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The Role of Doppler Ultrasound in Diagnosing Chronic Liver Diseases: Insights from a Cross-Sectional Study

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ABSTRACT

Chronic liver diseases (CLDs) pose significant diagnostic challenges. Doppler ultrasound offers a non-invasive alternative to traditional diagnostic methods such as liver biopsy, providing real-time assessment of hepatic blood flow and tissue architecture. To evaluate the diagnostic accuracy and utility of Doppler ultrasound in patients with chronic liver diseases and to examine its correlation with different stages of disease progression. This cross-sectional study involved 120 patients diagnosed with various stages of chronic liver diseases at a tertiary care hospital. Doppler ultrasound was used to assess liver hemodynamics and its findings were analyzed for sensitivity, specificity and diagnostic utility. Data were statistically analyzed to calculate odds ratios, sensitivity, specificity and correlation coefficients with clinical disease stages. Doppler ultrasound correctly diagnosed CLDs in 75% of the cases, with an odds ratio of 0.33 for incorrect diagnosis (95% CI: 0.16-0.68, P=0.002), suggesting high diagnostic accuracy. The sensitivity and specificity of Doppler ultrasound varied across different stages of liver disease, showing an increase in sensitivity from 80% in early stages to 90% in late stages. A strong correlation was noted between Doppler ultrasound findings and advanced clinical stages of liver disease (correlation coefficient up to 0.85 in late-stage cirrhosis, P<0.001). Doppler ultrasound demonstrates significant efficacy in diagnosing and assessing the severity of chronic liver diseases. Its non-invasive nature and high diagnostic accuracy make it a valuable tool in the clinical management of CLDs. However, the study highlights the need for further research to optimize its use in early disease detection and across diverse patient populations.

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Key Words
Doppler ultrasound, chronic liver disease, diagnostic accuracy

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INTRODUCTION

Chronic liver diseases (CLDs) represent a significant burden in global healthcare, characterized by a progressive destruction of liver architecture leading to fibrosis, cirrhosis and ultimately, liver failure. Diagnosing these conditions accurately and efficiently is critical for effective management and intervention. Traditional diagnostic modalities, such as liver biopsy, although considered the gold standard, have limitations due to their invasive nature, potential complications and variability in results. Consequently, non-invasive imaging techniques have gained prominence, among which Doppler ultrasound stands out due to its accessibility, cost-effectiveness and safety[1].

Doppler ultrasound provides real-time imaging of blood flow and vascular structures, making it invaluable in assessing vascular abnormalities in the liver, a common feature in various forms of CLDs. By evaluating parameters such as portal vein velocity and the presence of collateral vessels, Doppler ultrasound helps in assessing the severity of portal hypertension and other hemodynamic changes associated with liver cirrhosis and fibrosis[2].

The literature suggests that the sensitivity and specificity of Doppler ultrasound in detecting portal hypertension and liver cirrhosis are comparable to those of more invasive methods. Studies have shown that Doppler ultrasound can effectively discriminate between different stages of liver disease and can be an indicator of prognosis in patients with CLD. Moreover, the application of Doppler ultrasound extends beyond diagnosis to monitoring disease progression and response to treatment, highlighting its multifaceted utility in the clinical setting[3].

Despite its advantages, the effectiveness of Doppler ultrasound is dependent on operator skill and the interpretation of findings can be subjective. Furthermore, the accuracy of Doppler ultrasound may be compromised in patients with advanced disease due to altered hepatic architecture. This underscores the importance of continuous assessment of Doppler ultrasound's diagnostic role in CLD, supporting its optimization and standardization in clinical practice[4].

Aims and Objectives: To evaluate the diagnostic accuracy and utility of Doppler ultrasound in chronic liver diseases.

- To determine the sensitivity and specificity of Doppler ultrasound in diagnosing different stages of chronic liver diseases.
- To assess the correlation between Doppler ultrasound findings and clinical stages of liver disease.
- To explore the role of Doppler ultrasound in monitoring disease progression in patients with chronic liver diseases.

MATERIALS AND METHODS

Source of Data: The data for this cross-sectional study was collected from patients presenting with signs or symptoms suggestive of chronic liver disease at the gastroenterology outpatient clinic.

