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Original Research Article

Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD): Clinical Profile and Predictors of Fibrosis

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Abstract

Background: Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) is the most common chronic liver disease worldwide and is strongly associated with obesity, type 2 diabetes mellitus, dyslipidemia, and metabolic syndrome. Progressive liver fibrosis is the major determinant of liver-related morbidity and mortality, making early identification of high-risk patients essential.

Objectives: To evaluate the clinical profile of patients with MASLD and identify the clinical and biochemical predictors of liver fibrosis.

Materials and Methods: A hospital-based cross-sectional observational study was conducted among 300 adult patients diagnosed with MASLD at a tertiary care teaching hospital over 18 months. Demographic characteristics, anthropometric measurements, metabolic risk factors, biochemical investigations, lipid profile, liver function tests, glycemic parameters, and non-invasive fibrosis assessment were recorded. Statistical analysis was performed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, categorical variables as frequency and percentage, and multivariable logistic regression was used to determine independent predictors of fibrosis. A p-value <0.05 was considered statistically significant.

Results: The mean age of the participants was 48.6 ± 11.9 years, with 61.0% being males. Obesity, diabetes mellitus, dyslipidemia, and metabolic syndrome were common clinical features. Significant liver fibrosis was identified in 74 (24.7%) patients. Patients with fibrosis were significantly older and had higher body mass index, HbA1c, liver enzyme levels, and FIB-4 scores ($p<0.05$). Multivariable analysis identified age ≥50 years, obesity, diabetes mellitus, elevated AST, HbA1c >7%, and FIB-4 score >2.0 as independent predictors of fibrosis.

Conclusion: Nearly one-fourth of patients with MASLD had significant liver fibrosis. Advanced age, obesity, diabetes mellitus, poor glycemic control, elevated liver enzymes, and higher FIB-4 scores were significant predictors of fibrosis. Early risk stratification using clinical and non-invasive fibrosis assessment tools may facilitate timely intervention and reduce progression to advanced liver disease.

Keywords: Metabolic Dysfunction-Associated Steatotic Liver Disease; MASLD; Liver Fibrosis; Metabolic Syndrome; FIB-4; transient elastography.

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Introduction

Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD), previously referred to as non-alcoholic fatty liver disease (NAFLD), is now recognized as the most prevalent chronic liver disease worldwide. The updated nomenclature was introduced to better reflect the central role of metabolic dysfunction in disease pathogenesis and to replace the exclusion-based definition of NAFLD. MASLD is characterized by hepatic steatosis in individuals with one or more cardiometabolic risk factors, including obesity, type 2 diabetes mellitus, and dyslipidemia, hypertension, or insulin resistance. This revised terminology has improved the clinical applicability of the disease definition and emphasizes its close association with systemic metabolic disorders.[1] The burden of MASLD has increased dramatically over the past two decades owing to the global rise in obesity and metabolic syndrome. Epidemiological studies estimate that nearly one-third of the adult population is affected, making MASLD a leading cause of chronic liver disease

and an emerging indication for liver transplantation. Although many patients remain asymptomatic, the disease encompasses a spectrum ranging from simple steatosis to metabolic dysfunction-associated steatohepatitis (MASH), progressive fibrosis, cirrhosis, hepatocellular carcinoma, and liver-related mortality. In addition, cardiovascular disease remains the leading cause of death among patients with MASLD, highlighting its systemic metabolic impact.[2]

Recognizing these concerns, an international expert consensus proposed the concept of metabolic dysfunction-associated fatty liver disease (MAFLD), which shifted diagnostic emphasis from exclusion of alcohol intake to the presence of metabolic abnormalities. This approach acknowledged that insulin resistance, obesity, and cardiometabolic risk factors are the principal drivers of hepatic steatosis and disease progression. The evolution from MAFLD to MASLD further strengthened this concept by providing a globally accepted terminology that aligns with current understanding of disease mechanisms.[3]

Among all histological features of MASLD, liver fibrosis is considered the strongest predictor of long-term clinical outcomes. Large epidemiological analyses have demonstrated that the prevalence of steatotic liver disease continues to rise globally, paralleling increasing rates of obesity and diabetes mellitus. As a result, the number of patients at risk for advanced fibrosis and cirrhosis is expected to increase substantially, creating a major healthcare challenge worldwide.[4]

The prognostic significance of fibrosis has been clearly established. Angulo et al. demonstrated that fibrosis stage, rather than steatosis or hepatic inflammation alone, is independently associated with liver-related complications, overall mortality, and the need for liver transplantation. These findings shifted the clinical focus toward early identification of fibrosis as the primary objective in the evaluation and management of patients with MASLD.[5]

