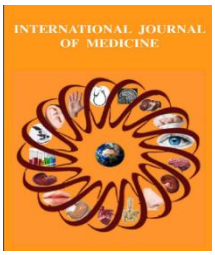

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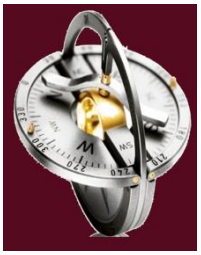

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Original Research

Role of Ultrasonography and Doppler Imaging in the Evaluation of Non-Alcoholic Fatty Liver Disease among Patients with Type 2 Diabetes Mellitus: An Observational Study

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Abstract

Background: Non-alcoholic fatty liver disease is frequently encountered in patients with type 2 diabetes mellitus and often remains clinically silent until metabolic or hepatic complications develop. Conventional ultrasonography is a practical first-line imaging tool for detecting hepatic steatosis, while Doppler imaging provides additional information on hepatic vascular haemodynamics. *Objectives:* To evaluate the role of grayscale ultrasonography and Doppler imaging in detecting and grading non-alcoholic fatty liver disease among patients with type 2 diabetes mellitus and to assess its relationship with clinical and biochemical parameters. *Methods:* This observational study was conducted in the Department of Radiodiagnosis, Kanyakumari Medical Mission Research Centre and Hospitals, Muttom, Kanyakumari District, Tamil Nadu, India, from February 2024 to July 2024. A total of 100 patients with type 2 diabetes mellitus underwent abdominal ultrasonography and Doppler assessment of portal venous and hepatic arterial parameters. Clinical, anthropometric, biochemical and imaging findings were analysed. *Results:* The mean age was 54.7 ± 9.6 years, and 58.0% were males. Ultrasonography detected fatty liver in 68.0% of patients. Grade I, Grade II and Grade III fatty liver were seen in 31.0%, 27.0% and 10.0%, respectively. Patients with fatty liver had higher body mass index, longer diabetes duration, higher HbA1c, triglycerides, alanine aminotransferase and aspartate aminotransferase. Doppler imaging showed lower portal vein flow velocity and higher hepatic artery resistive index among patients with fatty liver. *Conclusion:* Ultrasonography is useful for detecting and grading fatty liver in patients with type 2 diabetes mellitus, while Doppler imaging adds vascular haemodynamic assessment. The combined approach strengthens non-invasive evaluation of diabetic patients at risk for fatty liver disease.

Keywords: *Non-alcoholic fatty liver disease; Type 2 diabetes mellitus; Ultrasonography; Doppler imaging; Portal vein velocity; Hepatic artery resistive index.*

Introduction

Non-alcoholic fatty liver disease (NAFLD) represents one of the most common chronic liver disorders worldwide and has a close biological relationship with obesity, insulin resistance, dyslipidaemia and type 2 diabetes mellitus. Global meta-analytic evidence has shown that NAFLD affects a large and increasing proportion of adults, with a particularly heavy burden among patients with metabolic risk factors [1,2]. In patients with type 2 diabetes mellitus, the coexistence of hepatic steatosis is especially important because diabetes accelerates the progression from simple steatosis to steatohepatitis, fibrosis and advanced liver disease [3]. NAFLD is therefore not only a hepatic disorder but also a marker of wider metabolic dysfunction that requires early recognition in routine clinical practice.

The clinical detection of NAFLD is challenging because many affected patients have no specific symptoms and liver enzyme values remain normal in a sizeable proportion of cases. Practice guidance documents recommend that hepatic steatosis should be identified using imaging or histology after excluding secondary causes, significant alcohol intake and competing chronic liver diseases [4,5]. Liver biopsy remains the reference standard for histological classification, but its invasive nature, cost, sampling variability and limited suitability for routine screening restrict its use in most radiology and outpatient settings. This creates a strong clinical role for non-invasive imaging methods, particularly in diabetic populations where the expected prevalence is high.

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Conventional abdominal ultrasonography is widely available, inexpensive, radiation-free and suitable for repeated evaluation. Its diagnostic reliability is strongest for moderate to severe steatosis, and sonographic criteria such as increased hepatic echogenicity, hepatorenal contrast, poor visualisation of intrahepatic vessels and posterior beam attenuation are commonly used to grade fatty infiltration [8-10]. However, grayscale ultrasonography primarily reflects parenchymal echogenicity and provides limited insight into the haemodynamic consequences of fatty infiltration. Progressive deposition of fat within hepatocytes can compress hepatic sinusoids, alter portal venous inflow and influence hepatic arterial compensation. These vascular changes can be assessed using Doppler imaging.

