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SONOGRAPHIC ASSOCIATION OF FATTY LIVER GRADING WITH SERUM LIPID PROFILE AND BODY MASS INDEX

Original Research

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ABSTRACT

Background: Non-alcoholic fatty liver disease (NAFLD) is a major metabolic disorder characterized by hepatic fat accumulation in the absence of significant alcohol consumption. It is closely associated with obesity, dyslipidemia, insulin resistance, and type 2 diabetes mellitus. If left undiagnosed, NAFLD can progress to non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis, and hepatocellular carcinoma. Early detection using non-invasive modalities such as ultrasonography is essential to prevent long-term complications and improve patient outcomes.

Objective: To evaluate the association of ultrasonographically graded fatty liver with serum lipid profile and body mass index (BMI).

Methods: This analytical cross-sectional study was conducted at Ibraheem Health Care Center, Nowshera, over nine months. A total of 124 participants diagnosed with NAFLD via ultrasonography were included using non-probability consecutive sampling. Data on gender, age, height, weight, BMI, diabetes, hypertension, serum lipid profile, and fatty liver grades were collected. Fatty liver was categorized into Grade 0, I, II, and III based on sonographic findings. Serum lipid profiles, including total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL), and high-density lipoprotein (HDL), were measured. Statistical analysis was performed using SPSS version 25, with significance set at $p<0.05$.

Results: The mean age of participants was 48.5 ± 12.55 years, with 52.5% males and 47.5% females. Grade-wise fatty liver distribution included Grade 0 (8.1%), Grade I (37.1%), Grade II (44.4%), and Grade III (10.4%). BMI analysis showed that 54.8% were overweight and 40.4% were obese. Serum TC was abnormal in 33.2% of cases, TG in 35.5%, LDL in 6.4%, and low HDL in 5.6%. A statistically significant correlation was observed between increasing fatty liver grades and worsening lipid profile ($p=0.05$).

Conclusion: Ultrasonography proved to be a valuable non-invasive diagnostic tool for NAFLD detection and grading. Higher fatty liver grades were significantly associated with dyslipidemia and increased BMI, reinforcing the need for early metabolic screening and lifestyle interventions to prevent disease progression.

Keywords: Body mass index, Dyslipidemia, Fatty liver, Hypertension, Non-alcoholic fatty liver disease, Obesity, Ultrasonography.

INTRODUCTION

Fatty liver disease encompasses a spectrum of hepatic conditions ranging from simple steatosis to cirrhosis, with intermediary stages including non-alcoholic steatohepatitis (NASH), hepatic fibrosis, and hepatocellular dysfunction. Non-alcoholic fatty liver disease (NAFLD) is defined by macrovesicular fat accumulation in hepatocytes without evidence of significant alcohol consumption. NAFLD is often associated with metabolic disorders such as obesity, dyslipidemia, insulin resistance, and type 2 diabetes mellitus, all of which contribute to hepatic lipid accumulation and oxidative stress, ultimately leading to hepatocellular inflammation and fibrosis. Differentiating NAFLD from NASH requires histological evaluation via liver biopsy; however, this invasive method is limited by cost, sampling errors, and potential complications, necessitating the exploration of non-invasive diagnostic alternatives. Imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) provide detailed hepatic assessments, yet their accessibility and cost remain constraints. B-mode ultrasonography has emerged as the most widely used modality for detecting hepatic steatosis due to its affordability and ease of use. Sonographic indicators of fatty liver include increased hepatic parenchymal brightness, attenuation of ultrasound waves, loss of intrahepatic vascular wall distinction, and heightened echogenicity contrast between the liver and renal parenchyma (hepato-renal index). Among these, posterior hepatic lobe attenuation has demonstrated superior performance in detecting steatosis (1). The term NASH was first introduced by Ludwig in 1980 to describe a progressive hepatic condition characterized by hepatocellular inflammation, ballooning, and fibrosis in the absence of significant alcohol intake. NAFLD represents a disease continuum where simple steatosis exists at one end and cirrhosis at the other, with NASH serving as an intermediary stage that may progress to irreversible hepatic damage. The prevalence of NAFLD is rising globally, with estimates suggesting a 15–30% prevalence in the Indian population. Once considered a benign hepatic condition, NAFLD has been increasingly recognized as a precursor to cirrhosis, hepatocellular carcinoma, and cardiovascular disease, emphasizing the need for early detection and risk stratification. Radiological studies estimate NAFLD prevalence between 14% and 31% in adults, with obesity being a primary risk factor. Approximately 91% of individuals with a body mass index (BMI) exceeding 30 kg/m² exhibit hepatic steatosis on ultrasound, reinforcing the strong association between adiposity and fatty liver development. Additionally, waist circumference (WC) has emerged as a robust predictor of NAFLD severity, with a 42–44% increase in abdominal obesity observed among affected individuals (2,3).

