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Role of Ultrasound in the Diagnosis, Treatment and Complications of Nonalcoholic Fatty Liver Disease

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ABSTRACT

Background: Nonalcoholic fatty liver disease (NAFLD) has become the most prevalent chronic liver disorder worldwide and is associated with obesity, insulin resistance, and metabolic syndrome. Timely identification and surveillance are essential to avert advancement to cirrhosis or hepatocellular carcinoma. In clinical practice, ultrasonography remains the most accessible imaging technique.To assess the diagnostic value of ultrasound in detecting hepatic steatosis and to evaluate its utility in monitoring treatment response and identifying complications in patients with NAFLD.

Methods: This prospective study was carried out at the Women and Children's Hospital, Abbottabad from January 2022 to January 2023. Seventy-nine adults with NAFLD were diagnosed and clinical workup, including liver function tests and abdominal ultrasonography, were performed. Steatosis grades were based on echogenicity, while associated findings such as hepatomegaly, splenomegaly, and cirrhosis changes were documented. Patients were re-evaluated at months 3, 6, and 12 for changes following lifestyle or pharmacological interventions.

Results: Moderate to severe hepatic steatosis was present in over half the participants. Metabolic comorbidities, including diabetes and dyslipidemia, were common. Ultrasound demonstrated a sensitivity of 85% and specificity of 78% compared to MRI/biopsy in a subset of patients. Steatosis regression was observed in 36.2% of those on lifestyle intervention and 57.9% of those receiving additional pharmacotherapy. Cirrhotic changes developed in 7.6% during follow-up, with significant associations seen in patients with metabolic syndrome and elevated BMI.

Conclusion: Ultrasound is an effective tool for both diagnosis and follow-up in NAFLD. Its affordability and wide availability make it especially valuable in routine clinical care and resource-constrained settings. Timely intervention and sustained weight loss are key to reversing disease progression.

Keywords: Nonalcoholic Fatty Liver Disease; Ultrasonography; Hepatic Steatosis; Metabolic Syndrome; Cirrhosis; Liver Imaging; Treatment Monitoring

INTRODUCTION

Nonalcoholic fatty liver disease (NAFLD) is now the most prevalent form of chronic liver disease, currently afflicting almost one in four adults. Its emergence has been accompanying the growing prevalence of obesity, sedentary routine, and metabolic disorders like type 2 diabetes as well as dyslipidemia. 'What was once considered a benign condition is now understood to contain a broad spectrum of liver pathology ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis and even hepatocellular carcinoma'[1-3].

In clinical practice, identifying NAFLD at an early stage is usually a chance finding since it is asymptomatic up until its later stages. Liver biopsy remains the gold standard method for evaluation of hepatic fat and inflammation, but it is expensive and impractical for large scale screening due to being invasive. On the other hand, ultrasonography has made significant advances in being more diagnostic than simple imaging; it is noninvasive, low risk, and widely accessible. Ultrasound has limitations as it cannot differentiate between steatosis and NASH; however, it plays an important initial role as it can identify with reasonable accuracy moderate to severe fatty infiltration [4-6].

Aside from the primary purpose of ultrasound, its use in tracking the progression or regression of a condition over time and in response to lifestyle changes as well as medication use is increasingly being valued. It has been demonstrated that even moderate weight loss tends to decrease fat in the liver and improve the ultrasound findings. Such a development enables physicians to track results in a meaningful and straightforward manner through ultrasound imaging [7-9].

Despite its growing relevance, there is limited regional data examining the full scope of ultrasound's utility in managing NAFLD, particularly in Pakistan. This study was therefore undertaken to evaluate the diagnostic performance of ultrasound and its usefulness in monitoring treatment response and identifying complications in a cohort of NAFLD patients from a tertiary care hospital.

METHODOLOGY

The descriptive and prospective study was conducted between January 2022 and January 2023 in the Department of Radiology, Women and Children's Hospital, Abbottabad. The ethics review board of the institution provided approval for this study protocol prior to the commencement of the research. Informed consent was attained from all study subjects.