Doppler ultrasonography permits non-invasive measurement of portal vein diameter, portal venous velocity and hepatic arterial indices. Previous studies have shown that fatty liver is associated with altered portal venous flow, reduced vascular compliance and changes in hepatic artery resistance [11-14]. These observations support the addition of Doppler parameters to routine ultrasound assessment, particularly in type 2 diabetes mellitus where metabolic derangements and hepatic fat accumulation frequently coexist. The present study was undertaken to evaluate the role of grayscale ultrasonography and Doppler imaging in the detection and assessment of NAFLD among patients with type 2 diabetes mellitus. The objectives were to determine the prevalence and ultrasonographic grading of NAFLD, compare clinical and biochemical parameters between patients with and without fatty liver, and assess Doppler changes in relation to NAFLD status and sonographic disease grade.

METHODOLOGY

Study design and setting: This observational cross-sectional study was conducted in the Department of Radiodiagnosis, Kanyakumari Medical Mission Research Centre and Hospitals, Muttom, Kanyakumari District, Tamil Nadu, India, from February 2024 to July 2024. Adult patients with type 2 diabetes mellitus referred for abdominal ultrasonography were screened for enrolment.

Study population and sample size: A total of 100 consecutive eligible adult patients with established type 2 diabetes mellitus were included. Patients were excluded if they had significant alcohol intake, viral hepatitis, known cirrhosis, hepatic malignancy, previous liver surgery, acute hepatitis, pregnancy, ascites causing poor acoustic window, steatogenic drug exposure, or incomplete clinical and laboratory data.

Clinical and laboratory assessment: Age, sex, body mass index and duration of diabetes were recorded using a structured form. Fasting blood glucose, HbA1c, total cholesterol, triglycerides, alanine aminotransferase and aspartate aminotransferase were documented. NAFLD was defined by imaging evidence of steatosis after excluding secondary causes according to accepted practice guidance [4,5].

Ultrasonography technique: Grayscale abdominal ultrasonography was performed using a curvilinear transducer after appropriate fasting wherever feasible. The liver was assessed for size, echotexture, echogenicity relative to the renal cortex, visibility of intrahepatic vessels and posterior beam attenuation. Fatty liver was graded as Grade I for mild diffuse echogenicity with preserved vessel visibility, Grade II for moderate echogenicity with reduced vessel visualisation, and Grade III for marked echogenicity with poor posterior penetration or obscured vascular and diaphragmatic margins [8-10].

Doppler imaging: Colour and spectral Doppler evaluation was performed for portal venous and hepatic arterial haemodynamics. Portal vein diameter and flow velocity were measured from the main portal vein during quiet respiration with an acceptable Doppler angle. Hepatic artery resistive index and pulsatility index were obtained from reproducible waveforms, and splenic vein diameter was recorded. These measurements were interpreted along with grayscale findings because fatty infiltration alters portal venous velocity and hepatic arterial indices [11-14].

Statistical analysis: Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequency and percentage. Patients were grouped as no NAFLD and NAFLD present. Mean values were compared using the independent sample t-test, and categorical variables using the chi-square test. A p-value less than 0.05 was considered statistically significant.

Ethical considerations: Ethics approval details, including committee name and approval number, should be inserted by the authors before submission. Patient identifiers were not used, and confidentiality of clinical and imaging data was maintained throughout analysis, reporting and research documentation.

Results

A total of 100 patients with type 2 diabetes mellitus were included in the study. The mean age of the study population was 54.7 ± 9.6 years, with the highest proportion of patients belonging to the 51-60 years age group. Males constituted 58.0% of the study population, while females accounted for 42.0%. The mean body mass index was 27.3 ± 3.8 kg/m². Overweight and obesity were common, observed in 64.0% of patients. The mean duration of diabetes was 8.1 ± 5.2 years. The baseline demographic and clinical profile is shown in Table 1.

Table 1. Baseline demographic and clinical characteristics of the study population

Variable	Frequency / Mean	Percentage
Total patients	100	100.0
Mean age, years	54.7 ± 9.6	–
31-40 years	10	10.0
41-50 years	25	25.0
51-60 years	39	39.0
>60 years	26	26.0
Male	58	58.0
Female	42	42.0
Mean BMI, kg/m²	27.3 ± 3.8	–
Normal BMI	36	36.0
Overweight	42	42.0
Obese	22	22.0
Mean duration of diabetes, years	8.1 ± 5.2	–
Duration ≤5 years	38	38.0
Duration 6-10 years	35	35.0
Duration >10 years	27	27.0

On ultrasonographic evaluation, fatty liver changes were detected in 68 patients, giving a prevalence of NAFLD of 68.0% among patients with type 2 diabetes mellitus. Mild fatty liver was the most common grade, observed in 31.0% of patients, followed by moderate fatty liver in 27.0% and severe fatty liver in 10.0%. Hepatomegaly was observed in 37.0% of patients. The distribution of ultrasonographic findings is presented in Table 2.

