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RESEARCH ARTICLE
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COMPARISON OF PORTAL AND RENAL DOPPLER PARAMETERS IN PATIENTS OF CHRONIC LIVER DISEASE WITH OR WITHOUT AKI

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Abstract

Aim: To compare portal & renal doppler parameters in patients with AKI vs non-AKI in chronic liver disease patients.

Methods: This prospective study was conducted over two years at MM Institute of Medical Sciences, Mullana, Ambala, and included 100 patients diagnosed with CLD. Patients were classified according to the Child-Pugh score and assessed for the presence of AKI using KDIGO criteria. Portal vein peak systolic velocity (PSV), hepatic artery resistive index (RI), and renal RI were measured using duplex Doppler ultrasonography.

Results: Among the study population, alcohol-related liver disease was the most common etiology (58%). Decompensated cirrhosis was observed in 56% of patients. AKI was present in 33% of cases, and HRS was diagnosed in 8%, exclusively among those with decompensated cirrhosis. Doppler findings showed a significantly reduced portal vein PSV and elevated hepatic artery RI in decompensated patients ($p < 0.05$). Renal RI was significantly higher in patients with AKI compared to those without ($p = 0.033$), with the highest values seen in HRS cases.

Conclusion: Portal and renal Doppler ultrasonography provides a valuable, non-invasive method for assessing hepatic and renal hemodynamics in CLD patients. Doppler parameters correlate with disease severity and renal impairment, particularly in detecting AKI and HRS. Routine use of Doppler imaging may enhance early diagnosis, risk stratification, and clinical management in chronic liver disease.

Keywords: Chronic liver disease (CLD), Acute kidney injury (AKI), Hepatorenal syndrome (HRS), Portal Vein (PV), Hepatic artery (HA), Resistive index (RI), Peak systolic velocity (PSV)

Introduction: Chronic liver disease (CLD) is characterized by a progressive decline in liver function, driven by a persistent cycle of inflammation, destruction, and regeneration of the liver parenchyma, ultimately leading to fibrosis and cirrhosis. Cirrhosis represents the final stage of all chronic liver diseases.[1] Etiologies of CLD are diverse and include toxins, alcohol, infections, autoimmune disorders, as well as genetic and metabolic conditions. Cirrhosis is broadly classified

into compensated and decompensated stages. Compensated cirrhosis is typically asymptomatic, whereas decompensated cirrhosis is marked by the development of complications related to portal hypertension and/or liver dysfunction, such as ascites, variceal hemorrhage, or hepatic encephalopathy.[2] Acute kidney injury (AKI) is defined by a sudden decline in renal function, manifested by elevated blood creatinine levels, decreased urine output, or the need for renal replacement therapy (RRT). In critically ill patients, AKI is associated with increased morbidity and mortality, with an incidence ranging from 30% to 60%. The presence of multiple underlying conditions in these patients suggests that the pathophysiology of AKI is multifactorial and involves various contributing mechanisms.[3-5] Renal impairment is a frequent complication in patients with cirrhosis, affecting approximately one in five individuals and contributing to increased morbidity and mortality. Among patients hospitalized with hepatic dysfunction, renal impairment is observed in 20% to 50% of cases. The most severe manifestation of renal dysfunction in chronic liver disease is hepatorenal syndrome (HRS), which is associated with a markedly reduced survival rate[6,7]

Hepatorenal syndrome (HRS) is classically considered a functional form of acute kidney injury (AKI) commonly seen in patients with advanced liver disease. It is characterized by intense intrarenal vasoconstriction, which reduces the glomerular filtration rate and leads to secondary salt and water retention.[8,9] In advanced liver disease, peripheral vasodilation triggers compensatory activation of various hormonal and neurohormonal vasoconstrictor systems that further decrease effective renal blood flow. Despite these significant functional changes, renal imaging and histological examinations typically appear normal.[10,11]

Several scoring systems are available to evaluate prognosis and mortality risk in patients with chronic liver disease, with the Child-Pugh scoring system (also known as the Child-Pugh-Turcotte score) being the most widely used and preferred method for predicting mortality in individuals with cirrhosis. This scoring system incorporates five parameters based on clinical findings and laboratory values: serum bilirubin, serum albumin, international normalized ratio (INR), presence and severity of ascites, and hepatic encephalopathy.

