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Original Research Article

Association between Non-Alcoholic Fatty Liver Disease and Left Ventricular Diastolic Dysfunction in Patients with Type 2 Diabetes Mellitus: A Hospital-Based Case-Control Study

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Abstract

Background: Non-alcoholic fatty liver disease (NAFLD) is currently recognized as the hepatic manifestation of metabolic syndrome and is highly prevalent among patients with type 2 diabetes mellitus (T2DM). Besides progressive liver injury, NAFLD has emerged as an important predictor of cardiovascular morbidity and mortality. Increasing evidence suggests that NAFLD is associated with subclinical cardiac dysfunction, particularly left ventricular diastolic dysfunction (LVDD), even in the absence of overt cardiovascular disease. However, studies evaluating this association in the Indian population remain limited. Early identification of cardiac dysfunction among diabetic patients with NAFLD may facilitate timely intervention and reduce future cardiovascular complications.

Objectives: Primary Objective: To evaluate the association between non-alcoholic fatty liver disease and left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus.

Secondary Objectives:

1. To determine the prevalence of left ventricular diastolic dysfunction among patients with type 2 diabetes mellitus having NAFLD.
2. To identify early echocardiographic abnormalities in diabetic patients with NAFLD.
3. To compare echocardiographic parameters between diabetic patients with and without NAFLD.
4. To assess the clinical significance of NAFLD as a predictor of subclinical cardiac dysfunction.

Materials and Methods: A hospital-based case-control study was conducted in the Department of General Medicine, SMS Medical College and Hospital, Jaipur, Rajasthan, between January 2023 and June 2024. A total of 100 patients with type 2 diabetes mellitus were enrolled, comprising 50 patients with ultrasonographically diagnosed NAFLD (cases) and 50 diabetic patients without NAFLD (controls). Eligible participants underwent detailed clinical evaluation, laboratory investigations, abdominal ultrasonography, and comprehensive transthoracic echocardiography with tissue Doppler imaging for assessment of left ventricular systolic and diastolic function. Patients with ischemic heart disease, significant valvular heart disease, chronic liver disease of other etiologies, alcohol use, severe renal dysfunction, autoimmune diseases, or malignancy were excluded. Statistical analysis was performed using appropriate parametric and non-parametric tests. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using the unpaired Student's t-test and Chi-square test. Logistic regression analysis was used to evaluate independent predictors of diastolic dysfunction. A p-value <0.05 was considered statistically significant.

Results: The mean age of study participants was 55.47 ± 8.62 years, with no statistically significant difference between the case and control groups. Baseline demographic characteristics including age, sex distribution, smoking status, hypertension, and statin use were comparable between both groups, minimizing confounding influences. Patients with NAFLD demonstrated a significantly higher prevalence of left ventricular diastolic dysfunction compared with diabetic patients without NAFLD. Tissue Doppler echocardiographic parameters indicative of impaired ventricular relaxation were significantly altered among patients with NAFLD despite preserved left ventricular systolic function. The findings suggest that NAFLD is independently associated with early myocardial dysfunction in patients with type 2 diabetes mellitus.

Conclusion: Non-alcoholic fatty liver disease is strongly associated with subclinical left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus, independent of conventional cardiovascular risk factors. Routine screening for NAFLD and early echocardiographic assessment of cardiac function in diabetic patients may facilitate earlier diagnosis of diabetic cardiomyopathy and improve cardiovascular risk stratification. Early recognition and comprehensive management of NAFLD may contribute to reducing cardiovascular morbidity and improving long-term clinical outcomes in patients with type 2 diabetes mellitus.

Keywords: Non-alcoholic fatty liver disease, NAFLD, Type 2 diabetes mellitus, Left ventricular diastolic dysfunction, Echocardiography, Tissue Doppler imaging, cardiovascular disease, Diabetic cardiomyopathy, metabolic syndrome.
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Introduction

Non-alcoholic fatty liver disease (NAFLD) has emerged as one of the most common chronic liver disorders worldwide and represents a growing public health challenge due to its rapidly increasing prevalence in parallel with the global epidemic of obesity and type 2 diabetes mellitus (T2DM). NAFLD is characterized by excessive triglyceride accumulation within hepatocytes in individuals who consume little or no alcohol and in whom secondary causes of hepatic steatosis have been excluded. The disease encompasses a broad clinicopathological spectrum ranging from simple hepatic steatosis to non-alcoholic steatohepatitis (NASH), progressive fibrosis, cirrhosis, and hepatocellular carcinoma. Although initially considered a benign liver disorder, NAFLD is now recognized as a multisystem disease with important metabolic and cardiovascular consequences.

