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Renal Dysfunction In Chronic Liver Disease: A Cross-Sectional Analysis Of Prevalence, Etiology, And Biomarker Correlations At A Tertiary Care Center In Western India

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Abstract

Background & Aims: Renal dysfunction constitutes a serious complication in chronic liver disease (CLD), significantly increasing mortality. While the hemodynamic mechanisms are established, population-specific data on prevalence, etiological spectrum, and biomarker correlates remain limited in Western Indian contexts. This study aimed to characterize renal dysfunction in CLD patients at a tertiary care center in Bhavnagar, India.
Methods: In this cross-sectional study, we enrolled 127 consecutive CLD patients meeting inclusion criteria between January and June 2023. Renal dysfunction was defined as serum creatinine ≥1.5 mg/dL or 24-hour urine output <500 mL. Comprehensive clinical, demographic, and laboratory parameters were analyzed using appropriate statistical methods.
Results: The cohort demonstrated male predominance (94%) with mean age 47.7±12.6 years. Alcoholic liver disease was the predominant etiology (80.3%). Renal dysfunction prevalence was 33.9%, with upper gastrointestinal hemorrhage (51.2%) and infections (35.4%) as leading precipitants. Significant biomarker abnormalities included elevated serum bilirubin >2 mg/dL (69.3%), hypoalbuminemia <3.2 g/dL (49.6%), elevated serum creatinine >1.4 mg/dL (33.9%), and hyponatremia <135 mmol/L (19.7%). Hypoalbuminemia was significantly associated with infection-related renal dysfunction (81.4% versus 26.2% in hemorrhage-related cases, $p<0.001$).
Conclusion: Renal dysfunction is a prevalent complication in decompensated CLD, with distinct regional etiological patterns and biomarker correlates. Proactive renal surveillance and etiology-specific management strategies are imperative for improving outcomes in this population.

Keywords: Renal dysfunction, chronic liver disease, hepatorenal syndrome, cirrhosis, biomarkers, hypoalbuminemia, cross-sectional study.

Introduction

Chronic liver disease (CLD) represents a significant global health burden, with cirrhosis currently ranking as the 11th most common cause of death worldwide [1]. Renal dysfunction emerges as one of the most formidable complications of advanced CLD, substantially increasing mortality risk and complicating

clinical management [2]. The pathophysiological interplay between hepatic and renal dysfunction in cirrhosis is complex, primarily driven by portal hypertension-induced systemic vasodilation and consequent neurohumoral activation [3]. This hemodynamic derangement predisposes patients to functional renal impairment, ranging from subclinical hypoperfusion to overt hepatorenal syndrome (HRS).

The spectrum of renal dysfunction in CLD encompasses various entities, including pre-renal azotemia, acute tubular necrosis, and HRS—a functional renal failure specific to advanced liver disease characterized by intense renal vasoconstriction in the absence of structural kidney damage [4]. Current understanding recognizes HRS as part of a continuum of renal impairment in cirrhosis, with recent classifications distinguishing HRS-acute kidney injury (HRS-AKI) from HRS-non-AKI [5]. Diagnostic criteria have evolved to emphasize smaller changes in serum creatinine, facilitating earlier intervention [6].

While the association between CLD and renal dysfunction is well-established globally, population-specific epidemiological data remain limited, particularly in Western Indian contexts. Regional variations in CLD etiology, genetic factors, and healthcare access may significantly influence the prevalence, clinical presentation, and outcomes of renal complications. Previous studies have identified triggers such as infections (particularly spontaneous bacterial peritonitis) and gastrointestinal hemorrhage as common precipitants of renal dysfunction in cirrhosis [7], but the correlation between specific biochemical parameters and different etiologies of renal impairment warrants further investigation.