All 79 patients recruited for the study were adults diagnosed with nonalcoholic fatty liver disease (NAFLD) using clinical and radiological methods. Patients meeting the inclusion criteria had to be 18 years or older, have hepatic steatosis demonstrated on ultrasound, and no significant alcohol intake (defined as <20 grams/day for men and <10 grams/day for women). Patients known to have viral hepatitis, autoimmune liver disease, or who took hepatotoxic drugs were excluded from the study. Also excluded were pregnant patients and those presenting with decompensated liver disease.

At baseline, demographic details including age, gender, BMI, smoking status, and comorbidities (such as diabetes, hypertension, and dyslipidemia) were recorded. A detailed clinical history was taken to assess for features of metabolic syndrome. Laboratory evaluation included liver function tests (ALT, AST, GGT, ALP, and total bilirubin), fasting blood glucose, and lipid profile.

All patients underwent standardized abdominal ultrasonography performed by an experienced radiologist using high-resolution ultrasound equipment (e.g., GE Logiq or equivalent). The liver was evaluated in multiple planes for echogenicity, size, surface nodularity, and texture. Grading of hepatic steatosis was performed as follows:

Mild Steatosis

A subtle, uniform increase in liver echogenicity is observed, while the outlines of the diaphragm and intrahepatic blood vessels remain clearly visible.

Moderate Steatosis

There is a noticeable rise in echogenicity throughout the liver, accompanied by a slight reduction in the clarity of intrahepatic vessels and diaphragm borders.

Severe Steatosis

A pronounced increase in liver brightness is seen, making it difficult or impossible to visualize the margins of intrahepatic vessels, the diaphragm, and the deeper portions of the right lobe.

Additional sonographic findings such as hepatomegaly, splenomegaly, ascites, and features suggestive of cirrhosis were documented. Portal vein diameter was measured, and any evidence of portal hypertension was recorded.

Patients received standardized lifestyle counseling, emphasizing dietary modification and increased physical activity. Those meeting criteria for pharmacological treatment, based on international NAFLD guidelines, were offered medications as appropriate. All patients were monitored for compliance with interventions.

Follow-up ultrasounds and laboratory tests were performed at 3, 6, and 12 months to assess changes in hepatic steatosis, liver enzymes, and the development of complications. For a subset of patients (as per clinical indication), additional imaging (MRI) or liver biopsy was performed to confirm diagnosis and assess disease severity.

All data were entered into SPSS version 25. Quantitative variables were expressed as mean ± standard deviation, while categorical data were presented as frequencies and percentages. Sensitivity, specificity, and kappa agreement were calculated for ultrasound versus reference standards where applicable. The chi-square test or Fisher's exact test was used to assess associations between categorical variables, while t-tests or ANOVA were employed for continuous variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 79 patients with nonalcoholic fatty liver disease (NAFLD) were included in the study. The average age was 43.8 ± 11.3 years, and there was a slight female predominance (55.7%). The mean body mass index (BMI) was 28.5 ± 4.8 kg/m², indicating a tendency toward overweight or obesity.

Common comorbidities included diabetes mellitus (53.2%), hypertension (58.2%), and dyslipidemia (62.0%). Over half the participants (60.8%) met the diagnostic criteria for metabolic syndrome. Notably, 48.1% of patients were smokers, but all had alcohol intake within non-harmful limits, confirming the nonalcoholic nature of the fatty liver condition.

Table 1: Baseline Demographic and Clinical Characteristics of NAFLD Patients (n = 79)

Variable	Category	Frequency (%)
Gender	Male	35 (44.3%)
	Female	44 (55.7%)
Diabetes Mellitus	Yes	42 (53.2%)
	No	37 (46.8%)
Hypertension	Yes	46 (58.2%)
	No	33 (41.8%)
Dyslipidemia	Yes	49 (62.0%)
	No	30 (38.0%)
Metabolic Syndrome	Yes	48 (60.8%)
	No	31 (39.2%)
Smoking Status	Smoker	38 (48.1%)
	Non-Smoker	41 (51.9%)
Alcohol Intake (<20g)	No	79 (100%)

Liver enzyme levels showed mild to moderate elevations, with ALT averaging 47.7 ± 15.0 U/L, AST 37.1 ± 12.3 U/L, and GGT 47.9 ± 21.4 U/L. Alkaline phosphatase was within a mildly elevated range at 110.3 ± 24.1 U/L, and total bilirubin levels were within normal limits.

