Diabetes and Metabolism 52 (2026) 101766

Contents lists available at ScienceDirect

Diabetes & Metabolism

journal homepage: www.elsevier.com/locate/diabet

Original article

Risk stratification of MASLD-related advanced fibrosis using a novel point-of-care device: the Hepatoscope

Cyrielle Caussy [a,b,c,*], Bruno Vergès [d], Fabien Subtil [e,f], Amna Abichou-Klich [e,f], Valérie Hervieu [g], Damien Leleu [h], Laurent Milot [i], Bérénice Ségrestin [a], Sylvie Bin [j], Julien Berthiller [j], Alexia Rouland [d], Dominique Delaunay [a], Claire Primot [k], Samy Hadjadj [k], Bertrand Cariou [k], Philippe Moulin [b,l], Sybil Charrière [b,l], Emmanuel Disse [a,b]

[a] Hospices Civils de Lyon, Département Endocrinologie, Diabète et Nutrition, Hôpital Lyon Sud, 69495, Pierre-Bénite, France
[b] Univ Lyon, CarMen Laboratory, INSERM, INRA, INSA Lyon, Université Claude Bernard Lyon 1, 69495, Pierre-Bénite, France
[c] IHU Lyon - Institut d'Hépatologie de Lyon, Lyon, France
[d] Department of Endocrinology, Diabetes and Metabolic Disorders, Dijon University Hospital, INSERM Unit, CTM-UMR 1231, University of Burgundy Europe, Dijon, France
[e] Hospices Civils de Lyon, Service de Biostatistique, Lyon, France
[f] Université Claude Bernard Lyon 1, UMR 5558, CNRS, Villeurbanne, France
[g] Hospices Civils de Lyon, Biopathology of Tumours, GH Est (GHE) Hospital, Bron, France
[h] Department of Biochemistry, Dijon University Hospital, INSERM Unit, CTM-UMR 1231, University of Burgundy Europe, Dijon, France
[i] Hospices Civils de Lyon, Service de Radiologie, Hôpital Edouard Herriot, 5 Place d'Arsonval, 69003, Lyon, France
[j] Hospices Civils de Lyon, Pôle de Santé Publique, Service Recherche et Epidémiologie Cliniques, F-69003, Lyon, France
[k] Nantes Université, CHU Nantes, CNRS, INSERM, l'institut du Thorax, F-44000, Nantes, France
[l] Hospices Civils de Lyon, Fédération d'Endocrinologie, Diabète et Nutrition, Hôpital Cardiovasculaire, 69500, Bron, France

ARTICLE INFO

Keywords:
Diabetology
MASH
MASLD
Screening
Transient elastography

ABSTRACT

Aim: Patients with type 2 diabetes (T2D) and obesity are at increased risk of metabolic dysfunction-associated steatotic liver disease (MASLD) with advanced fibrosis (AF), requiring systematic non-invasive assessment using liver stiffness measurement (LSM) or the ELF test. However, access to these biomarkers remains limited in diabetology. We therefore evaluated the diagnostic performance of a new point-of-care ultrasound device, Hepatoscope, for the risk stratification of AF.

Methods: Participants with T2D and/or obesity and MASLD age 40–80 years, BMI <40 kg/m2 prospectively included in a multi-centre study (NCT04435054) underwent LSM using vibration controlled transient elastography (LSM-VCTE, FibroScan) and 2D-transient elastography (LSM-2DTE) using Hepatoscope version 1 and ELF. Post-acquisition reprocessing of the LSM-2DTE data using the CE approved version 2 (LSM-2DTE-2) was performed in a subgroup of n = 120 participants. The area under the ROC curve (AUROC) and 95% confidence interval (CI) were assessed for the detection of intermediate to high-risk of AF, defined by LSM-VCTE ≥ 8 kPa.

