

A Simple Clinical Prediction Score for Significant Liver Fibrosis Using VCTE as the Reference Standard in Thai Patients With MASLD

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Abstract

Background: Clinically significant liver fibrosis is the major determinant of adverse liver-related outcomes in patients with metabolic dysfunction-associated steatotic liver disease (MASLD). Vibration-controlled transient elastography (VCTE) with liver stiffness measurement (LSM) is the standard tool for the noninvasive assessment of hepatic fibrosis; however, its high cost and limited availability restrict its widespread use in Thai hospitals. A simple, accessible clinical tool may improve early detection and risk stratification.

Objectives: To develop and evaluate a simple clinical prediction score for identifying significant hepatic fibrosis (LSM-defined F2-F4) among Thai patients with MASLD obtained by VCTE as the reference standard.

Methods: This retrospective study analyzed 189 Thai patients with MASLD who underwent VCTE at Maharat Nakhon Ratchasima Hospital, Thailand, between April 2023 and March 2024. Clinically significant hepatic fibrosis was defined as LSM stage F2-F4, while F0-F1 was considered to indicate no or mild fibrosis. Demographic, clinical, and laboratory parameters were evaluated, and independent predictors of steatosis were identified using multivariable logistic regression. The β coefficients were converted into weighted scores to create the hepatic fibrosis prediction score. Model performance was assessed by discrimination, calibration, and internal validation using 1000 bootstrap resamples.

Results: The mean (SD) controlled attenuation parameter was 257.5 (48.7) dB/m, and 96 patients (50.8%) had clinically significant hepatic fibrosis (F2-F4). Significant predictors included older age, body mass index, diabetes, and aspartate aminotransferase (AST) level higher than 40 U/L. The final score incorporated these variables and demonstrated acceptable discrimination (area under the receiver operating characteristic curve [AUC], 0.743; 95% CI, 0.674-0.811) and an optimism-corrected AUC of 0.719 (95% CI, 0.651-0.786). Calibration was satisfactory (Hosmer-Lemeshow $\chi^2 = 6.66$, $P = .465$). Patients classified as high risk (> 4.0 points) had an 89.5% prevalence of clinically significant fibrosis and a positive likelihood ratio of 8.42.

Conclusions: The hepatic fibrosis score is a simple, inexpensive, and internally validated clinical prediction tool for identifying patients at high risk of clinically significant hepatic fibrosis among Thai patients with MASLD. Although it is not intended to replace VCTE, the score may facilitate initial risk stratification and help prioritize patients for further fibrosis assessment, particularly in primary care and resource-limited settings. External validation is warranted before routine clinical implementation.

Keywords: MASLD, Hepatic fibrosis, Prediction score, Vibration-controlled transient elastography, Clinical prediction model, Risk stratification, Thai patients

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Introduction

Metabolic dysfunction-associated steatotic liver disease (MASLD), formerly termed nonalcoholic fatty liver disease (NAFLD),¹⁻³ is now the leading cause of chronic liver disease worldwide, with increasing prevalence across Asian populations, including Thailand.⁴⁻¹² MASLD is strongly associated with obesity, insulin resistance, type 2 diabetes mellitus (DM), and other components of metabolic syndrome, and it carries the risk of progression to metabolic dysfunction-associated steatohepatitis (MASH), advanced fibrosis, cirrhosis, and hepatocellular carcinoma.^{1, 13, 14} Although hepatic steatosis is the defining pathological feature required for the diagnosis of MASLD, progressive fibrosis is the principal determinant of long-term liver-related outcomes and overall mortality.^{15, 16}

Conventional transabdominal ultrasonography remains the most widely used first-line imaging modality for detecting hepatic steatosis due to its availability and low cost.^{17, 18} However, it has limited sensitivity for mild disease and cannot quantify hepatic fat or stage its severity. Liver biopsy is the gold standard for the diagnosis of MASLD and MASH; however it is an invasive assessment with some risks. Vibration-controlled transient elastography (VCTE) simultaneously measures 2 complementary parameters in a single examination: the controlled attenuation parameter (CAP), which quantifies hepatic steatosis, and liver stiffness measurement (LSM), which estimates the severity of liver fibrosis.¹⁹⁻²⁶ Despite its clinical value, the high cost and limited accessibility of VCTE restrict its use in many Thai hospitals, particularly in resource-limited settings.