Sonographic assessment of fatty liver relies on echogenicity parameters relative to renal parenchyma, vessel obscuration, and posterior hepatic lobe attenuation. Additionally, focal fatty sparing (FFS) and focal fatty infiltration (FFI) present as distinct hepatic patterns requiring differentiation from other hepatic lesions. While FFS appears as non-steatotic regions within the liver, FFI manifests as localized hyper-echoic areas. The use of contrast-enhanced ultrasonography (CEUS) has shown potential in distinguishing FFI from focal hepatic lesions. Given the strong correlation between obesity, dyslipidemia, and NAFLD progression, metabolic factors play a crucial role in hepatic lipid accumulation. Dysregulated lipid metabolism, characterized by elevated triglycerides, increased free fatty acid flux, and insulin resistance, contributes to hepatic steatosis and inflammation. Notably, as fatty liver severity advances, serum lipid profiles, particularly triglyceride and cholesterol levels, tend to rise proportionally, making lipid profile evaluation a valuable tool for assessing metabolic dysfunction in NAFLD patients (4,5). The rising global burden of NAFLD necessitates effective screening tools that integrate clinical, metabolic, and imaging parameters for risk stratification. Despite its limitations, transabdominal ultrasonography remains a widely adopted, non-invasive modality for hepatic steatosis detection. Given the increasing prevalence of obesity and metabolic syndrome, understanding the association between ultrasound-graded fatty liver and serum lipid profiles may provide valuable insights into early disease identification and risk assessment. This study aims to evaluate the relationship between fatty liver grading on ultrasonography and serum lipid profiles while assessing the diagnostic utility of BMI and lipid parameters in predicting hepatic steatosis severity. Findings from this study will contribute to the growing body of evidence, potentially aiding in refining non-invasive diagnostic approaches for NAFLD and its metabolic implications (6).

METHODS

This cross-sectional analytical study was conducted at Ibraheem Health Care Center, Nowshera, over a period of nine months following the approval of the study protocol by the hospital's ethical committee. Ethical clearance was obtained in accordance with institutional guidelines, and written informed consent was secured from all participants, ensuring confidentiality and the right to withdraw at any

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stage. The sample size was determined as 124 participants based on a correlation coefficient ($\gamma = 0.249$) between low-density lipoprotein (LDL) and ultrasonographic grading of fatty liver, using a 5% margin of error, a 95% confidence level, and an 80% power of the test. The calculation followed the standard statistical formula, incorporating a two-tailed α of 0.05, a β of 0.20, and a computed standard normal deviation for α ($Z\alpha = 1.960$) and β ($Z\beta = 0.8416$). The final sample size was derived using the equation $N = [(Z\alpha+Z\beta) / C]^2 + 3$, where C was calculated as $0.5 * \ln[(1+\gamma) / (1-\gamma)] = 0.2543$. A non-probability, consecutive sampling technique was employed for participant selection (7). Patients of both genders, aged between 20 and 90 years, with ultrasound-confirmed fatty liver disease were included in the study. Individuals diagnosed with hepatitis B or C were excluded to avoid confounding factors that could influence hepatic pathology. The ultrasound evaluation was performed using an Aloka Prosound Alfa 5 ultrasound machine equipped with a curved array transducer operating at a frequency of 3.5–5 MHz. Standardized imaging protocols were followed to ensure accuracy, with the left hemi-liver examined from an anterior xyphoid approach while the patient remained in a supine position. The right hemi-liver was assessed via subcostal and intercostal scanning, with intercostal imaging performed during deep inspiration and subcostal imaging conducted with the patient in either a left lateral decubitus or left posterior oblique position. Fatty liver was classified into three grades based on sonographic criteria, including increased hepatic parenchymal brightness relative to the right renal cortex, vascular blurring, posterior beam attenuation, impaired diaphragm and gallbladder visualization, focal fatty sparing, and focal fatty infiltration (8).

