

Ultrasonographic Evaluation of Non-Alcoholic Fatty Liver Disease and Its Association with Metabolic parameters

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Abstract

Background: Non-alcoholic fatty liver disease (NAFLD) is a common hepatic manifestation of metabolic dysfunction and is frequently associated with obesity, insulin resistance, diabetes mellitus, hypertension and dyslipidemia. Ultrasonography provides a simple and non-invasive method for detecting hepatic steatosis.

Aim: To evaluate the ultrasonographic prevalence and grading of fatty liver and assess its association with metabolic parameters.

Materials and Methods: A hospital-based observational study was conducted among 200 adults who underwent abdominal ultrasonography along with clinical and biochemical evaluation. Anthropometric parameters including body mass index (BMI) and waist circumference, and metabolic parameters including fasting blood glucose, HbA1c, lipid profile and blood pressure were assessed. Fatty liver was graded on ultrasonography as Grade I, II or III. Associations between fatty liver and metabolic parameters were analyzed using appropriate statistical tests, with $p < 0.05$ considered statistically significant.

Results: The mean age of participants was 44.6 ± 11.8 years, with males comprising 54%. Ultrasonography revealed fatty liver in 86 (43%) participants, including Grade I in 48 (24%), Grade II in 30 (15%) and Grade III in 8 (4%). Participants with fatty liver had significantly higher BMI, waist circumference, fasting glucose, HbA1c, triglycerides, total cholesterol and LDL cholesterol, and lower HDL cholesterol compared with those without fatty liver ($p < 0.05$). Obesity, central obesity, diabetes mellitus, hypertension, hypertriglyceridemia and low HDL cholesterol were also significantly more frequent among participants with fatty liver. Metabolic abnormalities increased progressively with higher grades of fatty liver.

Conclusion: Ultrasonographically detected fatty liver was common in the study population and showed a significant association with multiple metabolic abnormalities. Ultrasonography, combined with metabolic assessment, can help identify individuals with hepatic steatosis and associated metabolic risk.

Keywords: Non-alcoholic fatty liver disease, ultrasonography, fatty liver, obesity, metabolic syndrome, dyslipidemia, diabetes mellitus.

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Introduction

Non-alcoholic fatty liver disease (NAFLD) is one of the most common chronic liver disorders and is characterized by excessive accumulation of fat in the liver in the absence of significant alcohol consumption or other secondary causes of hepatic steatosis. The disease encompasses a spectrum ranging from simple hepatic steatosis to non-alcoholic steatohepatitis, fibrosis, cirrhosis and hepatocellular carcinoma. [1-3]

NAFLD is closely associated with metabolic abnormalities, particularly obesity, central adiposity, insulin resistance, type 2 diabetes mellitus, dyslipidemia and hypertension. The metabolic syndrome and its individual components are strongly associated with hepatic fat accumulation, and the presence of NAFLD should prompt assessment for associated metabolic risk factors. Conversely, individuals with metabolic risk factors are at increased risk of developing NAFLD. [1]

The increasing prevalence of obesity and type 2 diabetes has contributed to the growing burden of NAFLD. Insulin resistance plays an important role in its pathogenesis by promoting increased delivery of free fatty acids to the liver and altered hepatic lipid metabolism. Diabetes and increasing metabolic risk are also associated with greater severity of NAFLD and an increased risk of disease progression. [1,2]

Ultrasonography is a widely available, non-invasive and relatively inexpensive imaging modality for detecting hepatic steatosis. Increased hepatic echogenicity, often described as a “bright liver,” is the characteristic sonographic appearance of fatty infiltration. The EASL-EASD-EASO guidelines recommend ultrasound as the preferred first-line imaging procedure for detecting NAFLD, particularly in routine clinical practice. [1]

Assessment of metabolic parameters is an important component of the evaluation of patients with fatty liver. Parameters such as body mass index, waist circumference, fasting blood glucose, HbA1c, triglycerides, HDL cholesterol and blood pressure provide information regarding the metabolic risk profile associated with hepatic steatosis. Guidelines recommend evaluation for these metabolic abnormalities when hepatic steatosis is identified on imaging. [1,2]

Although ultrasonography provides a practical method for identifying hepatic steatosis, the relationship between the degree of sonographic fatty liver and metabolic abnormalities is clinically relevant. Identifying patients with fatty liver together with adverse metabolic parameters may facilitate early risk assessment and appropriate management.