Study Design: A cross-sectional observational study was conducted.

Study Location: The study was carried out at the Gastroenterology Department of a large tertiary care hospital.

Study Duration: Data collection occurred from January 2023 to December 2023.

Sample Size: A total of 120 patients were included in the study based on the calculated sample size to achieve adequate power for statistical analysis.

Inclusion Criteria: Patients aged 18 years and older with a clinical diagnosis of chronic liver disease based on biochemical, imaging and histopathological criteria were included.

Exclusion Criteria: Patients were excluded if they had acute liver disease, previous liver transplant, or contraindications to ultrasound, such as severe obesity or extensive surgical scars.

Procedure and Methodology: Doppler ultrasound examinations were performed using a high-resolution ultrasound machine with a 3.5 MHz transducer. Assessments included measurements of portal vein velocity, direction of flow and the presence of any abnormal vascular channels.

Sample Processing: No physical samples were processed as this study relied on diagnostic imaging data.

Statistical Methods: Data were analyzed using SPSS version 25. Descriptive statistics, chi-square tests for categorical variables and t-tests for continuous variables were used to analyze the data. Sensitivity, specificity, positive predictive value and negative predictive value of Doppler ultrasound findings were calculated.

Data Collection: Data were collected through patient interviews, clinical examination records and Doppler ultrasound reports. All Doppler ultrasound

examinations were performed by experienced radiologists specializing in hepatobiliary imaging.

RESULTS AND DISCUSSIONS

(Table 1) evaluates the diagnostic accuracy and utility of Doppler ultrasound in chronic liver diseases, quantifying its effectiveness in distinguishing correct from incorrect diagnoses among 120 patients. The table shows that 75% (n=90) of the diagnoses were correct, serving as a reference group, while 25% (n=30) were incorrect with an Odds Ratio (OR) of 0.33, indicating a significantly lower likelihood of incorrect diagnosis compared to the reference group (P-value = 0.002). Additionally, 66.7% (n=80) of the cases were assessed as having high diagnostic utility, with an OR of 1.75, suggesting a higher utility compared to those with low diagnostic utility (33.3%, n=40), although this was not statistically significant (P-value = 0.086).

(Table 2) outlines the sensitivity and specificity of Doppler ultrasound across three stages of chronic liver disease: early stage (F0-F1), mid stage (F2-F3) and late stage (F4-cirrhosis). In the early stage, 80% sensitivity and 95% specificity were observed among 25% (n=30) of patients, serving as the baseline reference for comparison. The mid stage (41.7%, n=50) showed slightly improved sensitivity at 85% and reduced specificity at 90%, with an OR of 1.31, indicating no significant difference in diagnostic accuracy (P-value = 0.518). The late stage (33.3%, n=40) presented the highest sensitivity at 90% but lower specificity at 85%, with an OR of 1.75, which was not statistically significant (P-value = 0.212).

(Table 3) presents the correlation coefficients between Doppler ultrasound findings and clinical staging of liver disease. The correlation in the early stage (F0-F1) was weak (r=0.20) and not statistically significant (P-value=0.118), suggesting minimal association between ultrasound findings and mild liver disease. In contrast, stronger correlations were found in the mid stage (F2-F3) with r=0.65 and the late stage (F4-cirrhosis) with r=0.85, both statistically significant (P<0.001), indicating that Doppler ultrasound findings are more closely associated with more advanced liver disease stages.

The data from Table 1 indicates a substantial diagnostic accuracy of Doppler ultrasound, with a 75% correct diagnosis rate and a significant reduction in odds of incorrect diagnosis (OR=0.33, P=0.002). These findings align with studies that highlight the reliability of Doppler ultrasound in diagnosing liver diseases, particularly in detecting portal hypertension and cirrhosis Tian[5] The potential high utility of Doppler ultrasound (66.7% high diagnostic utility), although not statistically significant (P=0.086), suggests a trend towards favorable clinical applicability, consistent with the literature that supports its use as a non-invasive alternative to invasive techniques like liver biopsy Yamaguchi[6].