These limitations underscore the need for a simple, inexpensive, and readily applicable clinical prediction model that can identify patients at high risk of clinically significant fibrosis and prioritize referrals for VCTE examination. Therefore, the objectives of the present study were to develop and internally validate a simple clinical prediction score for identifying clinically significant liver fibrosis (F2-F4) using LSM obtained by VCTE as the reference standard.

Methods

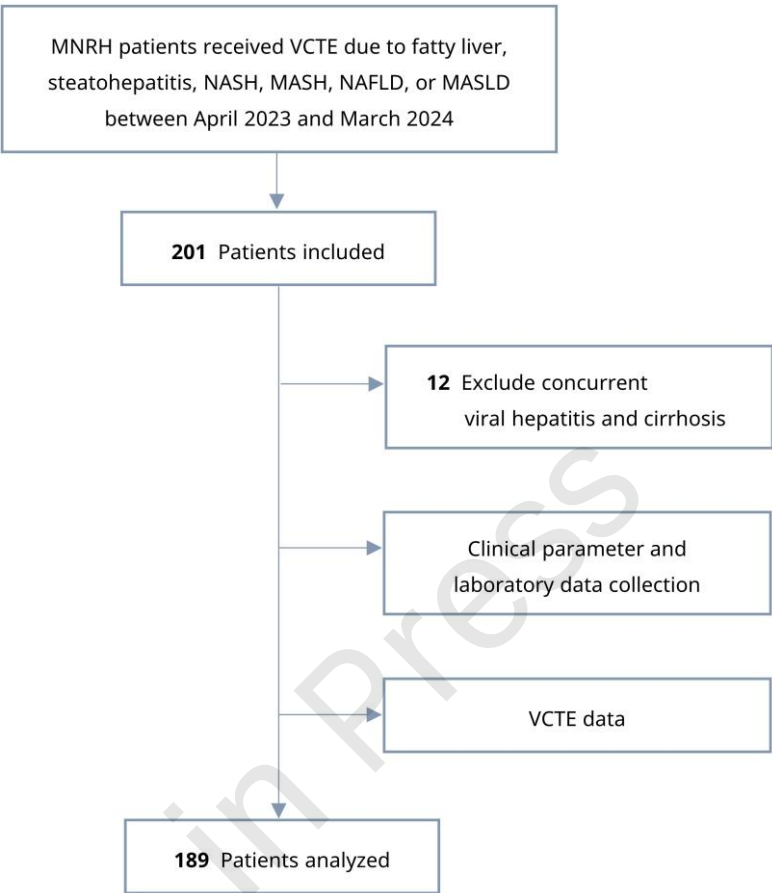
Study Design

This retrospective study included patients with MASLD who underwent VCTE assessment at Maharat Nakhon Ratchasima Hospital (MNRH) between April 2023 and March 2024. Clinical and laboratory data were collected from medical records at the time of VCTE evaluation (Figure 1). The study was approved by the Institutional Review Board of MNRH, Ministry of Public Health, Thailand.

VCTE Assessment

All patients underwent VCTE with CAP and LSM measurement using the FibroScan Expert 630 device (Echosens, Paris, France). CAP was expressed in decibels per meter (dB/m) as standard deviation (SD). Steatosis grades were defined as: S0, < 215 dB/m (fat < 10%); S1, 215-251 dB/m (10%-33%); S2, 252-295 dB/m (33%-66%); and S3, > 296 dB/m (> 66%).^{27, 28} LSM was expressed in kilopascals (kPa) as interquartile range (IQR). Fibrosis stages were classified as: F0, < 6.5 kPa; F1, 6.5-7.0 kPa; F2, 7.1-9.5 kPa; F3, 9.6-12.5 kPa; and F4, > 12.5 kPa. Hepatic steatosis was defined as S1-S3, and significant fibrosis as F2-F4.^{27, 28}

Figure 1. Study Flow



Abbreviations: MASH, metabolic dysfunction-associated steatohepatitis; MASLD, metabolic dysfunction-associated steatotic liver disease; MNRH, Maharat Nakhon Ratchasima Hospital; NAFLD, nonalcoholic fatty liver disease; NASH, nonalcoholic steatohepatitis; VCTE, vibration-controlled transient elastography.