Results: Among 294 participants (83.3% T2D, 42.5% female, 71.4% obesity), 24.8% had LSM-VCTE ≥ 8 kPa. Significant correlation was observed between LSM-VCTE and LSM-2DTE-1 r: 0.37 [0.26–0.47], $P < 0.001$ and was higher between LSM-VCTE and LSM-2DTE-2: r: 0.61 [0.47–0.71], $P < 0.001$. In the subgroup of 120 participants, the AUROC (95%CI) of LSM-2DTE-2 for the detection of LSM-VCTE ≥ 8 kPa was 0.81 (0.72–0.89) compared to 0.64 (0.52–0.75) for ELF.

Abbreviations: AF, advanced fibrosis; AUROC, area under the receiver operating characteristic curve; BMI, body mass index; B-mode, brightness mode ultrasound; CAP, controlled attenuation parameter; CI, confidence interval; ELF, enhanced liver fibrosis; FIB-4, fibrosis-4 score; FDA, food and drug administration; HA, hyaluronic acid; HCC, Hepatocellular carcinoma; IQR, interquartile range; IQR/M, interquartile range to median ratio; IRB, institutional review board; LREs, liver-related events; LSM, liver stiffness measurement; 2DTE, two-dimensional transient elastography; MASLD, metabolic dysfunction-associated steatotic liver disease; MASH, metabolic dysfunction-associated steatohepatitis; MRE, magnetic resonance elastography; MRI, magnetic resonance imaging; NAFLD, nonalcoholic fatty liver disease; NPV, negative predictive value; PDFF, proton density fat fraction; PIIINP, procollagen III N-terminal peptide; PPV, positive predictive value; QI, quality index; STARD, standards for reporting diagnostic accuracy studies; TIMP-1, tissue inhibitor of metalloproteinase 1; VCTE, vibration-controlled transient elastography.

* Corresponding author at: Hospices Civils de Lyon, Département Endocrinologie, Diabète et Nutrition, Hôpital Lyon Sud, 165 chemin du Grand Revoyet, 69495, Pierre-Bénite, France.
E-mail address: cyrielle.caussy@chu-lyon.fr (C. Caussy).

https://doi.org/10.1016/j.diabet.2026.101766
Received 22 March 2026; Received in revised form 4 May 2026; Accepted 6 May 2026
Available online 8 May 2026

Conclusion: This proof-of-concept study provides evidence supporting the role of LSM-2DTE using the Hepatoscope in the risk stratification of AF in diabetology settings. Larger studies are needed to validate its performance.

Introduction

Patients with type 2 diabetes (T2D) or obesity are at high risk of metabolic dysfunction-associated steatotic liver disease (MASLD) [1]. Both T2D and obesity are also known risk factors for the progression towards metabolic dysfunction-associated steatohepatitis (MASH) and liver fibrosis, which significantly increases the risk of liver-related events (LREs) such as hepatocarcinoma (HCC), hepatic decompensation (ascites, variceal haemorrhage, hepatic encephalopathy or hepatorenal syndrome), liver transplant, and liver-related death [2]. Hence, clinical guidelines from both diabetology and hepatology fields uniformly recommend a systematic screening and risk stratification for the presence of hepatic advanced fibrosis (AF, histological stage F $\geq$ 3) in patients living with T2D, or obesity with at least one cardiometabolic risk factor [1,3–7]. This screening enables to identify asymptomatic patients with MASLD-related AF requiring specialized care in hepatology.

The current recommended strategy relies on a two-step approach using a first line FIB-4 score to rule out AF, followed by a second-line test if FIB-4 is $\geq$ 1.30, in order to determine the risk of AF with a higher diagnostic accuracy. Liver stiffness measurement (LSM) by vibration-controlled transient elastography (VCTE™, FibroScan®, Echosens, France) is one of the currently recommended second-line imaging tests as it has been extensively studied in large population with biopsy-proven MASLD. Indeed, LSM using VCTE (LSM-VCTE) has a high accuracy (area under the curve (AUROC $>$ 0.8) for detecting AF [8]. Furthermore, LSM-VCTE $>$ 8 kPa has been identified as the optimal cut-off for hepatology referral as it captured patients with intermediate to high-risk of AF while a threshold $\geq$ 12 kPa for LSM-VCTE is associated with a high-risk of AF [8].