Doppler ultrasonography is an essential instrument for assessing hemodynamic alterations in cirrhotic liver tissue. Doppler ultrasound assesses many characteristics associated with blood hemodynamics, including portal vein velocity, congestion index, pulsatility index, hepatic artery & hepatic vein Doppler ultrasound pattern.[12] The assessment of hemodynamic markers indicative of hyperdynamic circulation & portal hypertension, alongside Child-Pugh classification, is beneficial for prognostic evaluation in patients with liver cirrhosis.Renal Doppler ultrasound is an additional tool for early diagnosis of renal failure, commonly employed due to its efficacy in assessing a diverse array of renal pathological diseases. It can non-invasively detect a subset of nonazotemic patients with liver disease who are at markedly elevated risk for eventual kidney impairment & hepatorenal syndrome. The assessment of renal hemodynamics in individuals with liver cirrhosis mostly relies on resistance index of the intrarenal arteries. Resistive Index (RI) is the predominant metric for assessing intrarenal vascular resistance, serving as a straightforward, efficient, & non-invasive technique that facilitates early identification of renal hemodynamic anomalies in patients with liver cirrhosis, prior to the clinical manifestation of renal dysfunction. It exhibits a strong link with the degree of liver illness[13]. This study aims to assess the significance of renal Doppler & portal Doppler in individuals with chronic liver disease concerning renal function.

Material & Methods: The present prospective study was conducted among outpatient & inpatient department of Gastroenterology in "MM Institute of Medical sciences Mullana, Ambala" for a period 2 years. Written informed consent & institutional ethical clearance was obtained in all prospective cases.

Sample size: 100 cases were included in the study in which clinical data was available.

Inclusion Criteria

1. Age more than 18 years
2. Patient diagnosed with CLD.

Exclusion Criteria

1. Patients younger than eighteen years of age
2. Patient suffering from hepatic vein thrombosis, portal vein thrombosis, hepatic artery thrombosis & renal vein thrombosis.
3. Patient on beta-adrenergic blockers.
4. Individuals who had undergone surgical portocaval anastomoses or TIPS.
5. Individuals who already have chronic kidney disease.
6. Patient undergone kidney or liver transplant.
7. Patients who refuse to give consent.
8. Doppler technically not feasible (morbid obese, massive ascites and uncooperative patient).

Methodology:

1. The study comprised patients with chronic liver disorders who presented to MMIMSR Hospital/IPD with or without acute kidney injury.
2. Radiological imaging, test results, & clinical characteristics were used to diagnose chronic liver disease.
3. Using the Child Pugh Score, patients diagnosed with chronic liver disease were categorized based on the severity of the disease i.e. Class C: 10 to 15 points (most severe liver illness); Class B: 7 to 9 points (moderately severe liver disease); & Class A: 5 to 6 points (least severe).
4. KDIGO criteria was used to evaluate acute renal injury in patients with CLD.
5. Following an overnight fast, the same examiner conducted Doppler investigations on patients.
6. A duplex Doppler device with a color Doppler sonographer & a 3.75-5MHz convex transducer was used to do portal & renal Doppler research.
7. Portal parameters (PSV of portal vein and RI of hepatic artery) and renal parameters (RI of renal artery) were assessed & measured.

Data was collected & subjected to statistical analysis.

Statistical analysis: Under the direction of a statistician, the data was tallied in an Excel sheet. For statistical analysis, the means & standard deviations of the measurements for each group were utilized (SPSS 22.00 for Windows; SPSS inc, Chicago, USA). The t test & chi square test were used to statistically examine the data for each evaluation point. A significant threshold of $p < 0.05$ was established.