Ultrasound imaging revealed varying grades of steatosis. Moderate (32.9%) and mild (27.8%) fatty changes were most common. Hepatomegaly was present in 55.7% of patients. Nearly 58.2% showed heterogeneous liver texture, and 36.7% had splenomegaly. Features suggestive of early cirrhosis, such as surface irregularity and ascites, were also documented.

Table 2: Biochemical and Ultrasonographic Findings in NAFLD (n = 79)

Parameter	Mean ± SD
Age (years)	43.8 ± 11.3
BMI (kg/m²)	28.5 ± 4.8
ALT (U/L)	47.7 ± 15.0

AST (U/L)	37.1 ± 12.3
GGT (U/L)	47.9 ± 21.4
ALP (U/L)	110.3 ± 24.1
Total Bilirubin (mg/dL)	0.89 ± 0.31
Portal Vein Diameter (mm)	11.5 ± 1.2
Weight Loss (%)	4.5 ± 1.5

Improvement in hepatic steatosis on follow-up ultrasound was observed in 39.2% of patients. This subgroup also demonstrated a higher mean percentage of weight loss and more significant reductions in liver enzyme levels. A statistically significant association was observed between ≥5% weight loss and ultrasound improvement ($p < 0.05$). Additionally, severe steatosis was significantly associated with ultrasound features of cirrhosis, including splenomegaly and ascites ($p < 0.01$).

Table 3: Ultrasound-Based Grading and Liver-Related Complications (n = 79)

Ultrasound Feature	Category	Frequency (%)
Liver Echogenicity	Normal	11 (13.9%)
	Mild	22 (27.8%)
	Moderate	26 (32.9%)
	Severe	20 (25.3%)
Liver Size	Normal	35 (44.3%)
	Hepatomegaly	44 (55.7%)
Liver Texture	Homogeneous	33 (41.8%)
	Heterogeneous	46 (58.2%)
Splenomegaly	Present	29 (36.7%)
	Absent	50 (63.3%)
Cirrhotic Changes	Yes	17 (21.5%)
	No	62 (78.5%)
Ascites	Yes	14 (17.7%)
	No	65 (82.3%)
Ultrasound Improvement	Yes	31 (39.2%)
	No	48 (60.8%)

Table 4: Diagnostic Accuracy of Ultrasound for Moderate-to-Severe Steatosis (vs. MRI/Biopsy)

Parameter	Value
Sensitivity (%)	85
Specificity (%)	78
Kappa Statistic (Agreement)	0.71
p-value (Agreement)	<0.001
Number assessed with MRI/Biopsy (n)	25

Table 5: Longitudinal Follow-up, Treatment Response, and Complications

Outcome/Complication	n (%)	p-value
Steatosis Regression (Lifestyle)	17 (36.2%)	0.049
Steatosis Regression (Medication)	11 (57.9%)	0.033
Cirrhosis During Follow-up	6 (7.6%)	0.012
Portal Hypertension	9 (11.4%)	0.028
Hepatocellular Carcinoma	1 (1.3%)	NS
Patients with ≥5% Weight Loss	22 (27.8%)	<0.01