Because liver biopsy is invasive, costly, and unsuitable for routine screening, considerable effort has been directed toward developing reliable non-invasive methods for fibrosis assessment. Sterling et al. introduced the Fibrosis-4 (FIB-4) index, which combines age, aminotransferase levels, and platelet count to estimate fibrosis risk using routinely available laboratory parameters. The FIB-4 score has since become one of the most widely validated and recommended first-line tools for identifying patients at risk of advanced fibrosis.[6] Further advances in non-invasive evaluation have been achieved through elastography-based techniques. Castera et al. demonstrated that transient elastography and other non-invasive imaging modalities accurately identify advanced fibrosis while substantially reducing the need for liver biopsy. These techniques have become integral components of current clinical practice, allowing efficient risk stratification and timely referral of high-risk patients for specialist management.[7]

Despite increasing awareness of MASLD, the clinical characteristics and predictors of fibrosis vary among different populations because of differences in ethnicity, lifestyle, and metabolic risk profiles. Identifying patients at increased risk of fibrosis using readily available clinical and biochemical parameters is essential for preventing progression to cirrhosis and liver-related complications. Therefore, the present study was undertaken to evaluate the clinical profile of patients with MASLD and identify the clinical and biochemical predictors of liver fibrosis using non-invasive assessment methods.

Materials and Methods

Study Design: A hospital-based cross-sectional observational study was conducted to evaluate the clinical profile of patients with Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) and identify predictors of liver fibrosis.

Study Setting: The study was carried out in the Department of Gastroenterology/General Medicine of a tertiary care teaching hospital.

Study Duration: The study was conducted over 18 months after obtaining approval from the Institutional Ethics Committee.

Study Population: A total of 300 adult patients diagnosed with MASLD based on clinical, biochemical, and radiological evidence of hepatic steatosis with at least one cardiometabolic risk factor were enrolled consecutively.

Inclusion Criteria

- Age ≥18 years.
- Diagnosis of MASLD based on current diagnostic criteria.
- Evidence of hepatic steatosis on ultrasonography or transient elastography.
- Written informed consent.

Exclusion Criteria

- Significant alcohol consumption.
- Viral hepatitis (HBV or HCV), autoimmune liver disease, Wilson's disease, or other chronic liver diseases.
- Hepatocellular carcinoma or decompensated cirrhosis.
- Incomplete clinical or laboratory data.

Data Collection: Demographic characteristics, body mass index (BMI), waist circumference,

blood pressure, diabetes mellitus, hypertension, dyslipidemia, liver function tests, fasting blood glucose, HbA1c, lipid profile, platelet count, and FIB-4 score were recorded. Liver fibrosis was assessed using non-invasive fibrosis assessment tools and transient elastography where indicated.

Outcome Measures: The primary outcome was the presence of significant liver fibrosis. Secondary outcomes included the association of demographic, metabolic, and biochemical variables with fibrosis severity.

Statistical Analysis: Data were analyzed using SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons were performed using the independent t-test and Chi-square test. Multivariable logistic regression was used to identify independent predictors of fibrosis. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants. Patient confidentiality was maintained throughout the study.

Results

A total of 300 patients diagnosed with Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) were included in the study. The mean age of the study population was 48.6 ± 11.9 years, and 183 (61.0%) were males. The majority of patients were overweight or obese and had one or more metabolic risk factors. Significant liver fibrosis, assessed using non-invasive fibrosis assessment tools and transient elastography where indicated, was identified in 74 patients (24.7%), whereas 226 patients (75.3%) had no evidence of significant fibrosis. Clinical, anthropometric, biochemical, and metabolic parameters were compared to identify predictors of fibrosis.

Table 1: Baseline demographic and clinical characteristics of patients with MASLD (n=300)

Variable	Number (n)	Percentage (%)
Age Group (years)		
18–39	66	22.0
40–49	84	28.0
50–59	87	29.0
≥60	63	21.0
Gender		
Male	183	61.0
Female	117	39.0
Body Mass Index		
Overweight (25–29.9 kg/m²)	108	36.0
Obese (≥30 kg/m²)	132	44.0
Normal weight	60	20.0
Comorbidities		
Type 2 diabetes mellitus	152	50.7
Hypertension	129	43.0
Dyslipidemia	141	47.0
Metabolic syndrome	176	58.7

The majority of patients were between 40 and 59 years (57.0%), while males constituted 61.0% of the study population. Obesity was present in 44.0%, diabetes mellitus in 50.7%, dyslipidemia in 47.0%, and metabolic syndrome in 58.7%, indicating that MASLD predominantly affected individuals with multiple metabolic risk factors.

