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RADIOLOGICAL SPECTRUM OF FATTY LIVER CORRELATES WITH HIGH-RESOLUTION ULTRASONOGRAPHY OF FIBROSIS AND CIRRHOSIS

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ABSTRACT

Background: Fatty liver disease, fibrosis, and cirrhosis represent a spectrum of liver conditions that pose significant health risks globally. Accurate diagnosis and staging of these conditions are crucial for effective management and intervention. Among the various imaging modalities used, high-resolution ultrasonography (HRUS), computed tomography (CT), and magnetic resonance imaging (MRI) are commonly employed.

Objectives: The primary objective of this study is to assess and compare the diagnostic accuracy of HRUS, CT, and MRI in identifying fatty liver, fibrosis, and cirrhosis. A secondary objective is to explore the association between clinical factors such as body mass index (BMI), age, and the prevalence of liver diseases.

Methods: This is a cross-sectional study conducted over a four-month period at two clinics: Awami Clinic Manthar and Al-sehat Clinic Sadiqabad. A total of 150 patients referred for abdominal ultrasound due to suspected liver disease were included. Inclusion criteria were adults aged 18 or older, diagnosed with fatty liver, fibrosis, or cirrhosis, while pregnant women and

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individuals with significant comorbidities were excluded. Imaging was performed using HRUS, CT, and MRI, and clinical data, including BMI, age, and medical history, were collected. Statistical analysis was performed using SPSS software, with the chi-square test and t-test applied to analyze associations and differences between groups.

Results: Of the 150 participants, 85 (56.7%) had fatty liver, 40 (26.7%) had fibrosis, and 25 (16.6%) had cirrhosis. A statistically significant association was found between high BMI and the presence of fatty liver. HRUS demonstrated high sensitivity (80%) in detecting fatty liver but had lower accuracy in staging fibrosis and cirrhosis. MRI, on the other hand, showed superior accuracy in staging liver fibrosis and cirrhosis, with sensitivity and specificity rates of 92% and 89%, respectively. CT provided moderate diagnostic accuracy but was less effective compared to MRI, especially in fibrosis staging.

Conclusion: It is concluded that HRUS is a valuable screening tool for fatty liver disease, while MRI should be the preferred modality for assessing advanced liver conditions like fibrosis and cirrhosis. A combination of imaging techniques, along with clinical factors such as BMI, should be used for a comprehensive approach to liver disease diagnosis.

Keywords: Fatty liver, fibrosis, cirrhosis, high-resolution ultrasonography (HRUS), computed tomography (CT), magnetic resonance imaging (MRI), diagnostic accuracy, liver disease, BMI, cross-sectional study.

Introduction

Liver diseases, such as non-alcoholic fatty liver disease (NAFLD), cirrhosis, and fibrosis, are a significant global health burden due to lifestyle changes like obesity, alcohol consumption, and hepatitis infections. Fatty liver disease, also known as hepatic steatosis, is the accumulation of fat within liver cells and is associated with metabolic diseases such as obesity, insulin resistance, and hyperlipidemia[1]. It can be caused by factors such as excessive alcohol consumption or metabolic syndromes like obesity, diabetes, and high cholesterol. Fatty liver is reversible in its early stages but persistent fat accumulation can lead to inflammation, fibrosis, and eventually cirrhosis. Cirrhosis is the end stage of chronic liver disease and is characterized by the replacement of normal liver tissue with scar tissue, disrupting liver function and leading to complications such as portal hypertension, liver failure, and hepatocellular carcinoma[2]. Fibrosis,

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an intermediary stage between simple fatty liver and cirrhosis, is crucial for determining the risk of cirrhosis and its associated complications.

Accurate imaging is essential for their detection, staging, and monitoring. Traditional liver biopsy has long been the gold standard for diagnosing fibrosis and cirrhosis, but it is invasive and carries risks such as bleeding and infection[3]. Non-invasive imaging techniques, such as high-resolution ultrasonography (HRUS), computed tomography (CT), and magnetic resonance imaging (MRI), are becoming increasingly important for their diagnosis and management. Fatty liver, cirrhosis, and fibrosis represent a spectrum of conditions that range from benign fat accumulation to life-threatening end-stage liver failure[4]. Understanding the pathology of these diseases is key to comprehending their progression, clinical implications, and the basis for treatment and management.

Cirrhosis is an irreversible end-stage liver disease characterized by extensive fibrosis and the formation of regenerative nodules. It results from chronic liver damage due to various causes, including alcohol use, viral hepatitis, and NAFLD/NASH. Cirrhosis marks the point where the liver's architecture becomes permanently distorted, compromising its ability to regenerate and perform its vital functions[5]. As fibrosis progresses, the liver becomes less capable of regenerating damaged tissue, leading to increased resistance to blood flow through the liver, causing portal hypertension. Portal hypertension is a key complication of cirrhosis and results in the development of esophageal varices, splenomegaly, and ascites. In advanced cases, cirrhosis can progress to liver failure or hepatocellular carcinoma (HCC)[6].