Table 2. Ultrasonographic findings among the study population

Ultrasonographic finding	Frequency	Percentage
No fatty liver	32	32.0
Fatty liver present	68	68.0
Grade I fatty liver	31	31.0
Grade II fatty liver	27	27.0
Grade III fatty liver	10	10.0
Hepatomegaly	37	37.0
Increased liver echogenicity	68	68.0
Reduced visualization of intrahepatic vessels	29	29.0
Posterior beam attenuation	18	18.0

Patients with ultrasonographic evidence of NAFLD had higher mean BMI, longer duration of diabetes, higher fasting blood glucose, increased HbA1c and higher triglyceride levels compared with patients without fatty liver. Mean alanine aminotransferase and aspartate aminotransferase values were also higher among patients with NAFLD. These differences were statistically significant for BMI, duration of diabetes, HbA1c, triglycerides, ALT and AST, as shown in Table 3.

Table 3. Comparison of clinical and biochemical parameters according to NAFLD status

Parameter	No NAFLD (n=32)	NAFLD present (n=68)	p-value
Age, years	52.8 ± 8.7	55.6 ± 9.9	0.172
BMI, kg/m²	24.9 ± 2.8	28.4 ± 3.6	<0.001
Duration of diabetes, years	5.9 ± 3.6	9.1 ± 5.4	0.003
Fasting blood glucose, mg/dL	146.3 ± 34.8	168.7 ± 42.6	0.014
HbA1c, %	7.6 ± 1.1	8.5 ± 1.4	0.002
Total cholesterol, mg/dL	181.6 ± 36.5	198.9 ± 41.8	0.051
Triglycerides, mg/dL	151.4 ± 48.7	204.6 ± 66.3	<0.001
ALT, IU/L	32.8 ± 12.4	48.9 ± 21.6	<0.001
AST, IU/L	29.6 ± 10.8	42.3 ± 18.5	<0.001

Doppler imaging showed measurable differences in hepatic vascular parameters between patients with and without NAFLD. Mean portal vein flow velocity was lower among patients with NAFLD compared with those without NAFLD. Hepatic artery resistive index and pulsatility index were higher in the NAFLD group. Portal vein diameter was also increased among patients with fatty liver. Doppler parameters are shown in Table 4.

Table 4. Doppler imaging parameters according to NAFLD status

Doppler parameter	No NAFLD (n=32)	NAFLD present (n=68)	p-value
Portal vein diameter, mm	10.4 ± 1.2	11.8 ± 1.5	<0.001
Portal vein flow velocity, cm/s	20.6 ± 3.8	15.9 ± 4.1	<0.001
Hepatic artery resistive index	0.63 ± 0.05	0.71 ± 0.07	<0.001
Hepatic artery pulsatility index	1.21 ± 0.18	1.46 ± 0.25	<0.001
Splenic vein diameter, mm	7.1 ± 0.9	7.8 ± 1.1	0.002

A progressive change in Doppler parameters was observed with increasing ultrasonographic grade of fatty liver. Portal vein flow velocity declined from 18.1 ± 3.6 cm/s in Grade I fatty liver to 12.3 ± 2.9 cm/s in Grade III fatty liver. In contrast, hepatic artery resistive index increased progressively with disease grade. This pattern indicates that Doppler imaging provides additional vascular information along with conventional grayscale ultrasonography. The grade-wise Doppler profile is presented in Table 5.

Table 5. Doppler parameters according to ultrasonographic grade of fatty liver

Parameter	Grade I (n=31)	Grade II (n=27)	Grade III (n=10)	p-value
Portal vein diameter, mm	11.2 ± 1.2	12.0 ± 1.3	12.9 ± 1.5	0.001
Portal vein flow velocity, cm/s	18.1 ± 3.6	15.2 ± 3.4	12.3 ± 2.9	<0.001
Hepatic artery resistive index	0.68 ± 0.05	0.72 ± 0.06	0.77 ± 0.06	<0.001
Hepatic artery pulsatility index	1.35 ± 0.20	1.49 ± 0.21	1.68 ± 0.26	<0.001

Overall, ultrasonography identified fatty liver changes in more than two-thirds of patients with type 2 diabetes mellitus. Doppler imaging added functional vascular assessment by demonstrating reduced portal venous flow velocity and increased hepatic arterial resistance among patients with NAFLD. These changes were more pronounced with increasing fatty liver grade, supporting the combined role of grayscale ultrasonography and Doppler imaging in the evaluation of NAFLD among diabetic patients.