Table 2: Comparison of patients with and without significant fibrosis

Variable	No Fibrosis (n=226)	Fibrosis (n=74)	p value
Mean age (years)	45.9 ± 10.6	57.2 ± 9.8	<0.001*
Male gender	132 (58.4%)	51 (68.9%)	0.114
BMI (kg/m²)	28.4 ± 3.5	31.7 ± 4.2	<0.001*
Diabetes mellitus	98 (43.4%)	54 (73.0%)	<0.001*
Hypertension	87 (38.5%)	42 (56.8%)	0.006*
Dyslipidemia	96 (42.5%)	45 (60.8%)	0.008*
Metabolic syndrome	120 (53.1%)	56 (75.7%)	0.001*

Patients with fibrosis were significantly older and had higher BMI than those without fibrosis (p<0.001). Diabetes mellitus, hypertension, dyslipidemia, and metabolic syndrome were significantly more common among patients with fibrosis, suggesting a strong association between

metabolic abnormalities and progressive liver disease.

Table 3: Laboratory profile according to fibrosis status

Parameter	No Fibrosis	Fibrosis	p value
ALT (U/L)	54.3 ± 19.4	71.6 ± 24.2	<0.001*
AST (U/L)	42.1 ± 15.6	63.5 ± 21.8	<0.001*
HbA1c (%)	6.7 ± 1.1	7.9 ± 1.3	<0.001*
Triglycerides (mg/dL)	178 ± 48	214 ± 55	<0.001*
FIB-4 Score	1.08 ± 0.42	2.64 ± 0.81	<0.001*

Patients with significant fibrosis had markedly higher liver enzyme levels, HbA1c, triglycerides, and FIB-4 scores than those without fibrosis. All biochemical differences were statistically significant, indicating that worsening metabolic control and hepatic injury are associated with fibrosis progression.

Table 4: Independent predictors of significant fibrosis (Multivariable logistic regression)

Variable	Adjusted OR	95% CI	p value
Age ≥50 years	2.81	1.52–5.18	0.001*
BMI ≥30 kg/m²	2.46	1.31–4.63	0.005*
Diabetes mellitus	3.52	1.86–6.68	<0.001*
HbA1c >7%	2.37	1.29–4.34	0.006*
Elevated AST	2.74	1.48–5.08	0.002*
FIB-4 >2.0	5.21	2.76–9.83	<0.001*

Multivariable analysis demonstrated that FIB-4 score >2.0 (OR 5.21) was the strongest independent predictor of significant fibrosis. Diabetes mellitus, age ≥50 years, obesity, elevated HbA1c, and raised AST levels also independently increased the likelihood of fibrosis.

Table 5: Distribution of fibrosis severity based on non-invasive assessment

Fibrosis Stage	Number (n)	Percentage (%)
No fibrosis	124	41.3
Mild fibrosis	102	34.0
Significant fibrosis	49	16.3
Advanced fibrosis	19	6.4
Cirrhosis	6	2.0

Among the study participants, 41.3% had no fibrosis, while 34.0% demonstrated mild fibrosis. Significant fibrosis and advanced fibrosis were observed in 16.3% and 6.4% of patients, respectively, whereas cirrhosis was identified in only 2.0%. Overall, nearly one-fourth of patients exhibited clinically significant fibrosis, emphasizing the importance of early fibrosis assessment in patients with MASLD.

Discussion

The present study evaluated the clinical profile of patients with Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) and identified the clinical and metabolic predictors of liver fibrosis. The findings demonstrated that nearly one-fourth of the patients had significant fibrosis, while advancing age, obesity, diabetes mellitus, poor glycemic control, elevated liver enzymes, and higher FIB-4 scores were independently associated with fibrosis. These observations reinforce the concept that fibrosis is the principal determinant of adverse outcomes in MASLD and emphasize the importance of early risk stratification using non-invasive methods. Recent advances in non-invasive fibrosis assessment have substantially improved the evaluation of patients with steatotic liver disease. Newsome et al. developed the FibroScan-AST (FAST) score, combining transient elastography, controlled attenuation parameter, and AST levels to identify patients with active steatohepatitis and significant fibrosis. Their study demonstrated that combining serum biomarkers with elastography improves diagnostic accuracy while reducing the need for liver biopsy. Similarly, the present study showed that non-invasive fibrosis assessment effectively identified patients with clinically significant fibrosis, supporting its role in routine clinical practice.[8] The prognostic significance of fibrosis has been further highlighted by Taylor et al., who conducted a systematic review and meta-analysis demonstrating that increasing fibrosis stage is strongly associated with liver-related complications, hepatocellular carcinoma, cardiovascular events, and all-cause mortality. The investigators concluded that fibrosis severity is the most reliable predictor of long-term outcomes in steatotic liver disease. Consistent with these findings, approximately one-fourth of patients in the present study had significant fibrosis, emphasizing the need for early identification and close monitoring of high-risk individuals.[9]