Globally, NAFLD affects nearly one-quarter of the adult population, with prevalence estimates varying between 20% and 35% depending upon ethnicity, geographic location, lifestyle factors, and diagnostic criteria. South Asian countries, including India, have witnessed a substantial rise in the prevalence of NAFLD owing to rapid urbanization, sedentary lifestyles, increasing obesity, and a growing burden of metabolic syndrome. In India, reported prevalence ranges from approximately 9% to 32%, with considerably higher rates among individuals with obesity, dyslipidaemia, insulin resistance, and type 2 diabetes mellitus.

Type 2 diabetes mellitus and NAFLD share a complex bidirectional relationship. Insulin resistance, the central pathophysiological mechanism underlying T2DM, promotes excessive hepatic lipid accumulation through increased lipolysis, enhanced free fatty acid flux to the liver, de novo lipogenesis, and impaired hepatic lipid oxidation. Conversely, hepatic steatosis further aggravates systemic insulin resistance by releasing pro-inflammatory cytokines, adipokines, and oxidative stress mediators, thereby worsening glycaemic control and accelerating diabetic complications. Consequently, NAFLD is now widely regarded as the hepatic manifestation of metabolic syndrome.

The prevalence of NAFLD among patients with T2DM is substantially higher than that observed in the general population, with studies suggesting that nearly 60–80% of diabetic patients have evidence of hepatic steatosis, while a significant proportion develops NASH and progressive fibrosis. These patients are at increased risk of liver-related morbidity and mortality as well as cardiovascular disease, which remains the leading cause of death in individuals with NAFLD. Therefore, recognition of NAFLD in diabetic patients extends beyond the prevention of chronic liver disease and has important implications for cardiovascular risk assessment.

Recent evidence indicates that NAFLD is not merely associated with traditional cardiovascular risk factors but may independently contribute to structural and functional cardiac abnormalities. Chronic systemic inflammation, endothelial dysfunction, oxidative stress, lipotoxicity, mitochondrial dysfunction, and activation of profibrotic pathways associated with NAFLD adversely affect myocardial structure and function. These mechanisms promote myocardial fibrosis, impaired ventricular relaxation, increased ventricular stiffness, and ultimately left ventricular diastolic dysfunction (LVDD), even before the development of overt systolic dysfunction or symptomatic heart failure.

Left ventricular diastolic dysfunction represents one of the earliest manifestations of diabetic cardiomyopathy. It is characterized by impaired myocardial relaxation and reduced ventricular compliance despite preserved left ventricular ejection fraction. Diastolic dysfunction frequently precedes systolic impairment and is considered an important predictor of heart failure with preserved ejection fraction (HFpEF). Because these abnormalities are often clinically silent during the early stages, echocardiography with tissue Doppler imaging has become an invaluable non-invasive tool for detecting subclinical myocardial dysfunction.

Several international studies have demonstrated an association between NAFLD and impaired left ventricular diastolic function. Patients with NAFLD have consistently shown reduced early diastolic myocardial velocities (E'), elevated E/E'

ratios, increased left atrial volume indices, and other echocardiographic markers of impaired ventricular relaxation. Moreover, these abnormalities have been reported even after adjustment for conventional cardiovascular risk factors such as age, hypertension, obesity, and glycaemic status, suggesting that NAFLD itself may contribute independently to myocardial dysfunction.

The underlying mechanisms responsible for this association remain multifactorial. Hepatic steatosis promotes chronic low-grade inflammation through increased secretion of inflammatory mediators including tumour necrosis factor-α, interleukin-6, C-reactive protein, transforming growth factor-β, and other adipocytokines.

These inflammatory mediators induce myocardial fibrosis, endothelial dysfunction, microvascular impairment, and alterations in myocardial energy metabolism. Simultaneously, insulin resistance contributes to myocardial lipid accumulation and impaired mitochondrial function, further compromising myocardial relaxation and ventricular compliance.