Discussion

The present observational study demonstrates a high burden of NAFLD among patients with type 2 diabetes mellitus, with ultrasonography detecting fatty liver in 68.0% of the study population. This finding is consistent with global evidence showing that NAFLD is highly prevalent among individuals with diabetes and metabolic dysfunction [3]. Similar ultrasound-based studies among diabetic populations have reported a strong association of NAFLD with obesity, longer duration of diabetes and adverse lipid profile [6,7]. In the present study, patients with NAFLD had higher mean BMI, longer diabetes duration, higher HbA1c and elevated triglycerides, supporting the close metabolic link between hepatic steatosis and poor glycaemic-lipid control.

Conventional ultrasonography detected a spectrum of fatty liver grades, with Grade I being the most frequent pattern. This is clinically relevant because early steatosis is generally asymptomatic and often identified only during imaging performed for screening or unrelated abdominal complaints. Ultrasonography remains a practical imaging method for detecting moderate to severe steatosis because it is accessible, inexpensive and free from ionising radiation [8]. The grading criteria used in this study were based on liver echogenicity, vessel visibility and beam attenuation, which are widely accepted sonographic markers of hepatic fat accumulation [9,10]. In resource-limited and high-volume clinical settings, this makes ultrasonography a reasonable first-line tool for evaluation of diabetic patients at risk of NAFLD.

The addition of Doppler imaging provided further functional information beyond grayscale echogenicity. Patients with NAFLD showed significantly lower portal vein flow velocity and higher portal vein diameter than those without fatty liver. This pattern supports the concept that hepatic fat deposition can compress sinusoidal channels, reduce intrahepatic vascular compliance and alter portal venous haemodynamics. Similar reductions in portal venous velocity and changes in portal Doppler indices have been reported in earlier studies of fatty liver disease [11-13]. In the present study, portal vein flow velocity also declined progressively with increasing fatty liver grade, strengthening its potential value as an adjunctive imaging parameter.

Hepatic artery resistive index and pulsatility index were significantly higher among patients with NAFLD and showed a progressive rise from Grade I to Grade III fatty liver. This observation suggests that hepatic arterial resistance changes in parallel with increasing parenchymal fat deposition. Previous Doppler-based studies have reported haemodynamic changes involving both the portal vein and hepatic artery in NAFLD, with correlation between Doppler indices and disease severity [14]. These changes are biologically plausible because hepatic steatosis affects the microvascular bed and can trigger compensatory arterial alterations when portal inflow decreases.

The findings of this study support the combined use of grayscale ultrasonography and Doppler imaging in the radiological evaluation of NAFLD among patients with type 2 diabetes mellitus. Grayscale ultrasound identifies the presence and grade of hepatic steatosis, while Doppler imaging adds information on portal venous and hepatic arterial haemodynamics. This integrated approach can improve risk recognition, guide metabolic evaluation and support follow-up planning. However, ultrasound and Doppler parameters cannot replace histology or advanced fibrosis assessment tools when steatohepatitis or significant fibrosis is clinically suspected.

Limitations

This single-centre study included 100 patients, limiting broad extrapolation across different diabetic populations. Histopathological confirmation, elastography and controlled attenuation parameter assessment were not performed. Doppler measurements are operator dependent and influenced by respiration, fasting status, machine settings and body habitus. Follow-up imaging, fibrosis progression, treatment response and liver-related clinical outcomes were not assessed during the study period, restricting longitudinal interpretation.

Conclusion

This study shows that NAFLD is highly prevalent among patients with type 2 diabetes mellitus, with ultrasonography detecting fatty liver in 68.0% of the study population. Higher BMI, longer diabetes duration, poor glycaemic control, hypertriglyceridaemia and elevated transaminases were associated with fatty liver. Doppler imaging demonstrated lower portal vein flow velocity and higher hepatic artery resistive and pulsatility indices in patients with NAFLD, with progressive changes across sonographic grades. Conventional ultrasonography remains a useful first-line method for screening and grading hepatic steatosis, while Doppler imaging adds haemodynamic information that strengthens non-invasive evaluation and supports early identification of diabetic patients requiring metabolic, hepatic and follow-up risk assessment in routine diabetic care.