The growing global burden of steatotic liver disease has also been emphasized by Younossi et al., whose systematic review reported a continuing increase in the prevalence of NAFLD/MASLD worldwide, largely driven by obesity, diabetes mellitus, and sedentary lifestyles. The authors highlighted that metabolic diseases are the principal contributors to progressive liver fibrosis. Similar observations were made in the present study, where obesity, diabetes mellitus, dyslipidemia, and metabolic syndrome were highly prevalent among patients with fibrosis, confirming the close relationship between metabolic dysfunction and disease progression.[10]

Population-based studies have further demonstrated the strong association between metabolic abnormalities and MASLD. Ciardullo and Perseghin reported that obesity, insulin resistance, type 2 diabetes mellitus, hypertension, and dyslipidemia were significantly associated with both MASLD prevalence and advanced fibrosis. The present study produced comparable findings, with obesity and diabetes mellitus emerging as independent predictors of fibrosis. These results suggest that comprehensive metabolic assessment should be an integral component of the evaluation of patients with MASLD.[11]

The biological mechanisms underlying fibrosis progression have been increasingly clarified. Eslam and George described how genetic susceptibility, insulin resistance, oxidative stress, chronic inflammation, and activation of hepatic stellate cells contribute to extracellular matrix deposition and progressive fibrosis.

They emphasized that persistent metabolic dysfunction accelerates fibrogenesis even in the absence of advanced hepatic inflammation. The present findings support these mechanisms, as patients with poor glycemic control and obesity demonstrated significantly greater fibrosis prevalence than those with better metabolic profiles.[12]

Surveillance and risk stratification remain central to MASLD management. Loomba et al. highlighted the importance of identifying patients with advanced fibrosis because they are at substantially greater risk of hepatocellular carcinoma and liver-related complications. The authors recommended systematic fibrosis assessment using validated non-invasive tools before considering surveillance strategies. In the present study, patients with elevated FIB-4 scores and abnormal liver enzymes were significantly more likely to have fibrosis, supporting the use of simple, readily available clinical tools for identifying individuals who require specialist evaluation.[13]

Patient-centered management has also gained increasing importance. Francque et al. emphasized that lifestyle modification, sustained weight reduction, glycemic control, and management of cardiovascular risk factors remain the cornerstone of MASLD treatment. They highlighted that early identification of fibrosis allows timely intervention before irreversible liver damage develops. These recommendations are consistent with the present findings, where metabolic abnormalities were closely associated with fibrosis, suggesting that aggressive control of metabolic risk factors may reduce disease progression.[14]

Advances in non-invasive biomarkers continue to improve fibrosis detection. Wong et al. reviewed available serum biomarkers and imaging modalities and concluded that combining simple fibrosis scores such as FIB-4 with transient elastography provides high diagnostic accuracy for identifying advanced fibrosis while minimizing unnecessary liver biopsies. The present study similarly demonstrated that higher FIB-4 scores were among the strongest independent predictors of fibrosis, supporting current recommendations that advocate sequential non-invasive assessment for routine clinical practice.[15]

Overall, the present study confirms that MASLD is predominantly a metabolic disease in which obesity, diabetes mellitus, dyslipidemia, and poor glycemic control contribute significantly to fibrosis progression. Non-invasive fibrosis assessment, particularly FIB-4 combined with elastography, offers a practical and reliable approach for identifying patients at increased risk of advanced liver disease. Early recognition of these high-risk individuals may facilitate timely lifestyle intervention, optimization of metabolic control, and appropriate specialist referral, thereby reducing progression to cirrhosis and liver-related complications.

Conclusion

MASLD is closely associated with obesity, diabetes mellitus, dyslipidemia, and other components of metabolic syndrome. Significant liver fibrosis was independently associated with advancing age, obesity, poor glycemic control, elevated liver enzymes, and higher FIB-4 scores. Early identification of high-risk patients using clinical and non-invasive fibrosis assessment tools may facilitate timely intervention, prevent disease progression, and improve long-term outcomes.

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