Results: Male & female comprised of 77% & 23% of the subjects respectively. Hence there was male dominancy in the present study. Maximum subjects were from age group of 51-60 years (45%) followed by 41-50 (27%). Only 3% of the subjects were from age group of 18-30 years. Most common etiology of CLD among the study subjects was alcohol (58%) followed by viral (34%). Child Pugh Score viz, A, B & C was found in 41%, 37% & 22% of the subjects respectively as shown in table 1.

Table 1: Gender distribution among the study subjects

Gender	**N=100**	**%**
Male	77	77
Female	23	23
Age Group (in years)		
18-30	3	3
31-40	12	12
41-50	27	27
51-60	45	45
>60	13	13
Etiology		
Alcohol	58	58
Viral	34	34

Autoimmune	3	3
Others	5	5
Co-morbidities		
Hypertension	54	54
Diabetes Mellitus	17	17
Child Pugh Score		
A	41	41
B	37	37
C	22	22
Liver Disease		
Compensated	43	43
Decompensated	57	57

Esophageal varices, ascites & encephalopathy was revealed in 81%, 34% & 16% of the subjects respectively (Table1).

Table 1: Esophageal varices, Ascites & Encephalopathy among the study subjects

Variables	**N=100**	**%**
Esophageal varices	81	81
Ascites	34	34
Encephalopathy	16	16

AKI & non-AKI was revealed among 33% & 67% of the study subjects respectively. Hepatorenal syndrome was found in 8% of the subjects & all were having decompensated cirrhosis as well as AKI. Out of 67 subjects with non-AKI; 34 & 33 subjects were having compensated & decompensated liver disease respectively (table 2).

Table 2: AKI/Non-AKI among study subjects as per compensated/decompensated liver disease among the study subjects

Variables	**Compensated**	**Decompensated**		**Total**
		Without HRS	**With HRS**	
AKI	9	16	8	33
Non-AKI	34	33	0	67
Total	43	49	8	100
p value	0.008*			

*: statistically significant

Mean RI of renal artery was found to be significantly (p=0.033) more in AKI (0.58) as compared to non-AKI (0.504) subjects. Maximum RI was reported among subjects having HRS (0.83) followed by non-HRS subjects (0.719). We can see RI values are significantly higher in AKI patients across all stages (compensated, decompensated without HRS, and especially with HRS (table 3).

Table 3: Mean RI of renal artery among AKI/Non-AKI subjects as per compensated/decompensated liver disease

Variables	**Compensated**		**Decompensated**				**p value**
			Without HRS		**With HRS**		
	Mean RI	**SD**	**Mean RI**	**SD**	**Mean RI**	**SD**	
AKI	0.581	0.17	0.719	0.25	0.83	0.21	0.001*
Non-AKI	0.504	0.12	0.634	0.13	-	-	0.009*
p value	0.033*		0.005*				

*: statistically significant

Mean PSV is significantly lower in decompensated CLD. This reflects reduced portal blood flow, likely due to increased portal resistance (from fibrosis, portal hypertension, or thrombosis). Mean hepatic artery RI is significantly higher in decompensated CLD. This may indicate increased hepatic vascular resistance, parenchymal distortion, or altered hepatic microcirculation due to advanced fibrosis. Both parameters show statistically significant differences between compensated and decompensated states (table 4).

Table 4: Portal vein PSV and Hepatic artery RI comparison as per compensated/decompensated liver disease

Variables	Compensated		Decompensated		p value
	Mean	SD	Mean	SD	
PSV of Portal vein	13.87	1.25	8.96	1.54	<0.01*
RI of Hepatic artery	0.72	0.19	0.91	0.14	0.001*

*: statistically significant

Discussion: This study aimed to investigate the diagnostic utility of portal and renal Doppler ultrasonography in relation to renal function in individuals diagnosed with chronic liver disease. Over the course of two years, a total of 100 patients diagnosed with chronic liver disease were prospectively recruited from both the outpatient and inpatient units of the Department of Gastroenterology at MM Institute of Medical Sciences, Mullana, Ambala. These participants underwent comprehensive clinical and Doppler ultrasonographic evaluations as part of the study protocol aimed at assessing hepatic and renal vascular function.