References

1. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of nonalcoholic fatty liver disease-meta-analytic assessment of prevalence, incidence, and outcomes. Hepatology. 2016;64(1):73-84. doi:10.1002/hep.28431. PMID:26707365.
2. Younossi ZM, Golabi P, Paik JM, Henry A, Van Dongen C, Henry L. The global epidemiology of nonalcoholic fatty liver disease and nonalcoholic steatohepatitis: a systematic review. Hepatology. 2023;77(4):1335-1347. doi:10.1097/HEP.0000000000000004. PMID:36626630.
3. Younossi ZM, Golabi P, de Avila L, Paik JM, Srishord M, Fukui N, et al. The global epidemiology of NAFLD and NASH in patients with type 2 diabetes: a systematic review and meta-analysis. J Hepatol. 2019;71(4):793-801. doi:10.1016/j.jhep.2019.06.021. PMID:31279902.
4. European Association for the Study of the Liver; European Association for the Study of Diabetes; European Association for the Study of Obesity. EASL-EASD-EASO Clinical Practice Guidelines for the management of non-alcoholic fatty liver disease. J Hepatol. 2016;64(6):1388-1402. doi:10.1016/j.jhep.2015.11.004. PMID:27062661.
5. Chalasani N, Younossi Z, Lavine JE, Charlton M, Cusi K, Rinella M, et al. The diagnosis and management of nonalcoholic fatty liver disease: practice guidance from the American Association for the Study of Liver Diseases. Hepatology. 2018;67(1):328-357. doi:10.1002/hep.29367. PMID:28714183.
6. Leite NC, Salles GF, Araujo AL, Villela-Nogueira CA, Cardoso CRL. Prevalence and associated factors of non-alcoholic fatty liver disease in patients with type-2 diabetes mellitus. Liver Int. 2009;29(1):113-119. doi:10.1111/j.1478-3231.2008.01718.x. PMID:18384521.
7. Williamson RM, Price JF, Glancy S, Perry E, Nee LD, Hayes PC, et al. Prevalence of and risk factors for hepatic steatosis and nonalcoholic fatty liver disease in people with type 2 diabetes: the Edinburgh Type 2 Diabetes Study. Diabetes Care. 2011;34(5):1139-1144. doi:10.2337/dc10-2229. PMID:21478462.
8. Hernaez R, Lazo M, Bonekamp S, Kamel I, Brancati FL, Guallar E, et al. Diagnostic accuracy and reliability of ultrasonography for the detection of fatty liver: a meta-analysis. Hepatology. 2011;54(3):1082-1090. doi:10.1002/hep.24452. PMID:21618575.
9. Hamaguchi M, Kojima T, Itoh Y, Harano Y, Fujii K, Nakajima T, et al. The severity of ultrasonographic findings in nonalcoholic fatty liver disease reflects metabolic syndrome and visceral fat accumulation. Am J Gastroenterol. 2007;102(12):2708-2715. doi:10.1111/j.1572-0241.2007.01526.x. PMID:17894848.
10. Ferraioli G, Soares Monteiro LB. Ultrasound-based techniques for the diagnosis of liver steatosis. World J Gastroenterol. 2019;25(40):6053-6062. doi:10.3748/wjg.v25.i40.6053. PMID:31686762.
11. Balci A, Karazincir S, Sumbas H, Oter Y, Egilmez E, Inandi T. Effects of diffuse fatty infiltration of the liver on portal vein flow hemodynamics. J Clin Ultrasound. 2008;36(3):134-140. doi:10.1002/jcu.20440. PMID:18196595.
12. Erdogmus B, Tamer A, Buyukkaya R, Yazici B, Buyukkaya A, Korkut E, et al. Portal vein hemodynamics in patients with non-alcoholic fatty liver disease. Tohoku J Exp Med. 2008;215(1):89-93. doi:10.1620/tjem.215.89. PMID:18509239.
13. Ulusan S, Yakar T, Koc Z. Evaluation of portal venous velocity with Doppler ultrasound in patients with nonalcoholic fatty liver disease. Korean J Radiol. 2011;12(4):450-455. doi:10.3348/kjr.2011.12.4.450. PMID:21852905.
14. Balasubramanian P, Boopathy V, Govindasamy E, Venkatesh BP. Assessment of portal venous and hepatic artery haemodynamic variation in non-alcoholic fatty liver disease patients. J Clin Diagn Res. 2016;10(8):TC07-TC10. doi:10.7860/JCDR/2016/20697.8267. PMID:27656524.