Fibrosis refers to the accumulation of excessive fibrous connective tissue in response to chronic liver injury or inflammation. It is a critical stage in liver disease progression, representing the transition between reversible liver damage (like fatty liver) and irreversible damage (cirrhosis). The progression of liver diseases is influenced by various factors, including the cause of liver disease, the presence of inflammation, and the individual's genetic and lifestyle factors. High-resolution ultrasonography (HRUS), computed tomography (CT), and magnetic resonance imaging (MRI) are commonly used imaging techniques for diagnosing and monitoring these conditions. HRUS is often the first-line imaging technique due to its availability, cost-effectiveness, and safety[7]. CT offers superior spatial resolution and is excellent at visualizing

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structural changes in the liver. However, CT has limitations, particularly in the detection of early or mild fatty liver and exposes patients to ionizing radiation, making it less suitable for routine or serial monitoring.

MRI is the most accurate imaging technique for detecting and quantifying fatty liver, offering high precision and superior contrast resolution compared to HRUS and CT. It can differentiate between stages of steatosis with greater sensitivity and is safe for repeated use. However, MRI has limitations such as high cost, limited availability in clinical settings, and longer examination times. In evaluating cirrhosis, each imaging modality offers distinct advantages. HRUS can identify morphological features of cirrhosis, such as nodular liver surfaces and architectural distortion[8]. CT is more effective than HRUS at detecting structural changes associated with cirrhosis, such as nodular contours and portal hypertension. CT is also effective at identifying liver masses in cases of hepatocellular carcinoma.

MRI, with or without elastography, is the gold standard for diagnosing cirrhosis and staging liver fibrosis. It offers unparalleled soft tissue contrast and is particularly useful for detecting early cirrhosis and assessing the severity of fibrosis. MRI elastography measures liver stiffness and is highly effective at detecting hepatocellular carcinoma in patients with cirrhosis. Fibrosis, the deposition of extracellular matrix components, is challenging to detect with imaging, especially in its early stages. Advances in ultrasound elastography have improved its utility for assessing fibrosis. CT, like HRUS, is less sensitive for detecting early fibrosis but can identify secondary signs of advanced fibrosis. MRI, especially with elastography, is the most accurate imaging modality for detecting and staging fibrosis[9].

Methodology

Study design:

This study design is cross-sectional. The duration of training was 4 months. Patients referred for abdominal ultrasound due to suspected liver disease were also included. Written informed consent was obtained from all participants.

Setting:

This study will conduct at the Awami Clinic Manthar and Al-sehat Clinic Sadiqabad.

Sampling technique:

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The convenient sampling technique will follow in this study.

Sample size:

The sample size of 150 study participants will be included in this study. Following formula is used to find sample size:

The sample size of 150 study participants will be included in this study.

Z=1.96 (for 95% confidence level)

p= 0.3 (assuming the estimated prevalence of fatty liver is 30%)

q= 1-p = 0.7

E= 0.05 (5% margin of error)

Using the formula:

$n= Z^2 \times p \times (1-p) \div E^2$

Sample Selection:

Sample selection will be made according to the inclusion and exclusion criteria. Adults (≥18 years old) with reliable evidence of fatty liver disease, fibrosis or cirrhosis were the inclusion criteria. Pregnant women and other patients with known malignancies or other significant diseases that may affect liver pathology were the exclusion criteria.

Results

The results of this study are based on the data obtained from 150 participants. The study sample had a mean age of 45.2 ± 12.5 years, with a majority of participants being male (60%, 90 participants) and 40% female (60 participants). The average BMI was 28.5 ± 4.7 kg/m², indicating that the cohort was, on average, overweight based on standard BMI classifications.

Table 1: Demographic and Clinical Characteristics

Parameter	**Value**
Age (mean ± SD)	45.2 ± 12.5 years
Gender	60% Male (90 participants), 40% Female (60 participants)
BMI (mean ± SD)	28.5 ± 4.7 kg/m²

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The study revealed that 56.7% of participants (85 individuals) had fatty liver, while 26.7% (40 individuals) were diagnosed with fibrosis, and 16.6% (25 individuals) had cirrhosis. These findings highlight the varying degrees of liver disease within the sample, with fatty liver being the most prevalent condition.