The implementation of this two-step screening strategy is often limited by the availability and accessibility of medical devices measuring LSM such as FibroScan, which is mostly available in hepatology clinics. Alternative blood-based non-invasive tests such as Enhanced Liver Fibrosis (ELF™) score are proposed with good diagnostic performance in patients with T2D and/or obesity [9], but ELF utilization is also limited due to the lack of reimbursement in several health care systems. Hence, there is a crucial need to improve the availability and accessibility of second-line non-invasive tests measuring LSM, especially in diabetology and nutrition clinics managing the majority of patients with at risk MASLD.

The Hepatoscope (E-Scopics, France) is a novel non-invasive ultra-portable ultrasound-based imaging medical device for the non-invasive assessment of chronic liver diseases, especially MASLD, and represents a potential alternative to the use of LSM-VCTE in the screening strategy. It performs LSM under anatomical image guidance (B-mode), using 50 Hz two-dimensional transient elastography (2DTE) [10,11]. Hence, this point-of-care system could be easily used in diabetology and nutrition clinics for the evaluation of patients with MASLD.

Our main hypothesis was that Hepatoscope's 2DTE® is a reliable non-invasive technology for the assessment of MASH-related liver fibrosis, which can be used as an alternative to LSM-VCTE for the risk stratification of liver AF in diabetology and nutrition clinics. Therefore, we performed a clinical investigation aiming at evaluating the diagnostic performance of Hepatoscope's LSM-2DTE for the identification of intermediate to high risk of AF, requiring referral to hepatology, in patients with T2D and/or obesity prospectively enrolled in a screening for MASLD-related AF in diabetology and nutrition clinics.

Patients and methods

Study design and population

"NAFLD-Screen" Screening for NAFLD-related Advanced Fibrosis in high-risk popuLation in Diabetology: uSe of the HepatosCope point-of-caRe transiEnt Elastography ultrasouNd was an ancillary study performed in participants prospectively recruited in four departments of diabetology and nutrition in France (Lyon South, Lyon East, Nantes and Dijon University Hospitals) between December 2022 and September 2024 in a larger NAFLD-Care study (NCT04435054) [9]. All participants underwent a standardized research visit including medical history, and comprehensive metabolic and liver assessment including blood-based ELF test and LSM-VCTE using FibroScan on the same day. Participants included in the ancillary NAFLD-Screen study agreed to undergo an additional LSM-2DTE using the Hepatoscope on the same day. All participants provided written informed consent prior to enrolment in the study. The NAFLD-Screen study was approved by the French IRB Ile de France XI number 2022-A01527–36. Patients who withdrew consent, those for whom the FibroScan interquartile range (IQR) was unavailable, or those with an IQR-to-median ratio greater than 0.3 were excluded from the analyses. The final study sample included patients with both an LSM-2DTE-1 and a valid LSM-VCTE (Fig. S1; see supplementary materials associated with this article on line).

Inclusion/exclusion criteria

The inclusion and exclusion criteria for the ancillary study NAFLD-Screen were identical to the main NAFLD-Care Study which have been previously detailed [9]. Briefly, inclusion criteria were an age between 40 and 80 years, patients with diagnosis of T2D or obesity class I or II (body mass index (BMI) $\geq$ 30 kg/m^2 and $<$ 40 kg/m^2), with hepatic steatosis determined by conventional abdominal ultrasound, who agreed to be included in the NAFLD-Screen ancillary study, who signed the informed consent form and were affiliated to a healthcare insurance plan.

The exclusion criteria were any other causes of chronic liver disease than MASLD (such as viral hepatitis B and C, autoimmune hepatitis, autoimmune cholestatic liver disorders, Wilson disease, alpha-1-antitrypsin deficiency, hemochromatosis, drug-induced liver disease, bile duct obstruction, known HIV infection, history of ingestion of medications known to produce steatosis) and/or excessive use of alcohol (defined as $>$ 30 g/day for males and $>$ 20 g/day for females) for a period longer than 2 years at any time over the last 10 years. Patients with known diagnosis of cirrhosis, with a life expectancy $<$5 years according to the investigator, and/or history of type 1 diabetes were also excluded.