Clinical and Laboratory Parameters

Additional clinical parameters included body mass index (BMI), categorized as normal (< 23 kg/m²), overweight (23.0-24.9 kg/m²), obese (25.0-29.9 kg/m²), and morbidly obese (≥ 30.0 kg/m²).²⁹ Laboratory data included triglycerides (TG: normal < 150 mg%, mildly elevated 151-199 mg%, and high 200-400 mg%), high-density lipoprotein cholesterol (HDL-C) level, platelet count, aspartate aminotransferase (AST), and alanine aminotransferase (ALT), categorized as normal (< 40 U/L), elevated (41-99 U/L), and markedly elevated (≥ 100 U/L).

Statistical Analysis

Continuous variables were summarized as mean (SD), and categorical variables as frequencies and percentages. Baseline characteristics were compared between patients with significant hepatic fibrosis (F2-F4) and those with no or mild fibrosis (F0-F1) using the student's *t* test for continuous variables and the chi-square test or Fisher exact test for categorical variables, as appropriate. Statistical analyses were performed using Stata, version 16.0 (StataCorp LLC).

Candidate predictors were selected according to a prespecified analytic sequence. First, variables were identified based on clinical plausibility, routine availability, and prior relevance to MASLD-related hepatic fibrosis, including demographic factors, metabolic comorbidities, and laboratory parameters. Second, univariable logistic regression was performed to estimate the crude association between each candidate predictor and significant hepatic fibrosis (F2-F4). Variables with clinical relevance and/or a P value $< .20$ in univariable analysis were retained as candidate predictors for penalized selection.

Least absolute shrinkage and selection operator (LASSO) logistic regression was then used as a penalized regression method for variable selection. LASSO adds an L1 penalty to the logistic regression likelihood, which shrinks regression coefficients toward zero; predictors with coefficients reduced to exactly zero are excluded, whereas predictors with non-zero coefficients are considered informative for prediction. The tuning parameter λ , which controls the degree of shrinkage, was selected using cross-validation. A larger λ produces a simpler model with fewer predictors, while a smaller λ retains more variables. The final set of candidate predictors was determined from variables with non-zero LASSO coefficients, with consideration of clinical interpretability and feasibility for bedside scoring.

Variables selected by LASSO were subsequently entered into a final multivariable logistic regression model to obtain adjusted odds ratios, 95% CIs, P values, and β coefficients. The final model was chosen to balance predictive performance, parsimony, and clinical usability. Regression beta coefficients from the final model were converted into weighted point values proportional to their effect sizes to develop the hepatic fibrosis prediction score.

Risk Stratification and Validation

The model's calibration and discrimination were evaluated using the Hosmer-Lemeshow goodness-of-fit test and a calibration plot, which compared the predicted probability of hepatic fibrosis with the observed outcomes. Discriminative ability was further assessed by calculating the area under the receiver operating characteristic curve (AUC). Internal validation was conducted using a bootstrapping procedure with 1000 replications.

Results

Patient Characteristics

A total of 189 patients with MASLD were included; 54.0% were female, with a mean (SD) age of 55.1 (12.0) years (range 19-88 years). The mean (SD) BMI was 27.5 (4.7) kg/m² (range 15.2-44.5 kg/m²). Common comorbidities were hypertension (49.2%), dyslipidemia (45.0%), and DM (27.0%). The mean (SD) CAP value, reflecting hepatic steatosis, was 257.5 (48.7) dB/m (range 120-359 dB/m).

Hepatic Fibrosis by LSM

Of these, 96 patients (50.8%) had significant hepatic fibrosis (F2-F4), whereas 93 (49.2%) had no or mild fibrosis (F0-F1). Patients with F2-F4 fibrosis had a higher burden of demographic and metabolic risk factors than those with F0-F1 fibrosis. Patients with significant fibrosis were more likely to be older than 60 years (46.9% vs 32.3%, $P = .040$), have a higher BMI ($P = .001$), DM (37.5% vs 16.1%, $P = .001$), hypertension (57.3% vs 40.9%, $P = .024$), low HDL-C (13.5% vs 4.3%, $P = .026$), and elevated AST levels ($P = .017$). In contrast, sex, dyslipidemia, platelet count, triglyceride level, and ALT category did not differ significantly between the groups (Table 1).

