microcytic, normocytic, or macrocytic anemia. The severity of anemia was graded according to the World Health Organization (WHO) criteria: mild (hemoglobin 11–11.9 g/dL in females and 11–12.9 g/dL in males), moderate (8–10.9 g/dL), and severe (<8 g/dL). Etiological correlations were made based on clinical presentation, history, and laboratory findings, particularly in relation to viral hepatitis, alcohol-related liver disease, autoimmune hepatitis, and non-alcoholic fatty liver disease.

Ethical approval for the study was obtained from the Institutional Ethical Review Boards of both participating hospitals. All patient data were handled with strict confidentiality, and the study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Patients were not subjected to any additional invasive procedures beyond their routine clinical care, and results were shared with the treating teams for appropriate management where necessary.

All data were entered and analyzed using IBM SPSS Statistics version 25.0. Quantitative variables such as age, hemoglobin levels, and red cell indices were presented as mean and standard deviation, while categorical variables such as gender, type of anemia, and etiological category of CLD were expressed as frequencies and percentages. The Chi-square test was used to evaluate associations between categorical variables such as type of anemia and underlying etiology of liver disease. A p-value of less than 0.05 was considered statistically significant.

RESULTS

This cross-sectional study enrolled a total of 90 patients diagnosed with chronic liver disease (CLD) from two tertiary care hospitals in Pakistan. The demographic and clinical characteristics of the study population are summarized below.

The mean age of the study participants was approximately 52 years, with a range between 20 and 80 years. Among the 90 patients, 60 were male (66.7%), and 30 were female (33.3%), as shown in Table 1. The male predominance in CLD could be attributed to the higher exposure to etiological risk factors such as viral hepatitis and alcohol consumption, as well as delayed healthcare-seeking behavior in males.

Table 1: Gender Distribution of CLD Patients

Gender	Frequency	Percentage (%)
Male	60	66.7
Female	30	33.3

Table 2: Etiology of Chronic Liver Disease in the Study Population

CLD Etiology	Frequency	Percentage (%)
Hepatitis C	40	44.4
Hepatitis B	18	20.0
Alcoholic Liver Disease	14	15.6
Non-Alcoholic Fatty Liver Disease (NAFLD)	14	15.6
Autoimmune Hepatitis	4	4.4

The etiological distribution of chronic liver disease is presented in Table 2. The most common underlying cause was Hepatitis C virus infection, observed in 44.4% (n=40) of the patients. This was followed by Hepatitis B infection in 20.0% (n=18), Alcoholic liver disease in 15.6% (n=14), and Non-Alcoholic Fatty Liver Disease (NAFLD) also in 15.6% (n=14) of the cases. A

smaller subset, 4.4% (n=4) of patients, had Autoimmune Hepatitis as the primary etiology. These findings are consistent with national epidemiological trends, where viral hepatitis remains the dominant cause of CLD in Pakistan.

The analysis of types of anemia revealed that the majority of patients suffered from microcytic anemia, which was found in 45.6% (n=41) of cases. Normocytic anemia was the second most common, identified in 38.9% (n=35) of patients. Macrocytic anemia was observed in 15.6% (n=14). These findings are illustrated in Table 3. The predominance of microcytic anemia likely reflects chronic gastrointestinal blood loss (e.g., from variceal bleeding) or nutritional iron deficiency, both of which are common in CLD. Normocytic anemia in these patients could be due to anemia of chronic disease, while macrocytic anemia may be linked to alcohol-induced bone marrow suppression or vitamin B12/folate deficiency.

Table 3: Types of Anemia Among CLD Patients

Type of Anemia	Frequency	Percentage (%)
Microcytic	41	45.6
Normocytic	35	38.9
Macrocytic	14	15.6

Regarding the severity of anemia, as classified by World Health Organization (WHO) criteria, moderate anemia was the most frequently observed, present in 52.2% (n=47) of patients. Mild anemia was noted in 26.7% (n=24), while severe anemia was found in 21.1% (n=19), as detailed in Table 4. Moderate to severe anemia levels were especially prevalent in patients with Hepatitis C, alcoholic liver disease, and NAFLD, indicating the multifactorial nature of anemia in CLD including poor nutritional status, chronic inflammation, and portal hypertension–related hypersplenism.

Table 4: Severity of Anemia in CLD Patients

Anemia Severity	Frequency	Percentage (%)
Moderate	47	52.2
Mild	24	26.7
Severe	19	21.1

Upon subgroup analysis, it was observed that microcytic anemia was significantly more common in patients with Hepatitis C and NAFLD, possibly due to chronic blood loss and iron deficiency. Macrocytic anemia was primarily associated with alcoholic liver disease, in line with the known suppressive effect of alcohol on hematopoiesis and its interference with folate metabolism. Normocytic anemia appeared more uniformly across all etiologies but was slightly more frequent in patients with autoimmune hepatitis and moderate-stage Hepatitis B. Furthermore, moderate anemia was dominant across all groups, highlighting a substantial but manageable burden that often goes unnoticed without targeted hematological screening.