Clinical assessment

Comprehensive clinical data were collected including demographic data, blood pressure, anthropometric parameters, medical history and metabolic co-morbid conditions including dyslipidaemia, hypertension, diabetes-related complications and anti-diabetes medication. Alcohol consumption was assessed using the Alcohol Use Disorders Identification Test (AUDIT) and Skinner Lifetime Drinking history questionnaires. Comprehensive laboratory testing including haemoglobin A1c (HbA1c) and hepatic function panel were performed in local laboratories on the same day as LSM at fasting state.

The enhanced liver fibrosis (ELF™)

Fasting patients' serum samples were collected and kept frozen at −80 °C until analysis. ELF™ measurements were centrally performed at the department of Biochemistry in Dijon University Hospital, using the Atellica® Solution (Siemens Healthineers, USA) according to the manufacturer's protocol. ELF™ simultaneously measures three biomarkers: hyaluronic acid (HA), tissue inhibitor of metalloproteinase 1 (TIMP-1), and procollagen III N-terminal peptide (PIIINP) [9]. A low and high thresholds of 9.8 and 11.3 were used to rule-in patients with a high probability of AF [12].

LSM-VCTE® using FibroScan

LSM-VCTE coupled with the measurement of controlled-attenuation parameter (CAP) were performed with FibroScan® (M Probe; XL Probe; Echosens, Paris, France) by well-trained health workers according to previously-described methods who were not blinded from clinical data and were not involved in LSM-2DTE measurements [13,14] please see supplemental data for detailed procedure. Technical failure was defined as the inability to obtain ten valid measurements or as an IQR/M > 30% [15]. A threshold of ≥ 8 kPa was used to identify patients with intermediate to high risk of AF and a threshold of ≥ 12 kPa was used to identify patients with a high probability of AF according to the most recent guidelines [1,3,4,16,17].

LSM-2DTE using Hepatoscope

Hepatoscope is an ultraportable ultrasound system indicated for LSM (kPa), which uses a unique curvilinear probe for all patients, connected to a laptop via USB-C cable on, to mechanically induce the propagation of low frequency (50 Hz) shear waves in the liver in a similar way to VCTE (Fig. 1), please see supplemental data for detailed procedure. LSM-2DTE was performed using the first prototype of the non-commercialized FDA-cleared version (LSM-2DTE-1) of Hepatoscope. To account for the latest algorithmic developments, per channel data corresponding to each individual stiffness value was retrospectively re-processed into LSM-2DTE-2, implemented in the commercialized CE-marked version of Hepatoscope. However, due to a technical issue in the data transfer, raw data was only available for 120 participants, for whom retro-processing was possible.

Clinical indication for liver biopsy

As clinical practice may differ according to different centres, the study centre agreed to follow a standardized clinical algorithm across all study centres specified in the study protocol [9]. This clinical algorithm was used to determine the indication for a liver biopsy to determine the stage of liver fibrosis. In case of clinically indicated liver biopsy, the pathology results were collected in the study database. All the liver biopsies performed in participants enrolled in the NAFLD-Care/NAFLD-Screen study were centrally reviewed at Lyon University Hospital by a senior MASH expert pathologist using the NASH CRN scoring system. The median time between LSM and liver biopsy was 24 weeks.

Magnetic resonance magnetic imaging, including liver fat quantification using proton density fat fraction (PDFF) and LSM using magnetic resonance elastography (LSM-MRE), was performed in a subgroup of participants. They were proposed to undergo an MRI assessment randomly depending on slots availability at study sites, using commercially available software and hardware (Resoundant, Inc., Rochester, MN), please see supplemental data for detailed procedure [9,13]. The presence of cirrhosis (stage F4) was defined by overt imaging diagnosis of cirrhosis [18,19] and for patients without overt diagnosis of cirrhosis, a high threshold > 3,62 kPa was used to rule-in the presence of AF [20]. The median time between LSM and MRI assessment was 3 weeks.