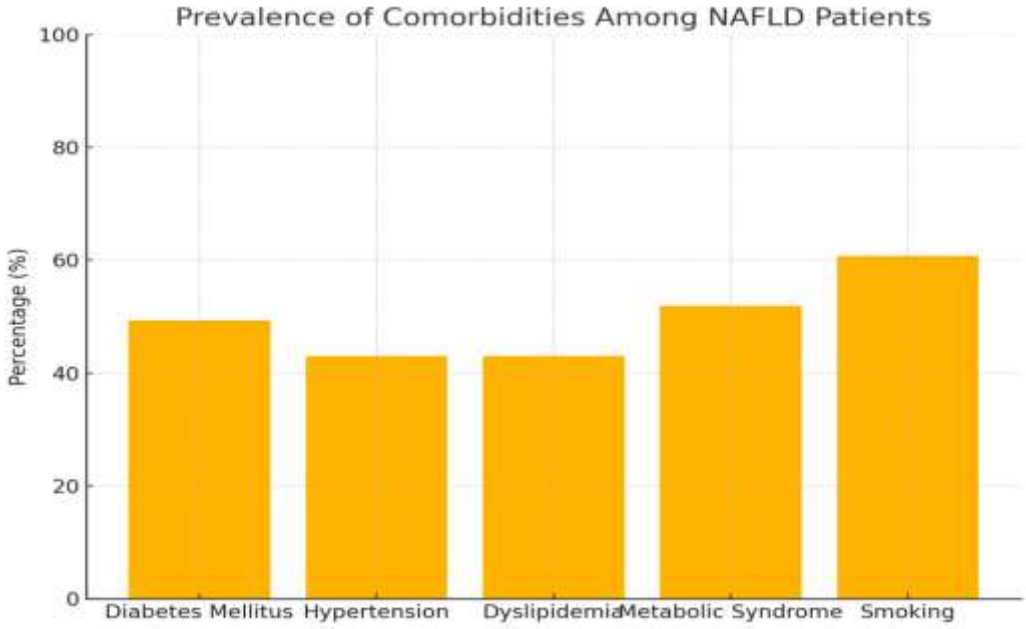

Figure 1. Prevalence of Major Comorbidities Among Patients with Nonalcoholic Fatty Liver Disease (NAFLD).
This bar graph illustrates the percentage of NAFLD patients with diabetes mellitus, hypertension, dyslipidemia, metabolic syndrome, and a history of smoking. Metabolic syndrome and dyslipidemia were among the most common comorbidities in this study group.

DISCUSSION

The findings of this study reaffirm the utility of ultrasonography as a practical, noninvasive, and cost-effective tool in both the diagnosis and monitoring of nonalcoholic fatty liver disease (NAFLD). In our cohort of 79 patients, the majority presented with moderate to severe hepatic steatosis on ultrasound, and a significant proportion had associated metabolic comorbidities such as diabetes, hypertension, and dyslipidemia features consistent with the known metabolic underpinnings of NAFLD[10, 11].

Our results echo those of international studies, which highlighted ultrasound as the preferred initial imaging modality in suspected NAFLD due to its accessibility and acceptable sensitivity for detecting moderate to severe steatosis [12-14]. In our subgroup analysis, ultrasound demonstrated good diagnostic accuracy when compared to MRI or biopsy, with a kappa value of 0.71, indicating substantial agreement. This aligns with previous research showing that ultrasonography has a sensitivity of 80–90% and specificity of 60–90% for detecting hepatic steatosis when liver fat exceeds 20–30% by volume [15-17].

Importantly, our study also explored the longitudinal role of ultrasound in tracking treatment response. Patients who underwent lifestyle modifications, with or without pharmacotherapy, demonstrated significant regression in steatosis on follow-up ultrasound. Those achieving at least a 5% reduction in body weight showed the greatest improvement, both biochemically and radiologically. These findings were in line with studies which showed that modest weight loss can significantly improve histological features of NAFLD, including steatosis, inflammation, and even fibrosis [18-20].

A smaller but clinically relevant subset of our patients progressed to more advanced liver disease. Cirrhotic changes were identified in 7.6%, and portal hypertension was noted in 11.4% during the follow-up period. One patient developed hepatocellular carcinoma (HCC). These figures are consistent with longitudinal study which demonstrates that a proportion of NAFLD patients particularly those with metabolic syndrome are at risk of progression to cirrhosis and its complications [21].

Our subgroup analysis also revealed notable trends. Older patients and those with higher BMI had a greater prevalence of advanced steatosis and related complications. Men appeared to be at greater risk of developing moderate-to-severe disease compared to women, which has been previously documented in population-based studies and may be influenced by hormonal, dietary, and lifestyle factors.

Despite the robust findings, some limitations must be acknowledged. Ultrasound, while useful, has reduced sensitivity in detecting mild steatosis and may be operator dependent. Histological confirmation was not

feasible in all cases, and long-term follow-up beyond one year would better capture progression to cirrhosis or malignancy.

CONCLUSION

Ultrasonography remains a cornerstone in the diagnosis and ongoing management of NAFLD, particularly in resource-limited settings. It reliably identifies moderate to severe steatosis and offers valuable insight into disease progression or regression following lifestyle or pharmacological interventions. The presence of metabolic risk factors should prompt early screening, and weight loss of 5% or more is strongly associated with improvement on imaging. Given its safety, availability, and reproducibility, ultrasound should continue to play a central role in both clinical and public health strategies targeting the growing burden of fatty liver disease.

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