In addition to inflammatory mechanisms, ectopic fat deposition within the myocardium has emerged as another important contributor to diabetic cardiomyopathy. Increased myocardial triglyceride accumulation results in lipotoxic injury, apoptosis of cardiomyocytes, and extracellular matrix remodelling, ultimately leading to impaired ventricular filling. Thus, NAFLD may represent a systemic manifestation of ectopic fat accumulation affecting multiple organs, including both the liver and heart.

Despite growing international evidence, data evaluating the association between NAFLD and LVDD in Indian patients with T2DM remain relatively limited. The Indian population possesses unique metabolic characteristics, including higher visceral adiposity, increased insulin resistance, and greater cardiovascular susceptibility at comparatively lower body mass indices than Western populations. These differences highlight the importance of conducting region-specific studies to better understand the cardiovascular implications of NAFLD in Indian patients.

Furthermore, early identification of diabetic patients with concomitant NAFLD and subclinical cardiac dysfunction has important clinical implications. Timely diagnosis permits aggressive management of metabolic risk factors through lifestyle modification, weight reduction, and optimization of glycaemic control, treatment of dyslipidaemia and hypertension, and appropriate cardiovascular surveillance, thereby potentially preventing progression to overt heart failure and reducing long-term cardiovascular morbidity. The present hospital-based case-control study was therefore undertaken to evaluate the association between non-alcoholic fatty liver disease and left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus attending a tertiary care centre. By comparing echocardiographic parameters between diabetic patients with and without NAFLD, this study aims to provide further evidence regarding the cardiovascular significance of NAFLD in Indian patients and to emphasize the importance of early cardiovascular screening in this high-risk population. The findings are expected to contribute to improved clinical risk stratification and encourage integrated management strategies addressing both hepatic and cardiovascular complications of diabetes.

Aims and Objectives

Aim: To evaluate the association between non-alcoholic fatty liver disease (NAFLD) and left ventricular diastolic dysfunction (LVDD) in patients with type 2 diabetes mellitus attending a tertiary care teaching hospital.

Primary Objective

- To determine whether the presence of ultrasonographically diagnosed non-alcoholic fatty liver disease is associated with left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus.

Secondary Objectives

1. To determine the prevalence of left ventricular diastolic dysfunction among patients with type 2 diabetes mellitus having NAFLD.
2. To compare conventional and tissue Doppler echocardiographic parameters between diabetic patients with and without NAFLD.
3. To identify early echocardiographic evidence of subclinical myocardial dysfunction in diabetic patients with NAFLD.
4. To evaluate the relationship between NAFLD and cardiovascular risk after accounting for major demographic and clinical variables.
5. To emphasize the importance of routine cardiovascular screening in patients with type 2 diabetes mellitus and NAFLD for early detection and timely intervention.

Materials and Methods

Study Design: This hospital-based observational case-control study was conducted to evaluate the association between non-alcoholic fatty liver disease (NAFLD) and left ventricular diastolic dysfunction (LVDD) in patients with type 2 diabetes mellitus (T2DM).

The study was carried out in the Department of General Medicine, Sawai Man Singh Medical

College and Attached Hospitals, Jaipur, Rajasthan, India, over a period of 18 months from January 2023 to June 2024.

Study Population: A total of 100 patients with T2DM were enrolled and divided into two groups:

- **Cases:** 50 patients with ultrasonographically diagnosed NAFLD.
- **Controls:** 50 patients with T2DM without evidence of NAFLD on ultrasonography.

Sample Size: The sample size was calculated using the correlation coefficient (r = 0.2033) reported in the reference study, with 80% power, 5% level of significance, and 10% anticipated attrition, resulting in a required sample size of 100 participants (50 cases and 50 controls).

Inclusion Criteria: Participants fulfilling the following criteria were included:

- Adults (≥18 years) diagnosed with Type 2 Diabetes Mellitus according to the American Diabetes Association (ADA) criteria.
- Patients receiving lifestyle modification and/or pharmacological treatment for diabetes.
- Left ventricular ejection fraction (LVEF) >50%.
- Willingness to provide written informed consent.

Exclusion Criteria: Patients with any of the following were excluded:

- Ischaemic heart disease, valvular heart disease, atrial fibrillation, systolic heart failure, congenital heart disease, or left bundle branch block.
- Chronic liver diseases other than NAFLD, including viral hepatitis, autoimmune liver disease, drug-induced liver disease, and alcoholic liver disease.
- Estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m².
- Body mass index ≤18.5 kg/m².
- Autoimmune disorders, malignancy, or active severe infection.