Reference standard

The reference standard use for the primary analyses was the indication for referral to specialized care in hepatology due to intermediate to high-risk of AF, which was defined by a valid LSM-VCTE ≥ 8 kPa according to the current guidelines [1,3–5,7,16].

As secondary analyses, the presence of high-risk for AF defined by a valid LSM-VCTE ≥ 12 kPa was considered.

Sensitivity analyses

As LSM-VCTE has an excellent NPV to rule-out the risk of AF but have a lower PPV for the diagnosis of the presence of AF [8], we also assessed the indication for the referral to specialized care in hepatology using a composite hierarchical criteria to provide an accurate assessment of the presence of intermediate to high risk of AF requiring specialized care in hepatology taking into account the results of the liver biopsy and MRE as follow [9] :

1. If liver biopsy was performed: high risk of AF was defined by the presence of histological stage of fibrosis F3 or F4, low risk of AF was defined by histological stage of fibrosis ≤ F2;
2. If liver biopsy was not performed and MRE available: high risk of AF was defined by the presence of overt imaging diagnosis of cirrhosis or LSM-MRE > 3,6 kPa, intermediate-risk of AF was defined by an LSM-MRE ≥ 2,6 and ≤ 3,6 kPa and low-risk of AF was defined by LSM-MRE < 2,6 kPa.
3. If a liver biopsy and MRE were not performed: high-risk of AF is

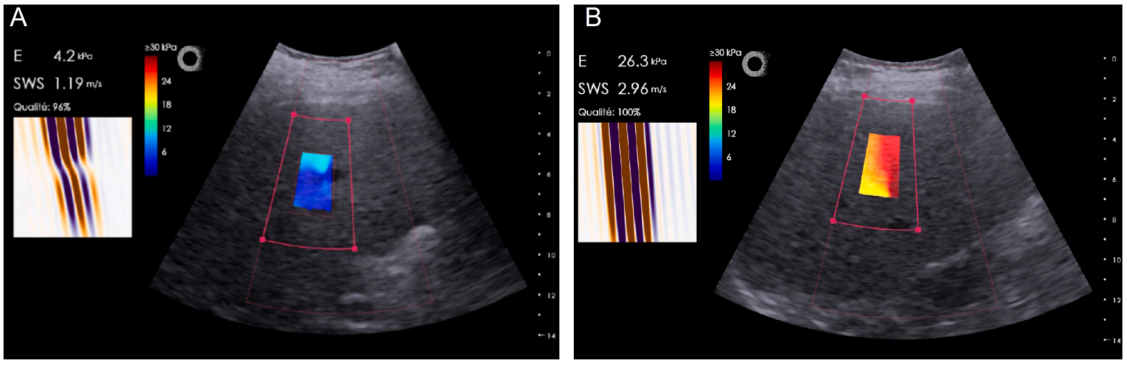

Fig. 1. LSM acquisition using Hepatoscope
Example of images of real-time B-Mode and region of interest with 2D shear wave elastography using Hepatoscope in patients included in the study. A image of a participant with low 2DTE-V1 of 4.2 kPa and confirmed with histological liver fibrosis stage F1. B. Image of a participant with high 2DTE-V1 of 26.3 kPa and confirmed presence of cirrhosis on MRI.

defined by LSM-VCTE ≥ 12 kPa, intermediate-risk was defined by LSM-VCTE ≥ 8 and ≤ 12 kPa, and low-risk of AF was defined by LSM-VCTE < 8 kPa.