Table 1. Clinical Characteristics of MASLD Patients Stratified by Hepatic Fibrosis (LSM F2-F4 vs F0-F1)

Factor	No. (%)		P Value
	Significant Fibrosis (F2-F4) (n = 96)	No or Mild Fibrosis (F0-F1) (n = 93)	
Age, y			
≥ 60	45 (46.9)	30 (32.3)	.040
Mean (SD)	55.9 (12.9)	54.3 (11.0)	.370
Female	52 (54.2)	50 (53.8)	.956
BMI, kg/m ²			
< 23.0	8 (8.3)	19 (20.4)	.001
23.0-24.9	9 (9.4)	20 (21.5)	
25.0-29.9	41 (42.7)	37 (39.8)	
> 30.0	38 (39.6)	17 (18.3)	
DM	36 (37.5)	15 (16.1)	.001
Hypertension	55 (57.3)	38 (40.9)	.024
Dyslipidemia	45 (46.9)	40 (43.0)	.593
HDL-C (< 40 mg%)	13 (13.5)	4 (4.3)	.026
Platelet (< 140 × 10 ⁹ /L)	6 (6.2)	2 (2.2)	.162
Triglyceride, mg/dL			
Normal (≤ 150)	52 (54.2)	56 (60.2)	.612
Mid high (151-199)	24 (25.0)	18 (19.4)	
High (200-400)	20 (20.8)	19 (20.4)	
ALT, U/L			
Normal (≤ 40)	59 (61.5)	64 (68.8)	.404
High (41-99)	26 (27.1)	23 (24.7)	
Very high (≥ 100)	11 (11.5)	6 (6.4)	
Median (IQR)	33.0 (25.0-57.0)	33.0 (24.0-45.0)	
AST, U/L			
Normal (≤ 40)	62 (64.6)	77 (82.8)	.017
High (41-99)	31 (32.3)	14 (15.0)	
Very high (≥ 100)	3 (3.1)	2 (2.2)	
Median (IQR)	33.0 (25.0-47.5)	30.0 (24.0-37.0)	

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; DM, diabetes mellitus; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LSM, liver stiffness measurement; MASLD, metabolic dysfunction-associated steatotic liver disease.

Independent Predictors of Hepatic Fibrosis

After univariable screening, clinically relevant variables and variables with *P* values < .20 were entered into the LASSO logistic regression procedure. The LASSO step supported a more parsimonious predictor set by shrinking variables with weaker incremental contribution toward zero. Variables retained with non-zero LASSO coefficients and supported by clinical relevance were then evaluated in the final multivariable logistic regression model.

The final multivariable model included age > 60 years, BMI category, DM, and AST > 40 U/L. Although hypertension and HDL-C < 40 mg% were significant in univariable comparisons, they were not retained in the final score because their additional predictive contributions was limited after penalized selection and multivariable assessment, and

they overlapped with other metabolic predictors. The final multivariable logistic regression model used to derive the F2-F4 fibrosis prediction score is presented (Table 2). Regression β coefficients were converted into practical point values, with higher points assigned to predictors with larger effect sizes.

Risk Score Development and Performance

The β coefficients were converted into weighted points to develop the hepatic fibrosis prediction score, which was formulated as follows: 1.5 (Age $\geq$ 60 years) + 2.5 (BMI $\geq$ 30 kg/m²) + 1 (BMI 25.0-29.9 kg/m²) + 1 (DM) + 1 (AST > 40 U/L).

Based on the total score, patients were stratified into low- (< 1.5 points), moderate- (1.5-3.5 points), and high-risk (> 4.0 points) categories. The prevalence of significant fibrosis increased progressively across the risk categories, from 25.5% in the low-risk group to 54.2% in the moderate-risk group and 95% in the high-risk group. The corresponding positive predictive values (PPVs) were 25.5% (95% CI, 14.3-39.6), 54.2% (95% CI, 44.8-63.4), and 95.0% (95% CI, 75.1-9.9), respectively. Likewise, the positive likelihood ratios (LR+) increased across risk categories from 0.3 (95% CI, 0.2-0.6) in the low-risk group to 1.1 (95% CI, 0.9-1.4) in the moderate-risk group and 18.4 (95% CI, 2.5-135.4) in the high-risk group (Table 3).

The total score was calculated by summing the points for all present predictors, with higher scores indicating a greater probability of F2-F4 fibrosis, supporting the score's clinical usefulness for identifying patients who may require further fibrosis assessment.