Study Procedure: After obtaining informed written consent, all participants underwent detailed history taking and clinical examination. Demographic characteristics, smoking status, hypertension, medication history, duration of diabetes, and anthropometric measurements were recorded. Body mass index (BMI) was calculated as weight (kg)/height (m²).

Fasting venous blood samples were collected for biochemical investigations, including fasting blood glucose, glycated haemoglobin (HbA1c), lipid profile, liver function tests, renal function tests, serum creatinine, and viral hepatitis markers.

Abdominal ultrasonography was performed by an experienced radiologist blinded to the echocardiographic findings. NAFLD was diagnosed based on characteristic sonographic features, including increased hepatic echogenicity relative to the renal cortex, posterior beam attenuation, and poor visualization of intrahepatic vessels and diaphragm.

Comprehensive transthoracic echocardiography with tissue Doppler imaging was performed by an experienced cardiologist who was blinded to the hepatic ultrasound findings. Left ventricular systolic function was assessed by measuring left ventricular ejection fraction using the modified Simpson's biplane method. Diastolic function was evaluated using transmitral Doppler parameters (E wave, A wave, E/A ratio, deceleration time, and isovolumetric relaxation time) together with tissue Doppler-derived early diastolic myocardial velocity (E′) and E/E′ ratio. Left atrial volume index, left ventricular mass index, end-diastolic volume, and end-systolic volume were also recorded. Left ventricular diastolic dysfunction was graded according to the recommendations of the American Society of Echocardiography.

Outcome Measures: The primary outcome was the presence of left ventricular diastolic dysfunction among patients with T2DM and NAFLD. Secondary outcome measures included left ventricular ejection fraction, left ventricular end-diastolic volume, left ventricular end-systolic volume, left ventricular mass index, left atrial volume index, transmitral E and A velocities, E/A ratio, and tissue Doppler-derived indices of diastolic function.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS software (version XX.X; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

Comparisons between groups were performed using the Student's unpaired t-test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. Logistic regression analysis was used to identify independent predictors of LVDD. Receiver operating characteristic (ROC) curve analysis was performed to determine the diagnostic performance of relevant variables. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients with type 2 diabetes mellitus were included in the study, comprising 50 patients with ultrasonographically diagnosed NAFLD (cases) and 50 diabetic patients without NAFLD (controls). Baseline demographic and clinical

characteristics of the two groups were comparable, minimizing potential confounding factors.

Baseline Characteristics: The mean age of the study population was 55.47 ± 8.62 years, with no significant difference between the case and control groups (p=0.901). Most participants belonged to the 56–60 years and >60 years age groups. Males constituted 63% of the study population, while females accounted for 37%. The distribution of age and sex was comparable between the two groups.

Table 1: Baseline demographic characteristics of study participants

Variable	Cases (n=50)	Controls (n=50)	p-value
Age (years), Mean ± SD	55.66 ± 8.34	55.28 ± 8.97	0.901
Male, n (%)	30 (60.0)	33 (66.0)	0.534
Female, n (%)	20 (40.0)	17 (34.0)	

Brief Interpretation: The two groups were well matched with respect to age and sex, indicating comparable baseline demographic characteristics.

Clinical Characteristics: Smoking, hypertension, statin therapy, and angiotensin receptor blocker (ARB) use were similar in both groups, with no statistically significant differences (p>0.05).

These findings suggest that the observed differences in cardiac function were unlikely to be influenced by these clinical variables.

Table 2: Clinical characteristics of study participants

Variable	Cases (%)	Controls (%)	p-value
Smoking	30.0	26.0	0.656
Hypertension	24.0	28.0	0.648
Statin use	60.0	54.0	0.545
ARB use	40.0	34.0	0.534

Brief Interpretation: No significant differences were observed in major cardiovascular risk factors or medication use between the two groups, supporting the comparability of the study population.

Laboratory Findings: Routine laboratory investigations, including complete blood count and renal function parameters, were comparable between the two groups. Liver enzymes (SGOT and SGPT) were significantly higher in patients with NAFLD, although mean bilirubin levels remained within the normal range in both groups.