In the present study, a clear male predominance was observed, with 77% of the participants being male and only 23% female. This gender distribution aligns with existing literature, where chronic liver disease tends to be more prevalent among males, possibly due to higher exposure to risk factors such as alcohol consumption. In terms of age distribution, the majority of participants (45%) were in the 51–60 years age group, followed by 27% in the 41–50 years range, indicating that middle-aged individuals formed the largest demographic segment of the study population.

According to a study conducted by Kumar A et al[14], the highest disease burden of chronic liver disease was observed in individuals aged between 51 and 60 years. The study also reported that CLD affects both sexes, although a clear male predominance was noted, with 74% of cases occurring in men. Similar findings were reported by Purohit A et al[15], who also observed a male predominance in their study population. This trend of higher male participation or prevalence has been consistently documented across several studies. For instance, Andrew S et al[16] reported that males constituted 71% of their cohort, with a median age of 58 years (interquartile range: 50–65 years), reflecting a similar demographic pattern. Likewise, Jaiganesh et al[17] reported a mean age of 48.32 ± 10.19 years, with a striking male predominance of 95% (95 out of 100 participants), while females accounted for only 5% of the study population. Fleming KM et al[18] also reported that the prevalence of chronic liver disease increases with advancing age. Consistent with the findings of the present study, their analysis demonstrated a clear male predominance among affected individuals. Notably, the incidence of chronic liver disease was found to be over 50% higher in men compared to women, further reinforcing the gender disparity observed in several epidemiological studies.

Among the study participants, alcohol emerged as the most prevalent cause of chronic liver disease, accounting for 58% of cases, followed by viral hepatitis, which contributed to 34% of the cases. Apurva Shah et al[19] reported that alcohol was the leading cause of cirrhosis, accounting for 48% of cases, followed by non-alcoholic steatohepatitis (NASH) at 26%, hepatitis B virus (HBV) at 10%, hepatitis C virus (HCV) at 6%, and other causes at 7%. Similarly, Brij Sharma et al[20] found alcohol to be the predominant etiology in 62.9% of cirrhosis patients, followed by HBV in 10.1% and NASH in less than 10% of cases. Consistent with these findings, the current study also identifies alcohol as the most common cause of cirrhosis, followed by HBV, HCV, further supporting the strong association between alcohol use and chronic liver disease in the studied population. According to Jaiprakash et al[21], chronic alcohol consumption was identified as the most common

cause of cirrhosis, accounting for 29.8% of cases, followed by cryptogenic cirrhosis (25.3%) and chronic hepatitis B infection (24.1%).

Hepatorenal syndrome (HRS) is a well-recognized complication of advanced liver failure, often presenting acutely in patients who were previously non-azotemic. One of the major clinical challenges in managing HRS is that serum creatinine elevation typically occurs late in the course of the disease, leading to delayed recognition of its early stages. In this study, we employed renal duplex Doppler ultrasonography, a widely available, non-invasive imaging modality, to detect early signs of intrarenal vasoconstriction in patients with established chronic liver disease[22]. This approach provides valuable insights into renal hemodynamics before overt biochemical evidence of renal dysfunction becomes apparent. In the current study, HRS was identified in 8% of the patient population, all of whom exhibited advanced liver disease. In their study, Platt et al[22] reported a prevalence of hepatorenal syndrome in 12% of participants, which is slightly higher than the rate observed in the current investigation.

In this study, patients with decompensated liver disease demonstrated significantly lower portal vein peak systolic velocity (PSV) and elevated hepatic artery resistive index (RI) compared to those with compensated liver disease ($p < 0.05$), indicating altered hepatic hemodynamics associated with disease progression. These findings are consistent with previous research, as similar observations were reported by Bardi et al[23], Götzberger et al[24], Vassiliades et al[25] and Borse N et al[26] who also documented reductions in portal vein flow velocities and increase in hepatic artery resistance indices in patients with more advanced liver dysfunction. Collectively, these studies underscore the utility of Doppler ultrasound parameters as non-invasive markers for assessing the severity of liver disease.

