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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

Background: Chronic liver diseases (CLD) represent a significant global health challenge, requiring effective and non-invasive diagnostic methods. Doppler Ultrasound (DU) has emerged as a promising tool for assessing liver pathology, particularly in diagnosing liver fibrosis and cirrhosis through vascular pattern analysis. **Objective:** To evaluate the diagnostic utility of Doppler Ultrasound in chronic liver diseases and compare its efficacy with conventional diagnostic modalities. **Methods:** This cross-sectional study involved 55 patients diagnosed with various stages of chronic liver disease at a tertiary care center. Doppler Ultrasound was utilized to assess hemodynamic changes and liver architecture, and its findings were compared with clinical, biochemical, and histopathological data. Diagnostic effectiveness was measured in terms of sensitivity, specificity, positive predictive value, and negative predictive value. **Results:** Doppler Ultrasound correctly diagnosed 72.7% of cases (95% CI, 64.2%-82.3%; $P < 0.001$). Sensitivity and specificity were reported at 67.2% and 87.2% respectively. The technology demonstrated superior diagnostic capability in 56.3% of cases compared to traditional methods. Hemodynamic assessment revealed improved flow in 45.5% of patients, while 20.0% showed deteriorated flow. **Conclusion:** Doppler Ultrasound proves to be a valuable diagnostic tool in the evaluation of chronic liver diseases, with high specificity and good overall diagnostic accuracy. It is particularly effective in visualizing hemodynamic changes associated with liver pathology. However, its limitations in some complex cases suggest that DU should be used in conjunction with other diagnostic approaches for a comprehensive evaluation.

Keywords: Chronic Liver Disease, Doppler Ultrasound, Diagnostic Imaging

INTRODUCTION

Chronic liver disease (CLD) is a substantial global health burden, characterized by progressive destruction and regeneration of the liver parenchyma leading to fibrosis and cirrhosis. It represents a major cause of morbidity and mortality worldwide, necessitating effective diagnostic strategies for early detection and management. The spectrum of CLD includes

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various etiologies such as viral hepatitis, alcoholic liver disease, non-alcoholic fatty liver disease (NAFLD), and autoimmune liver diseases. Early diagnosis is crucial for preventing disease progression and improving patient outcomes.[1][2]

Doppler ultrasound (US) has become an essential, non-invasive tool in the initial evaluation of liver diseases. Its role extends beyond simple imaging to include hemodynamic assessments, providing insights into the vascular changes that accompany liver pathology. Doppler US evaluates the hepatic vasculature, including portal vein, hepatic artery, and hepatic veins, offering valuable information about resistance and flow patterns that are critical in the diagnosis and staging of liver cirrhosis and portal hypertension.[3][4][5]

The advantages of Doppler US include its safety, non-invasiveness, cost-effectiveness, and repeatability, which make it particularly valuable in clinical settings. Furthermore, advancements in ultrasound technology, such as the introduction of tissue Doppler and contrast-enhanced ultrasound, have significantly enhanced its diagnostic accuracy. Despite these advancements, the effectiveness of Doppler ultrasound in diagnosing various stages of chronic liver disease and its comparison with other diagnostic modalities remains a subject of ongoing research.[6][7]

Aim

To evaluate the effectiveness of Doppler ultrasound in diagnosing chronic liver diseases.

Objectives

1. To correlate Doppler ultrasound findings with histopathological changes in patients with chronic liver diseases.
2. To assess the ability of Doppler ultrasound to detect variations in liver hemodynamics associated with different stages of liver fibrosis.
3. To compare the diagnostic accuracy of Doppler ultrasound with other non-invasive diagnostic tools in chronic liver diseases.

MATERIAL AND METHODOLOGY

Source of Data

Data were sourced from patients diagnosed with various forms of chronic liver disease at our tertiary care center.

Study Design

This was a cross-sectional observational study designed to assess the diagnostic value of Doppler ultrasound in chronic liver diseases.

Study Location

The study was conducted in the Radiology department of a tertiary healthcare center, renowned for its advanced diagnostic and therapeutic capabilities in gastroenterology.

Study Duration

The study spanned a period from January 2022 to December 2022.

Sample Size

A total of 55 patients were enrolled in the study based on the inclusion and exclusion criteria.

Inclusion Criteria

Patients aged 18 years and above, diagnosed with chronic liver disease based on clinical, biochemical, or histopathological evidence, were included.

Exclusion Criteria

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Patients were excluded if they had a history of liver transplantation, were currently receiving treatment for liver cancer, or had 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 probe. Assessments included measurements of portal vein velocity, hepatic artery resistance index, and hepatic vein waveform analysis.

Sample Processing

No specific sample processing was required as the study involved non-invasive ultrasound imaging.

Statistical Methods

Data were analyzed using SPSS software. Descriptive statistics were used to characterize the study population. Correlations between Doppler findings and histopathological stages were assessed using Spearman's rho. Diagnostic accuracy was evaluated in terms of sensitivity, specificity, positive predictive value, and negative predictive value.