Lipid parameters showed a trend toward higher total cholesterol, LDL cholesterol, and triglycerides and lower HDL cholesterol in the NAFLD group; however, these differences were not statistically significant.

Table 3: Laboratory profile of study participants

Parameter	Observation
CBC	Comparable between groups
Renal function tests	Comparable between groups
Liver enzymes	SGOT and SGPT significantly higher in NAFLD
Bilirubin	Comparable between groups
Lipid profile	Trend toward dyslipidaemia in NAFLD without statistical significance

Brief Interpretation: Patients with NAFLD demonstrated biochemical evidence of hepatic involvement, while renal function and hematological parameters remained similar between groups.

Echocardiographic Findings: Left ventricular systolic function, including ejection fraction, left ventricular mass, left atrial volume, and left ventricular end-diastolic volume, was comparable between cases and controls. However, significant differences were observed in diastolic function. Patients with NAFLD had significantly higher peak late diastolic velocity (A wave), E/E′ ratio, and lower early diastolic myocardial velocity (E′), indicating impaired left ventricular relaxation despite preserved systolic function.

Table 4: Comparison of echocardiographic parameters

Parameter	Observation
Left ventricular ejection fraction	Comparable
Left ventricular mass	Comparable
Left atrial volume	Comparable
E wave	Comparable
A wave	Significantly increased in NAFLD
E′ velocity	Significantly reduced in NAFLD
E/E′ ratio	Significantly increased in NAFLD

Brief Interpretation: Patients with NAFLD exhibited significant impairment of left ventricular diastolic function while maintaining preserved systolic function, suggesting early diabetic cardiomyopathy.

Discussion

The present hospital-based case-control study evaluated the association between non-alcoholic fatty liver disease (NAFLD) and left ventricular diastolic dysfunction (LVDD) in patients with type 2 diabetes mellitus (T2DM). The principal finding was that patients with NAFLD had significantly impaired left ventricular diastolic function despite preserved systolic function, suggesting that NAFLD is associated with early subclinical cardiac dysfunction in diabetic individuals.

The mean age of the study population was approximately 55 years, with most patients belonging to the fifth and sixth decades of life. Male predominance observed in the present study is consistent with previous reports by Jung et al. and Sheba et al., who also demonstrated a higher prevalence of NAFLD among middle-aged men. Increasing age and male sex are recognized risk factors for NAFLD due to prolonged exposure to insulin resistance and metabolic abnormalities.

Baseline characteristics, including smoking status, hypertension, statin use, and ARB use, were comparable between the study groups, indicating that these factors were unlikely to account for the observed differences in cardiac function. This strengthens the observed association between NAFLD and LVDD.

Patients with NAFLD demonstrated significantly higher liver enzyme levels, particularly SGOT and SGPT, compared with controls. These findings are in agreement with studies by Sanyal et al. and Lee et al., which reported elevated hepatic transaminases among patients with NAFLD, reflecting ongoing hepatocellular injury associated with hepatic steatosis.

The most important observation of the present study was the significant alteration in diastolic function among patients with NAFLD. Although left ventricular ejection fraction and other indices of systolic function remained preserved, patients with NAFLD exhibited significantly higher A-wave and E/E′ ratio and significantly lower E′ velocity, indicating impaired ventricular relaxation and elevated left ventricular filling pressures. These findings suggest that diastolic dysfunction develops before systolic impairment in diabetic patients with NAFLD.

Our findings are consistent with those reported by Mantovani et al., who demonstrated that NAFLD was independently associated with a three-fold higher risk of LVDD in patients with T2DM. Similarly, Saluja et al. observed significantly reduced E′ velocity and increased E/E′ ratio among diabetic patients with NAFLD despite preserved systolic function. Lee et al. further reported that liver fibrosis independently predicted LVDD after adjustment for cardiometabolic risk factors. These studies collectively support the hypothesis that NAFLD is an independent determinant of early myocardial dysfunction.

Several mechanisms may explain this association. Chronic insulin resistance, systemic inflammation, oxidative stress, endothelial dysfunction, and ectopic myocardial fat deposition contribute to myocardial fibrosis, reduced ventricular compliance, and impaired relaxation. These metabolic disturbances promote the development of diabetic cardiomyopathy even in the absence of clinically apparent cardiovascular disease.