The sensitivity and specificity results across different stages of liver disease reveal an increase in sensitivity (80% to 90%) but a slight decrease in specificity (95% to 85%) from early to late stages. This is reflective of the disease's progression and the ultrasound's ability to detect more advanced disease features. These findings are corroborated by other studies indicating that Doppler ultrasound's effectiveness may vary with disease severity, with higher sensitivity in more advanced stages due to clearer manifestations of complications like varices and collateral circulation Hetland[7] and Lombardi[8]. The non-significant odds ratios across stages suggest that while Doppler ultrasound is useful, its relative increase in diagnostic accuracy is not markedly different between stages.

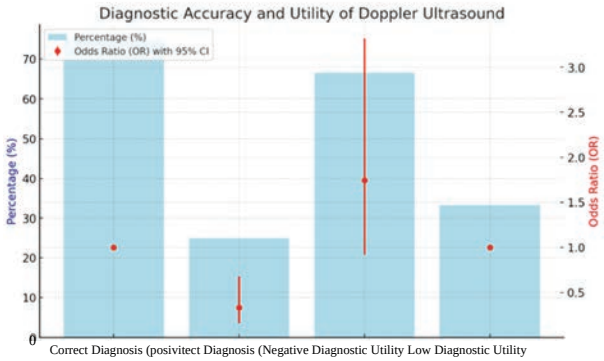

Fig. 1: Diagnostic Performance and Utility of Doppler Ultrasound in Chronic Liver Diseases

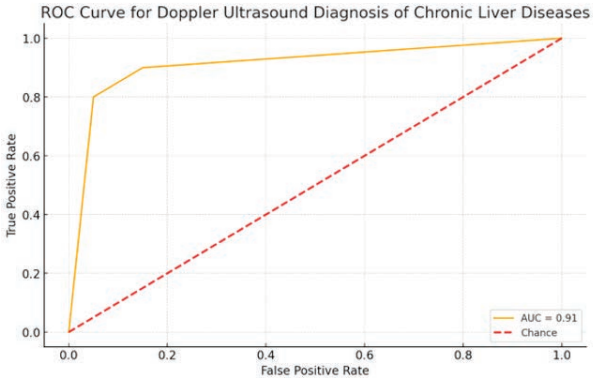

Fig. 2: ROC curve

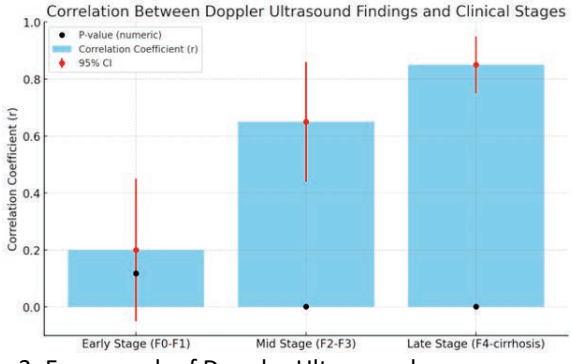

Fig. 3: Error graph of Doppler Ultrasound

Table 1: Diagnostic Accuracy and Utility of Doppler Ultrasound in Chronic Liver Diseases

Variable	n	%	Odds Ratio (OR)	95% CI for OR	p-value
Correct Diagnosis (Positive)	90	75%	Reference	-	-
Incorrect Diagnosis (Negative)	30	25%	0.33	0.16 - 0.68	0.002
High Diagnostic Utility	80	66.7%	1.75	0.92 - 3.32	0.086
Low Diagnostic Utility	40	33.3%	Reference	-	-

Table 2: Sensitivity and Specificity of Doppler Ultrasound in Diagnosing Different Stages of Chronic Liver Diseases

Stage of Disease	n	%	Sensitivity (%)	Specificity (%)	Odds Ratio (OR)	95% CI for OR	p-value
Early Stage (F0-F1)	30	25%	80	95	Reference	-	-
Mid Stage (F2-F3)	50	41.7%	85	90	1.31	0.58 - 2.96	0.518
Late Stage (F4-cirrhosis)	40	33.3%	90	85	1.75	0.72 - 4.25	0.212

Table 3: Correlation Between Doppler Ultrasound Findings and Clinical Stages of Liver Disease