Data collection encompassed both quantitative and qualitative variables. Quantitative variables included age, height, weight, body mass index (BMI), duration of diabetes, hypertension, total cholesterol, LDL, high-density lipoprotein (HDL), and triglycerides, whereas qualitative variables comprised gender, diabetes, hypertension, and ultrasonographic fatty liver grading. BMI was calculated using the formula: weight (kg) divided by height squared (m^2). Patients with a BMI of 25 or above were classified as overweight, while those with a BMI between 18.5 and 24.9 were categorized as normal. For lipid profile analysis, 5cc of venous blood was collected from each participant following an eight-hour fasting period. Biochemical analysis was performed using the MicroLab 300 chemistry analyzer to assess total cholesterol, LDL, HDL, and triglyceride levels (9). Statistical analysis was conducted using SPSS version 25. Descriptive statistics were applied, with quantitative variables reported as mean ± standard deviation (SD) and qualitative variables expressed as frequencies and percentages. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were assessed using a 2×2 contingency table. Correlation analyses were performed using Spearman's and Pearson's correlation coefficients, with a p-value of less than 0.05 considered statistically significant (10).

RESULTS

The study included 124 participants diagnosed with non-alcoholic fatty liver disease (NAFLD) through ultrasonography. Among them, 65 (52.5%) were males and 59 (47.5%) were females. The mean age of the participants was 48.5 years (SD ± 12.55), ranging from 25 to 72 years. The highest proportion of participants (32.2%) were in the 40–49 years age group, followed by 30–39 years (29%), 50–59 years (20.1%), 20–29 years (8.8%), and 60–69 years (7.2%). Fatty liver grading based on ultrasound revealed that 10 (8.1%) participants had Grade 0 (normal liver), 46 (37.1%) had Grade I, 55 (44.4%) had Grade II, and 13 (10.4%) had Grade III fatty liver. Body mass index (BMI) classification showed that 68 (54.8%) participants were overweight (BMI: 25–29.9), 50 (40.4%) were obese (BMI ≥30), and only 6 (4.8%) had a normal BMI (18–24.9).

Serum total cholesterol levels were assessed across fatty liver grades, with 61 (49.1%) participants having normal cholesterol levels, 22 (17.7%) showing borderline high levels, and 41 (33.2%) exhibiting abnormally high cholesterol levels. A progressive increase in abnormal cholesterol levels was observed with worsening fatty liver grades, with the highest proportion of abnormal values in Grade III cases. Serum triglyceride levels revealed that 38 (30.6%) individuals had normal triglycerides, 42 (33.9%) had borderline high levels, and 44 (35.5%) had abnormally high triglycerides. The proportion of individuals with very high triglycerides increased with fatty liver severity, reaching 76.9% in Grade III cases. Serum low-density lipoprotein (LDL) values showed that 46 (37.1%) participants had normal LDL levels, 70 (56.5%) had borderline high levels, and 8 (6.4%) had abnormally high LDL levels. The highest proportion of abnormal LDL values was noted in Grade III fatty liver cases. High-density lipoprotein (HDL) levels were also evaluated, with 105 (84.7%) participants showing normal HDL, 11 (8.8%) having borderline low values, and 7 (5.6%) presenting with very low HDL levels. Lower HDL levels were more common in earlier fatty liver grades, whereas Grade III cases demonstrated mostly normal HDL levels.

Diabetes prevalence among participants revealed that 88 (70.9%) individuals had normal fasting blood glucose levels, 8 (6.5%) were prediabetic, and 28 (22.6%) were diabetic. The prevalence of diabetes increased with fatty liver severity, with Grade III cases showing the highest proportion of diabetics. Hypertension analysis indicated that 87 (70.2%) participants had normal blood pressure, 9 (7.3%)