Therefore, the present study was undertaken to evaluate the ultrasonographic findings of non-alcoholic fatty liver disease and determine their association with selected metabolic parameters, including obesity, central adiposity, glycemic status and lipid profile.

Materials and Methods:

Study Design and Setting

A **hospital-based observational study** was conducted in the Department of Radiodiagnosis at a tertiary care hospital.

Study Population

The study included **200 adult participants** who underwent abdominal ultrasonography and for whom relevant anthropometric and metabolic parameters were available.

Inclusion Criteria

Participants were included if they:

- Were aged **18 years or above**.
- Underwent abdominal ultrasonography.

- Had available clinical, anthropometric and biochemical data.
- Gave informed consent for participation.

Exclusion Criteria

Participants were excluded if they had:

- Significant alcohol consumption.
- Known chronic viral hepatitis.
- Established chronic liver disease due to another cause.
- History of hepatotoxic drug use associated with hepatic steatosis.
- Inadequate ultrasonographic examination.
- Incomplete clinical or biochemical records.

Clinical and Anthropometric Assessment

Relevant demographic and clinical information was recorded using a structured proforma. Anthropometric measurements included **height, weight, body mass index (BMI) and waist circumference**. Blood pressure was measured using a standard sphygmomanometer after an appropriate period of rest.

BMI was calculated as weight in kilograms divided by height in metres squared.

Biochemical Assessment

After an overnight fast, venous blood samples were collected for estimation of:

- Fasting blood glucose
- Glycated haemoglobin (HbA1c)
- Total cholesterol
- Triglycerides
- HDL cholesterol
- LDL cholesterol
- Alanine aminotransferase (ALT)
- Aspartate aminotransferase (AST)

History of diabetes mellitus and hypertension was recorded based on previous diagnosis, medical records and current medication use.

Ultrasonographic Examination

Abdominal ultrasonography was performed after overnight fasting using a standard

ultrasound machine with an appropriate convex-array transducer.

The liver was systematically evaluated for **hepatic echogenicity, comparison with the right renal cortex, visualization of intrahepatic vessels and diaphragm, and attenuation of the ultrasound beam**.

Grading of Hepatic Steatosis

Ultrasonographic fatty liver was graded according to the degree of increased hepatic echogenicity and visualization of intrahepatic structures:

- **Grade I (mild):** Slight diffuse increase in hepatic echogenicity with normal visualization of the diaphragm and portal vein walls.
- **Grade II (moderate):** Moderate increase in hepatic echogenicity with partial reduction in visualization of portal vein walls and diaphragm.
- **Grade III (severe):** Marked increase in hepatic echogenicity with poor visualization of portal vein walls, diaphragm and deeper hepatic structures.

Assessment of Metabolic Parameters

The association between ultrasonographically detected fatty liver and metabolic parameters was assessed using **BMI, waist circumference, fasting blood glucose, HbA1c, lipid profile and blood pressure**. The frequency of obesity, central obesity, diabetes mellitus, hypertension, hypertriglyceridemia and low HDL cholesterol was also compared between participants with and without fatty liver.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as **mean $\pm$ standard deviation**, while categorical variables were presented as **frequency and percentage**. The independent-samples *t*-test was used to compare continuous variables between

participants with and without fatty liver. The **Chi-square test** was used to assess associations between categorical variables. A **p-value <0.05** was considered statistically significant.

Results:

A total of **200 adult participants** were included in the study. The mean age was **44.6**

± 11.8 years, and males constituted 54% of the study population.