Model Validation

The continuous hepatic fibrosis prediction score showed acceptable discrimination, with an area under AUC of 0.743 (95% CI, 0.674-0.811) (Figure 2). Following bootstrap internal validation with 1000 replications, the optimism-corrected AUC was 0.719 (95% CI, 0.651-0.786), indicating only a modest reduction in discrimination after correction for optimism. Calibration was satisfactory, with an expected-to-observed ratio of 1.003, calibration-in-the-large of -0.009, a calibration slope of 0.875, and a nonsignificant Hosmer-Lemeshow goodness-of-fit test ($\chi^2 = 6.66$, $P = .465$), suggesting good agreement between predicted and observed risks (Figure 3). The distribution of patients with and without clinically significant fibrosis across the prediction score further demonstrated a progressive increase in fibrosis prevalence with increasing score, supporting the model's ability to discriminate between risk categories (Figure 4).

Table 2. Independent Predictors of Hepatic Fibrosis (Multivariable Logistic Regression)

Factor	OR (95% CI)	P Value	β Coefficient	Score
Age ($\geq$ 60 y)	2.76 (1.36-5.62)	.005	1.02	1.5
BMI, kg/m ²				
> 30.0	7.35 (2.92-18.46)	< .001	1.99	2.5
25.0-29.9	2.17 (0.99-4.75)	.052	0.78	1.0
DM	2.25 (1.05-4.81)	.036	0.81	1.0
AST (> 40 U/L)	2.18 (1.02-4.65)	.044	0.78	1.0

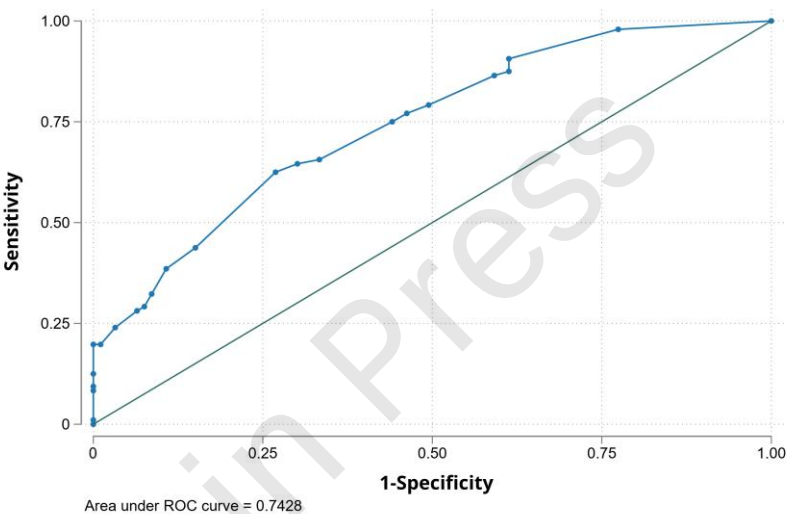
Abbreviations: AST, aspartate aminotransferase; BMI, body mass index; DM, diabetes mellitus; OR, odds ratio.

Table 3. Prevalence and Predictive Performance of the Hepatic Fibrosis Score

Risk Category	Score	No. (%)		PPV (95% CI)	LR+ (95% CI)	P Value
		Significant Fibrosis	No or Mild Fibrosis			
Low (n = 51)	< 1.5	13 (25.5)	38 (74.5)	25.5 (14.3-39.6)	0.3 (0.2-0.6)	< .001
Moderate (n = 118)	1.5-3.5	64 (54.2)	54 (45.8)	54.2 (44.8-63.4)	1.1 (0.9-1.4)	< .001
High (n = 20)	> 4.0	19 (95.0)	1 (5.0)	95.0 (75.1-99.9)	18.4 (2.5-135.4)	< .001

Abbreviations: PPV, positive predictive value; LR+, positive likelihood ratio.

Figure 2. Discrimination of the Total Hepatic Fibrosis Prediction Score



Abbreviation: ROC, receiver operating characteristic.