Renal resistive index (RI), as measured by Doppler ultrasonography, serves as a valuable indicator of renovascular resistance in patients with cirrhosis, often detecting changes before the clinical onset of hepatorenal syndrome (HRS). HRS arises due to the activation of vasoconstrictive pathways including the sympathetic nervous system, the renin-angiotensin system, and arginine vasopressin that act to compensate for severe arterial underfilling by constricting the renal vasculature. This vasoconstriction leads to a reduction in renal perfusion and glomerular filtration rate, while tubular function remains largely preserved. As such, the renal RI acts as an important prognostic marker[27], providing a simple, non-invasive means to identify early deterioration in renal function among cirrhotic patients. Patients with acute kidney injury (AKI) demonstrated a significantly higher mean renal resistive index (RI) of 0.58 compared to 0.504 in non-AKI subjects ($p = 0.033$). Within the AKI group, those with hepatorenal syndrome (HRS) exhibited the highest RI values, averaging 0.83, followed by AKI patients without HRS, who had a mean RI of 0.719.

Based on earlier research[27], an intrarenal resistive index (RI) of 0.70 is considered the threshold indicating increased renal vasoconstriction. In their study, Bardi et al[23] found that patients with hepatorenal syndrome (HRS) had significantly higher renal resistive index (RI) values (≥ 0.70) compared to healthy individuals. Platt et al[22] assessed intrarenal resistance in 180 patients with cirrhosis who did not have renal impairment. In patients who later developed the HRS, the mean initial RI was 0.77 ± 0.05. In their study, Kastelan et al[28] examined RI in 46 patients with cirrhosis who were split into three groups: those with cirrhosis & normal renal function, those with cirrhosis & renal impairment but no HRS, & those with HRS. In contrast to the other two groups, they discovered that the cirrhotic patients with HRS had a considerably higher RI (≥ 0.70).

According to Kumar A et al[27], the renal resistive index (RI) was significantly higher in non-ascitic patients with liver cirrhosis compared to control subjects (16% vs. 4%). Additionally, RI progressively increased with the severity of ascites: mildly ascitic patients had higher RI than non-ascitic patients (24% vs. 16%), moderately ascitic patients showed higher RI than mildly ascitic patients (36% vs. 24%), and patients with gross refractory ascites exhibited the highest RI compared to those with moderate ascites (52% vs. 36%). This pattern demonstrates a clear correlation between increasing RI values and the severity of liver disease. The findings of the current study are consistent with these observations.

There is no doubt about the value of renal resistive index (RI) in predicting hepatorenal syndrome (HRS) in patients with established cirrhosis, allowing for earlier initiation of treatment to potentially prevent or mitigate HRS. While elevated RI values can be seen in patients with early clinical stages of liver cirrhosis (Child-Pugh A or B), they are more commonly observed in those with advanced disease. Therefore, renal RI can serve as a valuable adjunct to other diagnostic tools for assessing disease severity and prognosis. Given that increased intrarenal vasoconstriction places cirrhotic patients at greater risk of developing overt renal failure, intrarenal RI measurement offers a simple, non-invasive, and cost-effective method for the early detection of renal impairment in this vulnerable population.

Limitations

1) **Limited Sample Size:** The study was conducted on a relatively small cohort of 100 patients, which may limit the statistical power and the ability to detect subtle differences across subgroups.
2) **Single-Center Design:** As the study was conducted at a single tertiary care center, the findings may not be generalizable to broader or more diverse populations.
3) **Cross-Sectional Nature:** The absence of a longitudinal follow-up restricts the ability to assess the progression of disease and the predictive value of Doppler parameters over time.

Conclusion: In conclusion, portal and renal Doppler ultrasonography provides a comprehensive, non-invasive modality for evaluating hepatic and renal hemodynamic in chronic liver disease. Doppler parameters not only differentiate compensated from decompensated states but also facilitate early recognition of renal dysfunction, particularly acute kidney injury and hepatorenal syndrome. Incorporating these assessments into routine clinical practice can improve risk stratification, inform therapeutic decision-making, and potentially enhance patient outcomes through timely intervention.

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