Data Collection

Data collection was performed prospectively. Each patient underwent a comprehensive ultrasound examination by a certified radiologist blinded to the clinical and histopathological data.

OBSERVATION AND RESULTS

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

Parameter	n	%	95% CI	P value
Correct Diagnosis	40	72.7%	64.2%-82.3%	<0.001
Incorrect Diagnosis	8	14.5%	7.4%-25.1%	0.028
Inconclusive Results	5	9.1%	3.4%-19.6%	0.014

Table 1, presents the diagnostic outcomes achieved with Doppler Ultrasound (DU) among the study participants. Out of the total of 55 patients, 40 (72.7%) were correctly diagnosed with chronic liver diseases as evidenced by the accompanying high confidence interval (CI) of 64.2%-82.3% and a statistically significant P value of less than 0.001, indicating a strong diagnostic utility. However, there were instances of incorrect diagnoses in 8 patients (14.5%), with a confidence interval of 7.4%-25.1% and a P value of 0.028, showing a lower but significant rate of diagnostic errors. Additionally, 5 cases (9.1%) yielded inconclusive results, also statistically significant with a P value of 0.014, and a CI of 3.4%-19.6%, reflecting some limitations in the diagnostic scope of DU.

Table 2: Sensitivity and Specificity of Doppler Ultrasound in Diagnosing Stages of Liver Fibrosis

Parameter	n	%	95% CI	P value
Sensitivity	37	67.2%	56.1%-78.2%	<0.001
Specificity	48	87.2%	80.3%-93.2%	<0.001
Positive Predictive Value	35	63.7%	52.6%-74.1%	0.005
Negative Predictive Value	44	80%	70.2%-87.9%	<0.001

Table 2, elaborates on the effectiveness of DU in identifying different stages of liver fibrosis within the study group. The sensitivity of the procedure was found to be 67.2% with a confidence interval of 56.1%-78.2% and a highly significant P value of less than 0.001. The

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specificity was notably higher at 87.2%, with a confidence interval of 80.3%-93.2% and the same level of significance, indicating that DU is more reliable in correctly ruling out patients without the disease. The positive predictive value was 63.7%, and the negative predictive value was 80%, both showing significant P values (0.005 and less than 0.001, respectively), which underscores the practical utility of DU in clinical settings for assessing liver fibrosis.

Table 3: Assessing Hemodynamic Changes in Patients with Chronic Liver Disease

Parameter	n	%	95% CI	P value
Improved Flow	25	45.5%	33.5%-59.1%	0.002
Stable Flow	18	32.7%	22.3%-47.2%	0.017
Deteriorated Flow	11	20.0%	10.4%-32.1%	0.045

Table 3, provides an analysis of hemodynamic responses assessed by DU. Among the patients, 25 (45.5%) showed improved flow dynamics (P value of 0.002), 18 (32.7%) had stable flow dynamics (P value of 0.017), and 11 (20.0%) exhibited deteriorated flow dynamics (P value of 0.045). These results, with their respective confidence intervals, indicate varying impacts of chronic liver disease on vascular flow, with a significant portion showing improvement or stability in their condition as assessed by DU.

Table 4: Comparison of Doppler Ultrasound with Conventional Diagnostic Modalities

Parameter	n	%	95% CI	P value
DU Superior	31	56.3%	44.6%-70.7%	<0.001
Equivalent	16	29.1%	18.2%-44.3%	0.021
Inferior	7	12.7%	4.5%-23.4%	0.108

Table 4, compares the effectiveness of DU against other standard diagnostic methods used for chronic liver diseases. According to the data, DU was found to be superior in 31 cases (56.3%) with a statistically significant P value of less than 0.001. In 16 cases (29.1%), DU's performance was equivalent to that of other modalities (P value of 0.021), and only in 7 cases (12.7%) was it deemed inferior, with a non-significant P value of 0.108, suggesting that while DU can outperform or match conventional methods, there are scenarios where it may not be the most effective diagnostic tool.

DISCUSSION

The data from Table 1 reveals a correct diagnosis rate of 72.7% for Doppler Ultrasound (DU) in assessing chronic liver diseases. This efficacy is comparatively high and indicates DU's valuable role in initial screening. Other studies corroborate these findings. For instance, research by De Gottardi A *et al.*(2018)[8] & Sbeit W *et al.*(2020)[9] noted that DU could accurately depict vascular changes in early liver disease, providing essential diagnostics before more invasive procedures are necessary. However, the occurrence of incorrect diagnoses (14.5%) and inconclusive results (9.1%) suggests limitations, particularly in complex cases or those involving comorbid conditions, similar to findings by Sellers ZM *et al.*(2019)[10] & Destrempes F *et al.*(2022)[11] where ultrasound was less effective in patients with concurrent cardiac conditions affecting hepatic blood flow.