This study aimed to bridge these knowledge gaps by comprehensively analyzing the prevalence, etiological spectrum, severity, and biochemical correlates of renal dysfunction in CLD patients at a tertiary care hospital in Bhavnagar, Western India. The findings provide valuable region-specific epidemiological data to inform clinical practice and resource allocation for this high-risk population.

Methods

Study Design and Setting

We conducted a hospital-based, cross-sectional study at the Department of General Medicine, Sir T Hospital, Bhavnagar, between January and June 2023. The study was approved by the Institutional Ethics Committee (Ref: 1195/2022) and conducted in accordance with the Declaration of Helsinki. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines were followed in the reporting of this study.

Participants

We screened 197 consecutive adult patients (>18 years) with CLD and suspected renal dysfunction. CLD diagnosis required the presence of clinical features (ascites or jaundice), ultrasound evidence (cirrhotic morphology or portal hypertension), and laboratory confirmation (INR >1.3 or albumin <3.5 g/dL). Exclusion criteria comprised pre-existing primary renal diseases, diabetes mellitus, hypertension, and recent nephrotoxic drug exposure (e.g., NSAIDs or aminoglycosides within 7 days). After applying exclusion criteria, 127 patients were enrolled in the study (Figure 1).

Variables and Data Sources

The primary outcome was renal dysfunction, operationally defined as serum creatinine ≥1.5 mg/dL or 24-hour urine output <500 mL. Secondary outcomes included etiological classification of renal dysfunction and correlation with biochemical parameters.

Data collection utilized a pre-validated case record form capturing demographic characteristics, CLD etiology, clinical presentation, and comprehensive laboratory parameters including serum creatinine, urea, bilirubin, albumin, sodium, and complete blood count. Hepatorenal syndrome was diagnosed using

International Club of Ascites 2015 criteria [6]. Abdominal ultrasounds were interpreted by radiologists blinded to clinical data to minimize bias.

Laboratory Methods

Serum creatinine was measured using the Jaffe method (Beckman Coulter AU680 analyzer). Other biochemical parameters were assessed using standardized automated analyzers with quality control measures implemented throughout the study period.

Statistical Methods

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean ± standard deviation for normally distributed variables; frequencies and percentages for categorical variables) characterized the cohort. Group comparisons used Chi-square tests for categorical variables and ANOVA for continuous variables. Correlations between biochemical parameters and renal dysfunction were assessed using Spearman's rho. Multivariable logistic regression adjusted for potential confounders including age and ascites severity. Statistical significance was set at $p < 0.05$.

Results

Participant Characteristics

The final analysis included 127 patients with a mean age of 47.7 ± 12.6 years. The cohort demonstrated marked male predominance (94%), with half of the participants (50%) aged between 41-60 years (Table 1).

Table 1: Demographic and clinical characteristics of study participants (n=127)

Characteristic	Value
Age (years)	
Mean ± SD	47.7 ± 12.6
18-40, n (%)	37 (29.1)
41-60, n (%)	63 (49.6)
>60, n (%)	27 (21.3)
Gender, n (%)	
Male	119 (93.7)
Female	8 (6.3)
Clinical presentation, n (%)	
Jaundice	88 (69.3)
Ascites on examination	39 (30.7)

Characteristic	Value
Pallor	23 (18.1)
Altered sensorium	11 (8.7)
Pedal edema	11 (8.7)

Etiology of Liver Disease and Renal Dysfunction

Alcoholic liver disease constituted the predominant etiology of CLD (80.3%), followed by hepatitis B (6.3%), hepatitis C (3.9%), and non-alcoholic steatohepatitis (3.1%) (Table 2). Upper gastrointestinal bleeding was the leading precipitant of renal dysfunction (51.2%), followed by infections including spontaneous bacterial peritonitis (35.4%). Hepatorenal syndrome type 2 accounted for 9.4% of renal dysfunction cases.