Among the 200 participants, **108 (54%) were males and 92 (46%) were females**. The mean BMI was 26.8 ± 4.1 kg/m², while the mean waist circumference was 91.4 ± 10.2 cm. (Table 1)

Table 1. Demographic and anthropometric characteristics

Parameter	Mean $\pm$ SD / n (%)
Age (years)	44.6 $\pm$ 11.8
Male	108 (54%)
Female	92 (46%)
BMI (kg/m ²)	26.8 $\pm$ 4.1
Waist circumference (cm)	91.4 $\pm$ 10.2

Ultrasonographic evidence of fatty liver was present in **86 (43%) participants**, while 114 (57%) had no evidence of fatty liver. Grade I fatty liver was the most frequent grade, accounting for 48 (24%) participants. (Table 2)

Table 2. Ultrasonographic grading of fatty liver

Ultrasonographic finding	Number (n)	Percentage (%)
Normal liver	114	57
Grade I fatty liver	48	24
Grade II fatty liver	30	15
Grade III fatty liver	8	4
Total	200	100

Participants with fatty liver had significantly higher **BMI, waist circumference, fasting blood glucose, HbA1c, triglycerides, total cholesterol and LDL cholesterol** compared with those without fatty liver. Mean HDL cholesterol was significantly lower in the fatty liver group. (Table 3)

Table 3. Comparison of metabolic parameters between participants with and without fatty liver

Parameter	Fatty liver (n=86) Mean $\pm$ SD	No fatty liver (n=114) Mean $\pm$ SD	p-value
BMI (kg/m ²)	29.1 $\pm$ 3.8	25.1 $\pm$ 3.5	<0.001
Waist circumference (cm)	97.2 $\pm$ 8.4	87.0 $\pm$ 9.1	<0.001
Fasting glucose (mg/dL)	112.6 $\pm$ 28.4	96.8 $\pm$ 18.7	<0.001
HbA1c (%)	6.1 $\pm$ 1.0	5.5 $\pm$ 0.6	<0.001
Triglycerides (mg/dL)	184.5 $\pm$ 72.6	131.8 $\pm$ 48.3	<0.001
Total cholesterol (mg/dL)	201.4 $\pm$ 42.8	181.6 $\pm$ 36.7	0.001
HDL cholesterol (mg/dL)	39.6 $\pm$ 8.2	46.1 $\pm$ 9.0	<0.001
LDL cholesterol (mg/dL)	124.8 $\pm$ 31.5	111.5 $\pm$ 28.7	0.003

Obesity, central obesity, diabetes mellitus, hypertension, hypertriglyceridemia and low HDL cholesterol were significantly more frequent among participants with fatty liver than among those without fatty liver. (Table 4)

Table 4. Association of metabolic risk factors with fatty liver

Metabolic risk factor	Fatty liver n (%)	No fatty liver n (%)	p-value
Obesity	42 (48.8)	25 (21.9)	<0.001
Central obesity	58 (67.4)	39 (34.2)	<0.001
Diabetes mellitus	30 (34.9)	18 (15.8)	0.002
Hypertension	36 (41.9)	25 (21.9)	0.003
Hypertriglyceridemia	38 (44.2)	20 (17.5)	<0.001
Low HDL cholesterol	46 (53.5)	32 (28.1)	<0.001

Mean BMI, waist circumference, fasting glucose, HbA1c and triglyceride levels increased progressively from Grade I to Grade III fatty liver, whereas HDL cholesterol showed a decreasing trend. (Table 5)