Figure 3. Calibration of the Hepatic Fibrosis Prediction Score

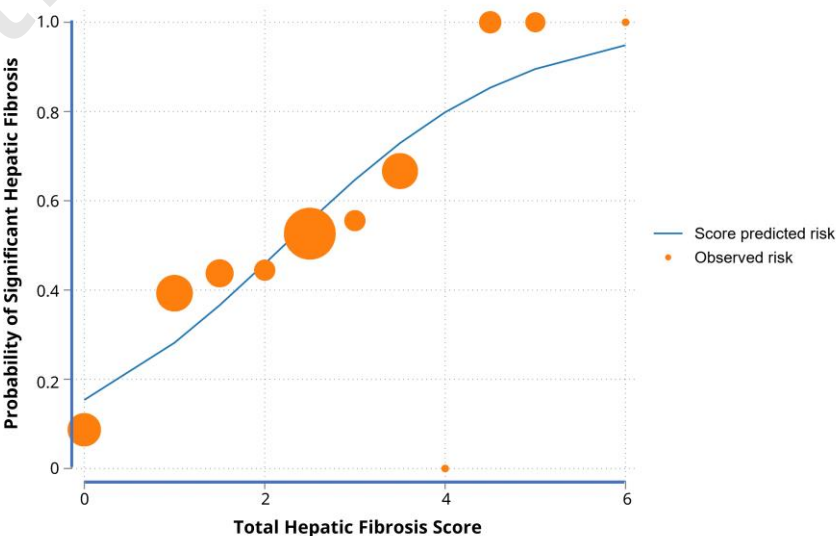
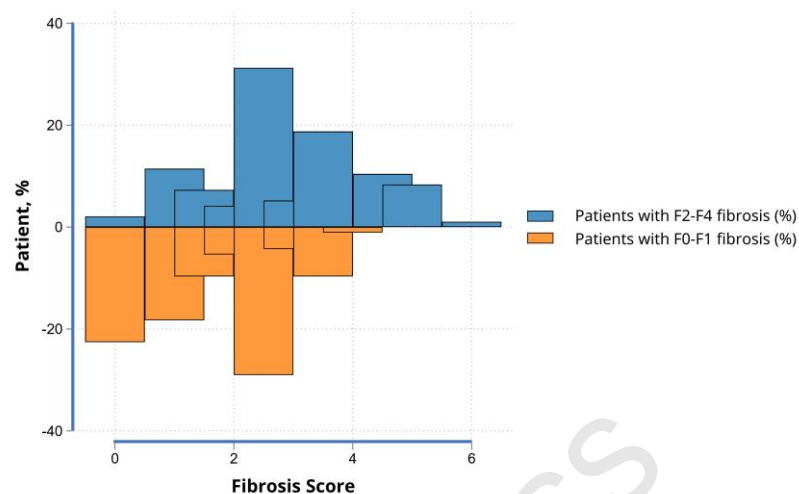


Figure 4. Distribution of the Hepatic Fibrosis Score Among Patients With and Without Clinically Significant Hepatic Fibrosis



Discussion

Among the 189 patients included in the study, 96 (50.8%) had significant hepatic fibrosis (F2-F4) as determined by LSM. The present study developed and internally validated a simple hepatic fibrosis prediction score for Thai patients with MASLD using routinely available clinical and laboratory variables. Four variables were identified as independent predictors of hepatic fibrosis, including older age, BMI category, DM, and elevated AST. Based on these predictors, the score was formulated as follows: 1.5 (Age ≥ 60 years) + 2.5 (BMI ≥ 30 kg/m²) + 1 (BMI 25.0-29.9 kg/m²) + 1 (DM) + 1 (AST > 40 U/L). The resulting score demonstrated acceptable discrimination (AUC 0.743) and successfully stratified patients into clinically meaningful risk categories. The prevalence of significant fibrosis increased progressively across risk categories, from 25.5% in the low-risk group to 95.0% in the high-risk group, supporting the score's ability to identify patients at increased risk of clinically significant hepatic fibrosis.

Over the past decade, numerous noninvasive biomarkers and prediction models have been developed for fibrosis assessment in MASLD, including the fibrosis-4 index (FIB-4), NAFLD fibrosis score (NFS), aspartate aminotransferase-to-platelet ratio index (APRI), steatosis-associated fibrosis estimator (SAFE), and fibrosis-8 index.²⁹⁻³³ These tools have provided clinically useful approaches for excluding or identifying advanced fibrosis; however, their diagnostic performance may vary across populations, clinical settings, and fibrosis thresholds, and several models were developed primarily in Western or mixed-etiology cohorts. In routine practice, particularly in settings where VCTE is not universally available, there remains a need for a simple, population-relevant risk stratification tool that can be applied using readily available clinical and laboratory variables. The rationale for developing the present score was therefore to provide a pragmatic and easily implementable tool for Thai patients with MASLD that can support early identification of individuals at increased risk of clinically significant fibrosis and guide appropriate referral for further fibrosis assessment. Although the discriminative performance of the present model (AUC 0.743) is within the range reported for established

noninvasive scores, direct comparisons should be interpreted cautiously because of differences in patient populations, fibrosis definitions, and diagnostic reference standards. The novelty of the proposed score lies in its derivation from a Thai MASLD cohort using simple parameters that are routinely available in clinical practice, with the intended role of complementing, rather than replacing, established noninvasive fibrosis assessment tools and VCTE.