Table 2: Etiology of chronic liver disease and precipitants of renal dysfunction (n=127)

Variable	n	%
CLD Etiology		
Alcoholic liver disease	102	80.3
Hepatitis B	8	6.3
Hepatitis C	5	3.9
Non-alcoholic steatohepatitis	4	3.1
Idiopathic	8	6.3
Renal Dysfunction Precipitants		
Upper GI bleeding	65	51.2
Infections (SBP, AGE, others)	43	35.4
Hepatorenal syndrome type 2	12	9.4
Idiopathic	7	5.5

Laboratory Parameters

Key laboratory findings are summarized in Table 3. Notable abnormalities included elevated serum bilirubin (>2 mg/dL) in 69.3% of patients, hypoalbuminemia (<3.2 g/dL) in 49.6%, elevated serum creatinine (>1.4 mg/dL) in 33.9%, and hyponatremia (<135 mEq/L) in 19.7%. Ultrasound examination revealed ascites in 81.9% of patients and shrunken liver morphology in 92.1%.

Table 3: Laboratory parameters of study participants (n=127)

Parameter	Mean ± SD	Normal Range
Serum creatinine (mg/dL)	1.26 ± 0.32	0.6-1.4
Serum urea (mg/dL)	43.11 ± 15.68	15-40
Serum sodium (mEq/L)	137.2 ± 4.68	135-145
Serum bilirubin total (mg/dL)	2.58 ± 0.98	<1.2
Serum albumin (g/dL)	3.19 ± 0.48	3.5-5.2
Prothrombin time (seconds)	24.10 ± 2.69	11-13.5
International Normalized Ratio	1.40 ± 0.21	0.8-1.2

Laboratory Parameters by Etiology of Renal Dysfunction

Stratified analysis revealed significant associations between biochemical parameters and specific precipitants of renal dysfunction (Table 4). Hypoalbuminemia (<3.2 g/dL) was substantially more prevalent in patients with infection-related renal dysfunction (81.4%) compared to those with upper GI bleeding (26.2%) or HRS-2 (41.7%) ($p<0.001$). Conversely, hyponatremia (<135 mEq/L) was most frequent in the upper GI bleeding group (26.2%).

Table 4: Distribution of laboratory abnormalities by cause of renal dysfunction

Laboratory Abnormality	Upper GI Bleeding (n=65)	Infection (n=43)	HRS-2 (n=12)	p-value
Elevated creatinine (>1.4 mg/dL)	17 (26.2%)	13 (30.2%)	10 (83.3%)	0.001
Hyponatremia (<135 mEq/L)	17 (26.2%)	1 (2.3%)	2 (16.7%)	0.002
Elevated bilirubin (>2.0 mg/dL)	44 (67.7%)	33 (76.7%)	5 (41.7%)	0.053
Hypoalbuminemia (<3.2 g/dL)	17 (26.2%)	35 (81.4%)	5 (41.7%)	<0.001

Laboratory Abnormality	Upper GI Bleeding (n=65)	Infection (n=43)	HRS-2 (n=12)	p-value

Discussion

This cross-sectional study provides comprehensive characterization of renal dysfunction in CLD patients from a Western Indian tertiary care center, revealing several noteworthy findings. The high prevalence of renal dysfunction (33.9%) underscores the substantial burden of this complication in decompensated CLD, consistent with previous reports documenting renal impairment in 20-50% of cirrhotic patients [8].

The demographic profile of our cohort, with marked male predominance (94%) and mean age of 47.7 years, reflects regional epidemiological patterns of CLD. The overwhelming predominance of alcoholic liver disease (80.3%) as the underlying etiology contrasts with Western cohorts where non-alcoholic fatty liver disease has emerged as the leading cause of CLD [9], highlighting important geographical variations in disease patterns. This etiological distribution aligns with previous Indian studies reporting alcohol as the predominant cause of CLD, though the proportion in our cohort exceeds most previous reports [10].