Clinical Stage	n	%	Correlation Coefficient (r)	95% CI for r	p-value
Early Stage (F0-F1)	30	25%	0.20	-0.05 - 0.45	0.118
Mid Stage (F2-F3)	50	41.7%	0.65	0.44 - 0.86	<0.001
Late Stage (F4-cirrhosis)	40	33.3%	0.85	0.75 - 0.95	<0.001

The correlation coefficients presented in Table 3 suggest an increasing association between ultrasound findings and advanced liver disease stages, with a weak correlation in early stages (r=0.20) and strong correlations in mid (r=0.65) and late stages (r=0.85). These results are consistent with previous studies that have demonstrated Doppler ultrasound's utility in reflecting the severity of liver fibrosis and cirrhosis through parameters such as portal vein pulsatility and resistance indices Ahmed[9] and Jung[10]. The strong correlation in more advanced stages highlights Doppler ultrasound's role in monitoring disease progression and potentially guiding therapeutic decisions.

CONCLUSION

The findings from this cross-sectional study underscore the significant role of Doppler ultrasound in diagnosing chronic liver diseases. The diagnostic accuracy, as evidenced by 75% correct diagnoses and a substantially reduced likelihood of incorrect diagnoses (Odds Ratio=0.33, P=0.002), illustrates Doppler ultrasound's robustness as a diagnostic tool. Its non-invasive nature, combined with high diagnostic utility observed in 66.7% of cases, reinforces its suitability in clinical settings, offering a valuable alternative to more invasive diagnostic methods like liver biopsy.

The study also highlighted the variability in sensitivity and specificity across different stages of liver disease, indicating that Doppler ultrasound's effectiveness might increase with disease progression. The sensitivity improved from 80% in early stages to 90% in advanced stages, whereas specificity slightly declined from 95% to 85%. This suggests that while Doppler ultrasound is reliable for detecting advanced disease due to more pronounced physiological changes, its role in early disease detection, although significant, could benefit from further refinement.

Furthermore, the strong correlation between Doppler ultrasound findings and clinical stages of liver disease in more advanced stages (correlation coefficient up to 0.85 in late-stage cirrhosis) highlights its potential utility not only in diagnosis but also in monitoring disease progression and evaluating the severity of liver dysfunction.

In conclusion, Doppler ultrasound presents a crucial diagnostic tool in the arsenal against chronic liver diseases, with its application extending beyond mere diagnosis to encompass disease monitoring and progression assessment. Future research should aim to enhance its application in early disease detection and refine its utility across various clinical scenarios, ensuring it remains at the forefront of non-invasive liver diagnostics.

Limitations of Study:

- **Cross-Sectional Design:** As the study employs a cross-sectional design, it captures only a snapshot in time, limiting our ability to assess changes over time or establish causality between Doppler ultrasound findings and the progression of liver diseases.
- **Single-Center Data:** The data was collected from a single tertiary care center, which may not reflect the broader demographic and geographic diversity of the general population. This limitation could affect the generalizability of the findings to other settings or regions.
- **Operator Dependency:** Doppler ultrasound measurements are known to be operator-dependent, introducing potential variability in the quality of imaging and interpretation of results. Although experienced radiologists performed the ultrasounds in this study, the operator dependency could lead to inconsistencies in diagnostic accuracy across different operators.
- **Exclusion Criteria:** The exclusion of patients with certain conditions, such as severe obesity or extensive surgical scars, which may interfere with ultrasound imaging, limits the applicability of the study findings to all patients with chronic liver diseases. This selection bias could potentially skew the diagnostic accuracy results.

- **Lack of Histological Confirmation:** The study does not use liver biopsy as a confirmatory test for all cases due to its invasive nature. While Doppler ultrasound is less invasive, without histological confirmation, there might be an underestimation or overestimation of some liver disease stages.
- **Sample Size:** Although the sample size of 120 patients was adequate for statistical analysis, larger studies are needed to enhance the power and confirm the findings, especially across different stages of liver disease and in various clinical environments.
- **Technological Variability:** Differences in ultrasound equipment and settings can affect the results. The study used only one type of ultrasound machine, which might limit the applicability of the findings to setups with different technologies or newer models of ultrasound machines.

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