The variables retained in the final model are biologically plausible and consistent with the current understanding of MASLD progression. Obesity, particularly BMI ≥ 30 kg/m², was the strongest predictor, emphasizing the central role of adiposity in hepatic fibrogenesis. DM also independently predicted significant fibrosis, reflecting the contribution of insulin resistance and metabolic dysfunction.^{31, 33} Older age likely represents cumulative metabolic injury over time, whereas elevated AST may indicate ongoing hepatocellular injury and more advanced liver disease.^{31, 33} Clinically, the proposed score is intended to serve as an initial risk stratification tool to identify patients who may benefit from further evaluation with VCTE or specialist referral. Its potential advantages include ease of calculation, reliance on routinely collected variables, and applicability in general clinical settings where access to elastography may be limited. By prioritizing patients with a higher probability of significant fibrosis, the score may help optimize the use of VCTE, reduce unnecessary referrals among low-risk individuals, and support more efficient allocation of healthcare resources. Thus, the score should be viewed as a complementary triage tool within a stepwise fibrosis assessment pathway rather than a stand-alone diagnostic test.

Previous studies from Thailand have mainly focused on predicting hepatic steatosis or identifying individuals with NAFLD/MASLD using clinical risk scores, particularly among patients with metabolic syndrome or prediabetes.³⁴⁻³⁶ In contrast, relatively few studies have evaluated prediction models specifically for significant hepatic fibrosis in Thai patients with MASLD using VCTE as the reference standard. Therefore, the present study may add to the existing evidence by providing a simple fibrosis prediction model derived from a Thai cohort and may contribute to future efforts aimed at improving early risk stratification in routine clinical practice.

Several limitations should be considered when interpreting the findings of this study. First, the retrospective design may have introduced information bias related to incomplete clinical data, variability in the timing of laboratory assessments, and potential unmeasured confounding factors that could influence the association between clinical predictors and hepatic fibrosis. Second, this study was conducted at a single tertiary-care center, which may have resulted in selection bias and may limit the generalizability of the proposed score to other healthcare settings, including primary care, community hospitals, and populations with different demographic or metabolic characteristics. Third, LSM by VCTE was used as the reference standard for significant hepatic fibrosis rather than liver histology. Although VCTE is widely accepted as a non-invasive method for fibrosis assessment, misclassification of fibrosis stage cannot be entirely excluded. Finally, the proposed score underwent internal validation only. Therefore, prospective external validation in independent, multicenter cohorts is warranted to confirm its reproducibility, calibration, diagnostic performance, and clinical utility before implementation in broader clinical practice. Future studies should also compare the performance of this hepatic fibrosis score with established noninvasive fibrosis models, including FIB-4, NFS, APRI, SAFE, and FibroScan-AST, and should evaluate whether its application can improve referral pathways, optimize resource allocation, and ultimately improve patient outcomes in real-world clinical settings.

Conclusions

The hepatic fibrosis prediction score, derived from simple clinical and laboratory parameters, demonstrated acceptable predictive performance for identifying clinically significant hepatic fibrosis in Thai patients with MASLD. Although not intended to replace VCTE, the score may serve as a useful triage tool to prioritize patients for further noninvasive fibrosis assessment, particularly in settings where access to VCTE is limited.

Additional Information

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Ethics Approval: The study was approved by the Institutional Review Board of Maharat Nakhon Ratchasima Hospital, Ministry of Public Health, Thailand (No. 026/2025 on 20 February 2025).

Clinical Trial Consideration: This study does not report on a clinical trial.

Financial Support: No financial support was provided for this study.

Conflict of Interest: The authors declare no conflict of interest.

Author Contributions:

Conceptualization: Somchai Luangjaru

Formal Analysis: All authors

Investigation: All authors

Methodology: All authors

Visualization: Somchai Luangjaru

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Writing – Review & Editing: Somchai Luangjaru

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