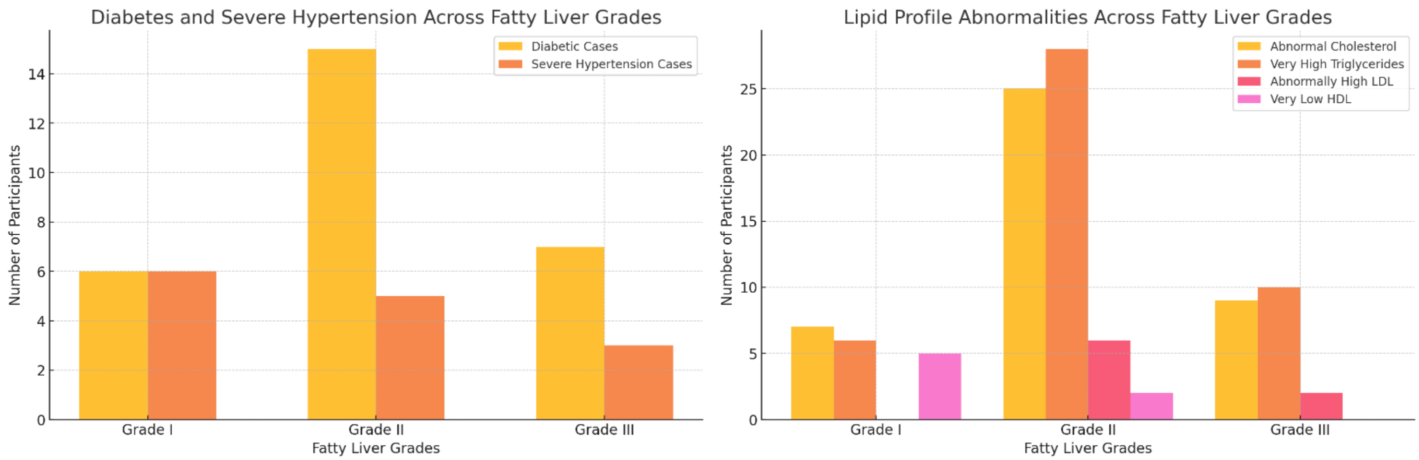
had mild hypertension, and 14 (11.3%) had moderate hypertension, while 14 (11.3%) had severe hypertension. The proportion of individuals with moderate to severe hypertension increased with higher fatty liver grades.

Table 1: Grade-wise Distribution of Lipid Profile and Diabetes

Parameter	Grade I	Grade II	Grade III	Total (%)
Total Cholesterol - Normal	33	25	3	61 (49.1%)
Total Cholesterol - Borderline High	12	9	1	22 (17.7%)
Total Cholesterol - Abnormal	7	25	9	41 (33.2%)
Triglycerides - Normal	25	13	0	38 (30.6%)
Triglycerides - Borderline High	20	19	3	42 (33.9%)
Triglycerides - Very High	6	28	10	44 (35.5%)
LDL - Normal	12	34	0	46
LDL - Borderline High	29	30	11	70
LDL - Abnormally High	0	6	2	8
HDL - Normal	44	49	13	105 (84.7%)
HDL - Borderline Low	2	9	0	11 (8.8%)
HDL - Very Low	5	2	0	7 (5.6%)
Diabetes - Normal	41	41	6	88 (70.9%)
Diabetes - Pre-diabetic	4	4	0	8 (6.5%)
Diabetes - Diabetic	6	15	7	28 (22.6%)

Table 2: 6-hypertension classification of the individuals

Grade fatty liver	Normal	Mild HTN	Moderate HTN	Sever HTN
Grade I	38	2	5	6
Grade II	42	6	7	5
Grade III	7	1	2	3
Total	87 (70.2%)	9 (7.3%)	14 (11.3%)	14 (11.3%)



DISCUSSION

Non-alcoholic fatty liver disease (NAFLD) has emerged as a significant public health concern, with a rising prevalence in both Western and Asian populations. Initially considered a disease associated with Western lifestyles characterized by high-fat diets, sedentary behavior, and increasing obesity rates, NAFLD has now become a global burden. The disease has shown a marked rise in prevalence in the Asia-Pacific region, including India, the Philippines, and Australia, reflecting the shift in dietary habits and metabolic risk factors. The growing incidence of obesity and type 2 diabetes has further contributed to the increasing burden of NAFLD. Studies indicate that approximately 20% of obese individuals and 5% of overweight individuals develop NAFLD, with a significantly higher prevalence in those with type 2 diabetes, demonstrating a 2.6-fold increased risk. Global estimates suggest that up to 60% of individuals diagnosed with type 2 diabetes reside in Asia, emphasizing the strong association between metabolic dysfunction and hepatic steatosis (11). Historically, NAFLD was predominantly observed in females with obesity, diabetes, and hypertension in Western populations. However, regional differences exist, with studies from India and other South Asian countries reporting a higher prevalence in males who are non-diabetic and non-hypertensive. These variations highlight the influence of genetic, environmental, and lifestyle factors on disease epidemiology. In this study, the age range of participants was 21 to 72 years, with a mean age of 48.5 years. Males had a slightly higher mean age (48 years) compared to females (42.5 years). NAFLD often remains asymptomatic, leading to incidental detection during routine medical checkups or evaluations for metabolic disorders. In this study, 28 individuals (22.6%) remained asymptomatic, whereas 54 (43.5%) presented with liver-related symptoms such as right hypochondrial pain, fatigue, nausea, abdominal distension, and malaise, with malaise and nausea being the most frequently reported symptoms (12,13).