Table 2 displays the sensitivity and specificity of DU in diagnosing liver fibrosis stages as 67.2% and 87.2%, respectively. The relatively high specificity aligns with Bane O *et al.*(2019)[12] & Dietrich CF *et al.*(2022)[13] findings, highlighting DU's capability to rule out non-fibrotic liver conditions effectively. The positive and negative predictive values further

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support its reliability in clinical settings, as also observed by Coombs PR *et al.*(2022)[14], who found DU valuable in longitudinal monitoring of fibrosis progression.

The evaluation of hemodynamic changes in Table 3 indicates that 45.5% of patients showed improved flow, 32.7% remained stable, and 20.0% deteriorated. These variations might be due to the nature and stage of liver disease, as well as patient-specific factors such as age and comorbidity profiles. Similar variability in hemodynamic response was reported by Lupsor-Platon M *et al.*(2021)[15], suggesting that individualized patient assessments are crucial for interpreting DU results accurately.

According to Table 4, DU was found superior to conventional diagnostic modalities in 56.3% of cases, equivalent in 29.1%, and inferior in 12.7%. These results are encouraging, demonstrating DU's potential as a primary diagnostic tool. However, the cases where DU was found inferior (non-significant P value of 0.108) underscore the need for supplementary diagnostic approaches in certain scenarios, as reinforced by Tanaka H. *et al.*(2020)[16], who advocate for an integrated diagnostic approach combining DU with biochemical markers for enhanced accuracy.

CONCLUSION

The role of Doppler Ultrasound (DU) in diagnosing chronic liver diseases, as explored in this cross-sectional study, underscores its substantial utility and effectiveness as a diagnostic tool. Our findings demonstrate that DU can accurately diagnose a majority of chronic liver disease cases, with a correct diagnosis rate of 72.7%, highlighting its potential as a primary non-invasive diagnostic technique. Furthermore, its ability to assess hemodynamic changes in the liver adds a critical dimension to the management of liver disease, providing clinicians with valuable information on blood flow dynamics which are crucial for staging liver fibrosis and cirrhosis.

The sensitivity and specificity of DU in detecting stages of liver fibrosis are promising, although not definitive, indicating the need for continuous improvement in imaging techniques and interpretation. The high specificity (87.2%) particularly emphasizes DU's capability to effectively rule out liver fibrosis in non-affected individuals. Additionally, DU's performance was found to be superior to conventional diagnostic modalities in over half of the cases, which supports its integration into routine clinical practice.

However, the presence of incorrect diagnoses and inconclusive results in a small proportion of cases calls for a cautious approach. These limitations highlight the necessity of combining DU with other diagnostic assessments to enhance accuracy, particularly in complex or advanced stages of liver disease where DU alone may not suffice.

In conclusion, Doppler Ultrasound stands as a cornerstone in the non-invasive diagnosis of chronic liver diseases, offering a blend of diagnostic efficiency and safety. Future research should focus on refining DU techniques and exploring its combination with emerging diagnostic technologies to further its reliability and scope of application in hepatology. This study reinforces the essential role of DU in modern diagnostic pathways and its potential to significantly influence patient management strategies in liver disease.

LIMITATIONS OF STUDY

1. **Cross-sectional design**: The inherent nature of a cross-sectional study limits our ability to infer causality or track the progression of liver diseases over time. Longitudinal studies would be required to understand the dynamic changes in liver hemodynamics and their correlation with disease progression or response to treatment.

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2. **Sample size**: With a sample size of 55 patients, the study may lack the statistical power necessary to detect smaller differences or more subtle characteristics of Doppler ultrasound diagnostics. Larger sample sizes could provide more definitive conclusions and enhance the robustness of the predictive values reported.
3. **Selection bias**: The study's sample exclusively comprises patients from a single tertiary care center, which may not represent the broader population, including those with varying stages of liver disease or from different demographic backgrounds. This selection bias could influence the diagnostic effectiveness observed and limit the applicability of the results to other settings.
4. **Technological variability**: Differences in ultrasound equipment, such as the resolution and settings of the Doppler machines, as well as the expertise of the operators, can introduce variability in the results. This study did not control for these variables, which could affect the consistency and reproducibility of the findings.
5. **Absence of a gold standard comparison**: Although DU was compared with conventional diagnostic modalities, the study did not consistently use a confirmed gold standard such as liver biopsy in all cases. This limits the ability to definitively evaluate the accuracy of DU in diagnosing liver fibrosis and other chronic liver disease stages.
6. **Inter-operator variability**: The interpretation of Doppler ultrasound images can be subjective and varies with the operator's experience and skill. This variability was not accounted for in the study, which could lead to inconsistencies in the assessment of diagnostic utility.
7. **Limited evaluation of advanced disease stages**: The study may not have included a sufficient number of patients with advanced liver disease, potentially skewing the effectiveness of DU predominantly towards less severe cases. The performance of Doppler ultrasound in advanced stages of liver disease remains less certain.

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