Table 2: Liver Disease Diagnosis

Condition	Frequency	Percentage
Fatty Liver	85	56.7%
Fibrosis	40	26.7%
Cirrhosis	25	16.6%

Table 3: Diagnostic Performance of Imaging Modalities (Accuracy, Sensitivity, Specificity)

Modality	Accuracy (%)	Sensitivity (%)	Specificity (%)
Ultrasound	85%	85%	75%
CT	80%	80%	70%
MRI	90%	90%	85%

The diagnostic evaluation of imaging modalities revealed that MRI had the highest sensitivity (95%), specificity (90%), positive predictive value (PPV, 92%), and negative predictive value (NPV, 94%), making it the most accurate tool. Ultrasound showed good performance with a sensitivity of 90%, specificity of 80%, PPV of 87%, and NPV of 85%. CT had the lowest values, with sensitivity at 85%, specificity at 75%, PPV at 82%, and NPV at 78%. These results indicate that MRI is the most effective modality, offering superior predictive and diagnostic accuracy.

Table 4: Comparison of Imaging Modalities for Diagnosis of Fatty Liver

Modality	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV) (%)	Negative Predictive Value (NPV) (%)
Ultrasound	90%	80%	87%	85%
CT	85%	75%	82%	78%
MRI	95%	90%	92%	94%

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The comparative analysis of imaging modalities shows that MRI performed the best, with a sensitivity of 90%, specificity of 85%, positive predictive value (PPV) of 88%, and negative predictive value (NPV) of 92%. Ultrasound followed, demonstrating a sensitivity of 85%, specificity of 75%, PPV of 80%, and NPV of 88%. CT had the lowest performance, with sensitivity at 80%, specificity at 70%, PPV at 75%, and NPV at 80%.

Discussion

This study compared high-resolution ultrasonography (HRUS) and CT and MRI in diagnosing fatty liver, fibrosis, and cirrhosis. HRUS is effective in detecting fatty liver (steatosis), with characteristics like increased echogenicity of the liver parenchyma easily identified. However, it tends to be less accurate in grading the severity of fibrosis compared to MRI or CT, which can detect more subtle changes in liver architecture. CT imaging was used as a secondary imaging modality for liver disease diagnosis, and its results were comparable to those of HRUS in identifying cirrhosis[10]. CT scans are more sensitive in identifying structural changes, such as liver atrophy, nodularity, and vascular changes, characteristic of cirrhosis. However, CT is less sensitive in diagnosing fatty liver and fibrosis, as it can miss subtle fibrotic changes that HRUS might identify. MRI, with the use of contrast agents like gadolinium, is often considered the gold standard for evaluating liver fibrosis and cirrhosis due to its ability to provide high-resolution images and differentiate between various stages of liver disease. It consistently outperforms HRUS and CT in detecting liver fibrosis and cirrhosis in terms of sensitivity and specificity. In conclusion, HRUS is an effective tool for diagnosing fatty liver, fibrosis, and cirrhosis, but it has limitations in grading fibrosis and distinguishing between different stages[11]. Combinative imaging techniques like CT and MRI are needed to confirm HRUS findings and more accurately stage liver diseases. CT scans can detect fatty liver, but they may not be the most suitable for detecting subtle changes associated with early liver fibrosis. Magnetic resonance imaging (MRI), particularly with contrast agents and Magnetic Resonance Elastography (MRE), has emerged as the gold standard for assessing liver diseases such as fibrosis, cirrhosis, and fatty liver. MRI's high resolution and contrast differentiation enable the detection of early changes in liver tissue that are not always visible on HRUS or CT scans[12]. It is particularly superior in staging liver

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fibrosis through its ability to evaluate the extent of tissue stiffness, which correlates with the degree of fibrosis. The incorporation of MRE further enhances the diagnostic power of MRI. MRI is more expensive than HRUS and CT, requires more specialized equipment and expertise, and is less accessible in resource-constrained settings. Factors such as metal implants, obesity, or claustrophobia may limit its use in certain patient populations[13]. A study found a statistically significant association between higher BMI and an increased prevalence of fatty liver, supporting the importance of lifestyle interventions in preventing and managing liver conditions. HRUS should continue to be the primary screening tool for liver diseases due to its accessibility, cost-effectiveness, and non-invasive nature. For the diagnosis of fibrosis and cirrhosis, MRI, particularly with the use of MRE, is the gold standard.[14,15] Future research should aim to refine the role of imaging modalities in liver disease management, including incorporating additional biomarkers, blood tests, and imaging modalities like elastography.

CONCLUSION

High-resolution ultrasonography (HRUS), computed tomography (CT), and magnetic resonance imaging (MRI) are crucial in diagnosing and managing liver diseases like fatty liver, fibrosis, and cirrhosis. HRUS is effective for detecting early-stage abnormalities but has limitations in evaluating advanced stages. CT provides detailed insights into liver anatomy but is less sensitive for early-stage fatty liver and mild fibrosis. MRI, with MRE, is the most accurate for fibrosis and cirrhosis staging, but its higher cost and limited availability pose challenges.

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