Table 5. Metabolic parameters according to grade of fatty liver

Parameter	Grade I (n=48) Mean ± SD	Grade II (n=30) Mean ± SD	Grade III (n=8) Mean ± SD
BMI (kg/m ²)	27.8 ± 3.2	30.1 ± 3.5	32.2 ± 3.8
Waist circumference (cm)	93.6 ± 7.5	99.1 ± 7.9	103.4 ± 8.2
Fasting glucose (mg/dL)	104.2 ± 21.3	120.6 ± 27.5	137.8 ± 31.2
HbA1c (%)	5.8 ± 0.7	6.3 ± 0.9	6.8 ± 1.1
Triglycerides (mg/dL)	163.4 ± 54.2	202.7 ± 66.5	231.5 ± 78.4
HDL cholesterol (mg/dL)	41.5 ± 7.6	38.2 ± 7.4	35.1 ± 6.8

Discussion:

Non-alcoholic fatty liver disease (NAFLD) is closely associated with metabolic abnormalities, particularly obesity, insulin resistance, dyslipidemia, diabetes mellitus and hypertension. In the present study, fatty liver was detected by ultrasonography in 86 of 200 participants (43%). This finding indicates a substantial burden of hepatic steatosis among adults attending the study setting. Previous epidemiological studies have also demonstrated a strong association between NAFLD and metabolic risk factors. [4,5]

In the present study, participants with fatty liver had significantly higher BMI and waist circumference than those without fatty liver. Mean BMI was 29.1 ± 3.8 kg/m² in the fatty liver group compared with 25.1 ± 3.5 kg/m² in those without fatty liver, while mean waist circumference was 97.2 ± 8.4 cm and 87.0 ± 9.1 cm, respectively. The higher prevalence of obesity and central obesity among

individuals with fatty liver further supports the relationship between excess adiposity and hepatic steatosis. Bedogni et al. reported obesity and metabolic abnormalities as important risk factors for NAFLD. [4]

A significant association was also observed between fatty liver and glucose metabolism. Participants with fatty liver had higher fasting blood glucose and HbA1c levels than those without fatty liver. Diabetes mellitus was present in 34.9% of participants with fatty liver compared with 15.8% of those without fatty liver. These findings are consistent with the recognized relationship between insulin resistance, impaired glucose metabolism and hepatic fat accumulation. Marchesini et al. demonstrated a strong association between NAFLD and insulin resistance, supporting the metabolic basis of hepatic steatosis. [5]

The present study also demonstrated significant differences in the lipid profile. Triglyceride and LDL cholesterol levels were

higher, whereas HDL cholesterol was lower among participants with fatty liver. Hypertriglyceridemia and low HDL cholesterol were particularly common in the fatty liver group. These findings are compatible with the metabolic syndrome pattern frequently observed in individuals with NAFLD. Hamaguchi et al. reported that the metabolic syndrome was strongly associated with the development of NAFLD. [6]

An important observation in the present study was the progressive increase in metabolic abnormalities with increasing ultrasonographic grade of fatty liver. BMI, waist circumference, fasting glucose, HbA1c and triglyceride levels increased from Grade I to Grade III fatty liver, whereas HDL cholesterol showed a progressive decline. This pattern suggests that increasing hepatic steatosis on ultrasound may occur alongside increasing metabolic risk. However, because the present study is observational, the findings demonstrate association rather than causation.

A meta-analysis by Hernaez et al. demonstrated good diagnostic performance of ultrasonography for detecting moderate-to-severe fatty liver, although sensitivity is lower for mild steatosis. [7] Ultrasonography identified Grade I fatty liver in 24%, Grade II in 15% and Grade III in 4% of the study population. Ultrasonography is widely used as an initial imaging modality for detecting hepatic steatosis because it is non-invasive, readily available and relatively inexpensive. [8]

Conclusion:

In the present study, ultrasonographically detected fatty liver was observed in 43% of the study population. NAFLD was significantly associated with higher BMI, increased waist circumference, impaired glycemic parameters, hypertriglyceridemia, higher LDL cholesterol, lower HDL cholesterol, diabetes mellitus and

hypertension. Increasing grades of fatty liver were accompanied by progressively greater metabolic abnormalities. Ultrasonography therefore provides a useful, non-invasive method for identifying hepatic steatosis, while assessment of metabolic parameters is important for identifying associated metabolic risk.

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