The identification of upper gastrointestinal hemorrhage and infections as leading precipitants of renal dysfunction corroborates existing literature on triggers of acute kidney injury in cirrhosis [7]. The pathophysiological mechanisms linking these events to renal impairment involve further compromise of effective arterial blood volume in already hemodynamically unstable cirrhotic patients. Gastrointestinal hemorrhage leads to true volume depletion, while infections, particularly spontaneous bacterial peritonitis, exacerbate systemic vasodilation through inflammatory cytokine release and bacterial translocation [11].

A key finding of our study is the strong association between hypoalbuminemia and infection-related renal dysfunction, observed in 81.4% of such cases. This correlation underscores the multifactorial role of albumin in cirrhosis - beyond its function as a marker of hepatic synthetic capability, albumin plays crucial roles in maintaining circulatory integrity, binding endotoxins, and modulating inflammatory responses [12]. The significant disparity in hypoalbuminemia prevalence between infection-related renal dysfunction (81.4%) and hemorrhage-related cases (26.2%) suggests distinct pathophysiological pathways and supports the potential utility of targeted albumin infusion in infected, hypoalbuminemic CLD patients, consistent with demonstrated benefits in spontaneous bacterial peritonitis [13].

The high prevalence of hyponatremia (19.7%) in our cohort, particularly among patients with hemorrhage-induced renal dysfunction (26.2%), reflects the severity of underlying circulatory dysfunction and neurohormonal activation in advanced cirrhosis. Hyponatremia in cirrhosis results from non-osmotic arginine vasopressin release secondary to effective arterial hypovolemia, and its presence correlates with disease severity and mortality risk [14].

Notably, the mean serum creatinine in our cohort (1.26 mg/dL) may underestimate the true degree of renal impairment, as patients with advanced cirrhosis often have reduced muscle mass and consequently lower creatinine generation [15]. This limitation underscores the need for more sensitive biomarkers of renal function in cirrhosis, such as cystatin C, though practical constraints often limit their routine use in resource-limited settings.

The ultrasonographic findings of ascites in 81.9% of patients and shrunken liver in 92.1% indicate advanced disease stage in our cohort, consistent with the tertiary care setting of this study. These findings align with

the high prevalence of other markers of decompensation including elevated bilirubin (69.3%) and prolonged INR (mean 1.40).

Limitations

Several limitations warrant consideration in interpreting our findings. The cross-sectional design precludes assessment of temporal relationships and long-term outcomes. The single-center nature may limit generalizability, though the consecutive enrollment minimizes selection bias. The operational definition of renal dysfunction based on serum creatinine and urine output, while clinically practical, may lack sensitivity for early renal impairment compared to newer biomarkers. Additionally, the exclusion of patients with diabetes and hypertension, while intended to isolate liver-related renal dysfunction, may limit complete representation of the CLD population. Finally, the lack of longitudinal data prevents assessment of renal recovery trajectories and mortality associations.

Clinical and Research Implications

Despite these limitations, our findings have important clinical implications. The high prevalence of renal dysfunction in this CLD cohort underscores the necessity for proactive renal surveillance in decompensated patients. The distinct biomarker patterns associated with different precipitants of renal impairment suggest potential for targeted management strategies—particularly albumin supplementation in hypoalbuminemic patients with infections. Future prospective studies should validate these associations and evaluate interventions based on identified risk factors.

Conclusion

This study demonstrates a high prevalence of renal dysfunction in patients with chronic liver disease at a tertiary care center in Western India, with alcoholic liver disease constituting the predominant etiology. Upper gastrointestinal hemorrhage and infections represent the most common precipitants, with distinct biomarker correlates—hypoalbuminemia strongly associates with infection-related renal dysfunction, while hyponatremia predominates in hemorrhage-related cases. These findings highlight the importance of etiology-specific risk stratification and management approaches for renal complications in CLD. Enhanced renal surveillance, prompt identification and treatment of precipitating factors, and consideration of biomarker-guided interventions may improve outcomes in this high-risk population.

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