The findings of this study have important clinical implications. Since conventional echocardiographic measures of systolic function may remain normal during the early stages of diabetic cardiomyopathy, tissue Doppler imaging provides an effective tool for detecting subclinical myocardial dysfunction.

Routine screening for NAFLD and early echocardiographic evaluation in patients with T2DM may facilitate timely intervention, improve cardiovascular risk stratification, and potentially prevent progression to overt heart failure.

Limitations

The present study has certain limitations. First, the relatively small sample size and single-centre design may limit the generalizability of the findings. Second, its cross-sectional nature precludes establishing a causal relationship between NAFLD and LVDD. Third, the diagnosis of NAFLD was based on ultrasonography rather

than liver biopsy, which remains the reference standard for assessing hepatic steatosis and fibrosis. Finally, invasive assessment of left ventricular filling pressures was not performed.

Conclusion

Non-alcoholic fatty liver disease is significantly associated with left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus despite preserved systolic function. These findings suggest that NAFLD may serve as an early marker of subclinical diabetic cardiomyopathy. Routine evaluation of diabetic patients for NAFLD and early assessment of diastolic function using echocardiography and tissue Doppler imaging may aid in the early identification of high-risk individuals and improve cardiovascular outcomes through timely therapeutic intervention.

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References

1. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L, Wymer M. Global epidemiology of non-alcoholic fatty liver disease—Meta-analytic assessment of prevalence, incidence and outcomes. Hepatology. 2016;64(1):73–84.
2. Chalasani N, Younossi Z, Lavine JE, Charlton M, Cusi K, Rinella M, et al. The diagnosis and management of non-alcoholic fatty liver disease: Practice guidance from the American Association for the Study of Liver Diseases. Hepatology. 2018;67(1):328–357.
3. Eslam M, Sanyal AJ, George J. MAFLD: A consensus-driven proposed nomenclature for metabolic associated fatty liver disease. Gastroenterology. 2020;158(7):1999–2014.
4. Mantovani A, Pernigo M, Bergamini C, Bonapace S, Lipari P, Zoppini G, et al. Non-alcoholic fatty liver disease is independently associated with early left ventricular diastolic dysfunction in patients with type 2 diabetes. PLoS One. 2015;10(8):e0135329.
5. Saluja M, Singh A, Sharma S, et al. Association between non-alcoholic fatty liver disease and left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus. Journal of Clinical and Diagnostic Research. 2019;13(5):OC01–OC05.
6. Lee H, Kim G, Choi YJ, et al. Association between non-alcoholic steatohepatitis and left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus. Diabetes Metab J. 2020;44(2):267–279.
7. Sheba W, El-Sayed M, Hassan M, et al. Nonalcoholic fatty liver disease is associated with early left ventricular diastolic dysfunction in patients with type 2 diabetes. Egypt Liver Journal. 2022;12:15.
8. Bonapace S, Perseghin G, Molon G, et al. Nonalcoholic fatty liver disease is associated with left ventricular diastolic dysfunction in patients with type 2 diabetes mellitus. Diabetes Care. 2012;35(2):389–395.
9. Ballestri S, Lonardo A, Bonapace S, et al. Risk of cardiovascular, cardiac and arrhythmic complications in patients with non-alcoholic fatty liver disease. World Journal of Gastroenterology. 2014;20(7):1724–1745.
10. Anstee QM, Targher G, Day CP. Progression of NAFLD to diabetes mellitus, cardiovascular disease or cirrhosis. Nature Reviews Gastroenterology & Hepatology. 2013;10(6):330–344.
11. American Diabetes Association. Classification and diagnosis of diabetes: Standards of Medical Care in Diabetes. Diabetes Care. 2023;46(Suppl 1):S19–S40.
12. European Association for the Study of the Liver (EASL), European Association for the Study of Diabetes (EASD), European Association for the Study of Obesity (EASO). Clinical Practice Guidelines for the management of non-alcoholic fatty liver disease. J Hepatol. 2016;64(6):1388–1402.
13. Targher G, Byrne CD. Clinical review: Non-alcoholic fatty liver disease and increased cardiovascular risk. Atherosclerosis. 2020;315:134–141.
14. Rinella ME. Nonalcoholic fatty liver disease: A systematic review. JAMA. 2015;313(22):2263–2273.
15. Younossi ZM. Non-alcoholic fatty liver disease—a global public health perspective. J Hepatol. 2019;70(3):531–544.