Fatty liver grading revealed that the majority of cases were classified as Grade I (37.1%) and Grade II (44.4%), with a smaller proportion (10.4%) presenting with Grade III disease. A significant association was observed between NAFLD severity and dyslipidemia. Elevated serum total cholesterol, triglycerides, and low-density lipoprotein (LDL) levels were found in 50.2%, 59.6%, and 37.4% of individuals, respectively, while low high-density lipoprotein (HDL) levels were noted in 54.5% of cases. Increasing fatty liver grades correlated with a progressive worsening of lipid profiles, consistent with prior studies that have established a strong link between hepatic steatosis and dyslipidemia. The observed statistical significance between serum lipid levels and fatty liver grades ($p = 0.05$) further supports this association (14). The pathophysiology of NAFLD remains incompletely understood, although insulin resistance plays a central role in disease development. Hepatic triglyceride accumulation is a prerequisite for steatosis, yet the primary metabolic abnormalities leading to lipid retention are not entirely elucidated. Disruptions in hepatic lipid metabolism, oxidative stress, and chronic low-grade inflammation have been implicated in NAFLD progression, with genetic predisposition and antioxidant system dysregulation further influencing disease severity. Given the increasing burden of NAFLD, early detection and risk stratification are critical to prevent progression to advanced liver disease, including cirrhosis and hepatocellular carcinoma (15,16).

Liver biopsy remains the gold standard for diagnosing NAFLD; however, its invasiveness, cost, risk of complications, and sampling errors limit its widespread application. Ultrasonography offers a reliable, non-invasive, and cost-effective alternative for diagnosing fatty liver. The significant correlation between fatty liver grading and serum lipid abnormalities in this study reinforces the clinical utility of ultrasound in NAFLD detection. While ultrasound lacks the ability to quantify hepatic fat content precisely, it remains a practical

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first-line imaging modality that reduces unnecessary exposure to invasive procedures. Future research should focus on improving non-invasive diagnostic approaches, incorporating advanced imaging techniques such as elastography and controlled attenuation parameter (CAP) analysis to enhance accuracy in detecting hepatic fibrosis and steatosis severity (17,18). Despite its strengths, this study has certain limitations, including its cross-sectional design, which precludes causal inference. The reliance on ultrasonographic grading, while widely used, is subject to inter-observer variability. Additionally, the study did not account for dietary habits, physical activity levels, or genetic factors, which may contribute to NAFLD development and progression. Future studies should incorporate longitudinal follow-ups to assess disease progression and evaluate the impact of lifestyle modifications on fatty liver outcomes. Expanding the study to include a broader population with diverse metabolic profiles would further strengthen the findings and provide a more comprehensive understanding of NAFLD pathophysiology (19,20).

CONCLUSION

This study concludes that ultrasonography serves as a reliable, non-invasive tool for the initial detection and grading of hepatic steatosis, offering a practical approach for identifying individuals at risk of metabolic dysfunction. The findings highlight a strong association between increasing fatty liver severity and abnormalities in lipid profiles, as well as higher body mass indexes, reinforcing the role of metabolic disturbances in disease progression. Given its accessibility and cost-effectiveness, ultrasonography remains a valuable first-line diagnostic modality, aiding in early detection and risk stratification. These insights emphasize the need for proactive screening and lifestyle interventions to mitigate the long-term complications of non-alcoholic fatty liver disease.

Author Contribution

Author	Contribution
Muhammad Ibrahim*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Gul Bahader*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Irum Raheem	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Babar Issac	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Fiaz Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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