In conclusion, the results of this study underscore the high prevalence and complex pathophysiology of anemia in chronic liver disease patients. The findings highlight the need for routine screening, classification, and individualized management of anemia in this patient population, particularly in those with viral hepatitis and alcohol-related liver conditions. The stratification of anemia by morphology and severity offers crucial insights for clinicians to optimize treatment strategies and improve overall patient outcomes.

DISCUSSION

This study provides comprehensive insight into the prevalence, morphological classification, and severity of anemia among patients with chronic liver disease (CLD) in a Pakistani clinical context. The findings affirm that anemia is a highly prevalent comorbidity in CLD, with over 90% of patients in this cohort exhibiting varying degrees of hematological impairment. The observed male predominance (66.7%) in CLD cases aligns with regional epidemiological data, reflecting greater exposure to risk factors such as hepatitis C virus (HCV) infection and alcohol consumption among males[12,13].

The etiological analysis revealed that HCV was the most frequent cause of CLD, consistent with the high endemicity of this virus in Pakistan. Hepatitis B, alcoholic liver disease, and NAFLD were also significant contributors. This distribution emphasizes the ongoing burden of infectious diseases alongside the rising impact of lifestyle-related liver pathology[14].

A key finding of the present study is the predominance of microcytic anemia (45.6%), most likely secondary to chronic gastrointestinal blood loss due to portal hypertension, iron deficiency, or poor dietary intake. This was followed by normocytic anemia (38.9%), which may reflect anemia of chronic disease, bone marrow suppression, or early-stage nutritional deficiency. Macrocytic anemia (15.6%) was less common but significantly associated with alcoholic liver disease, likely due to alcohol-induced bone marrow toxicity and folate/B12 malabsorption. These patterns are consistent with previous studies indicating multifactorial mechanisms contributing to anemia in CLD, including iron sequestration, hypersplenism, chronic inflammation, and malnutrition[15].

In terms of severity, moderate anemia (52.2%) was most commonly observed, followed by mild (26.7%) and severe anemia (21.1%). The high proportion of patients with moderate to severe anemia is clinically significant, as such degrees of anemia are associated with reduced oxygen delivery to tissues, fatigue, cognitive impairment, and diminished quality of life. Furthermore, anemia in CLD has been linked to poor prognostic outcomes, including increased hospitalizations, hepatic encephalopathy, and higher Model for End-Stage Liver Disease (MELD) scores[16].

The association between anemia type and CLD etiology was evident in this study. Patients with HCV and NAFLD had a higher frequency of microcytic anemia, possibly due to long-standing occult bleeding and malnutrition, while macrocytic anemia was largely confined to alcoholic liver disease, corroborating previous evidence of alcohol-related marrow suppression[17]. Patients with autoimmune hepatitis and hepatitis B, on the other hand, showed more cases of normocytic anemia, possibly reflecting inflammation-mediated changes and early-stage marrow involvement[18].

This study also underscores the importance of early detection and categorization of anemia in patients with CLD. Identification of the specific type and cause of anemia is essential not only for symptomatic management but also for improving liver-related outcomes[19]. For instance, iron supplementation may benefit microcytic patients, while macrocytic anemia requires vitamin repletion and alcohol abstinence counseling. Additionally, timely antiviral therapy in hepatitis B and C patients can indirectly reduce anemia severity by slowing disease progression and reducing inflammation[20-22].

Despite its strengths, the study has some limitations. The sample size, although statistically adequate, may not fully represent all geographic and ethnic populations of Pakistan. The cross-sectional design limits the ability to draw causal inferences between liver disease progression and anemia development[23]. Additionally, bone marrow studies were not conducted, which could have provided further clarity on the underlying mechanisms in refractory anemia cases. Nonetheless, the findings offer valuable guidance for clinicians and policy-makers addressing hematologic complications in CLD[24,25].

CONCLUSION

This study highlights a high prevalence of anemia among patients with chronic liver disease in Pakistan, with microcytic and moderate anemia being the most common presentations. The data demonstrate significant associations between anemia type and the underlying etiology of liver disease, particularly linking microcytic anemia with HCV and NAFLD, and macrocytic anemia with alcoholic liver disease. The study emphasizes the need for routine hematologic screening and tailored management approaches to

improve patient outcomes. Given the multifactorial nature of anemia in CLD including iron deficiency, nutritional deficits, hypersplenism, and chronic inflammation a one-size-fits-all approach is insufficient. Effective management must be etiology-specific and severity-based, incorporating nutritional support, antiviral treatment, and regular monitoring of hematological parameters. Future studies with longitudinal follow-up and bone marrow correlation are recommended to further elucidate the pathophysiological mechanisms and guide therapeutic strategies.

Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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