Statistical analysis

Continuous variables were described by median and interquartile range; categorical variables were described by the frequency and percentage for each category. Comparisons between the population with available LSM-2DTE-1 and LSM-2DTE-2 were performed using the Chi-square or Fischer's exact tests for categorical variables, and non-parametric Wilcoxon test for continuous variables. Correlation and agreement between continuous variables were assessed using Spearman's correlation coefficient and a Bland-Altman plot, respectively. The diagnostic performances of LSM-2DTE-2 and ELF for the detection of participants with risk of AF (defined by the VCTE or by the composite hierarchical endpoint) were assessed using the area under the empirical receiver operating characteristic curve (AUROC) with the 95% confidence interval (CI) based on Delong method. The optimal threshold was determined by Younden Index. Sensitivities and specificities for the optimal threshold and for predefined thresholds were estimated with their 95%IC based on the bootstrap method. Thresholds of 2DTE-2 for fixed specificity or sensitivity at 80% were determined by computing non-parametric ROC curve to identify the threshold achieving the target sensitivity. Statistical analyses were performed using R software, version 4.4.1, SPSS Statistics ® Version 23 (SPSS IBM, New York, U.S.A.), MEDCalc® V23.3.7 and GraphPad Prism version 9.4. All *P*-values were two-tailed, and *P*-values < 0.050 were considered statistically significant. The reporting of this study conformed to STARD guidelines is presented in Table S1; see supplementary materials associated with this article on line [21].

Results

Baseline characteristics

Among the 308 participants included in the study, 294 participants with a valid VCTE and a LSM-2DTE-1 were analysed (Fig. S1; see supplementary materials associated with this article on line). Additional analysis on LSM-2DTE-2, which corresponds to the current commercially available version of the Hepatoscope, was performed in a subgroup of 120 participants with available raw data, after retro-processing (Fig. S1; see supplementary materials associated with this article on line). The LSM-2DTE-1 study population included 83.3% with T2D and 71.4% with class I-II obesity, 42.5% were female, with a median age of 61 years (IQR 53–67). The median BMI was 32.6 kg/m² (IQR 29.4–36.0), the median LSM-VCTE was 6.10 kPa and median LSM-2DTE-1 was: 5.7 kPa. Among them, 24.8% had and VCTE ≥ 8 kPa and 25.2% had intermediate to high-risk of AF requiring referral in hepatology using a composite hierarchical endpoint based upon a liver biopsy for 27 participants, MRE for 55 participants and LSM-VCTE for the remaining 212 including 178 with LSM-VCTE < 8 kPa (Fig. S2; see supplementary materials associated with this article on line). The baseline characteristics of the population with available LSM-2DTE-2 were similar with no statistical difference between the median LSM-VCTE or the distribution of the risk of advanced fibrosis including 31.7% with VCTE ≥ 8 kPa and 31.7% with intermediate to high risk of AF requiring referral in hepatology using a composite hierarchical endpoint based upon a liver biopsy for 19 participants, MRE for 26 participants and LSM-VCTE for the remaining 75 including 59 with LSM-VCTE < 8 kPa (Table 1, Fig. S2; see supplementary materials associated with this article on line).

Comparison between LSM using 2DTE and VCTE

LSM-2DTE-1 were significantly correlated with LSM-VCTE: Spearman correlation r (95% confidence interval (CI): 0.37 [95%CI: 0.27–0.47], *P* < 0.001 (Fig. 2A). The correlation between LSM-2DTE-2 and LSM-VCTE was higher: 0.61 [95%CI: 0.49–0.71], *P* < 0.001 (Fig. 2B). No significant bias was observed between LSM-2DTE-1 or LSM-2DTE-2 and LSM-VCTE as shown by the Bland-Altman analysis (Fig. 2C-D).

Table 1
Baseline characteristics of the study populations with Hepatoscope 2DTE-1 versus 2DTE-2 assessment.

Characteristics	LSM-2DTE-1 population (n = 294)	LSM-2DTE-2 population (n = 120)	*P*-value
Anthropometrics			
Age (years)	61.0 (53.3 - 67.0)	60.0 (53.8 - 65.3)	0.333
Female (n, %)	125 (42.5%)	44 (36.7%)	0.323
Clinics			
T2D (n, %)	245 (83.3%)	97 (80.8%)	0.641
BMI (kg/m²)	32.6 (29.4 - 36.0)	32.3 (29.0 - 35.7)	0.494
Obesity (n, %)	210 (71.4%)	83 (69.2%)	0.734
Blood Chemistry			
ASAT (UI/l)	29.0 (23.0 - 38.0)	32.0 (24.0 - 41.0)	0.043
ALAT (UI/l)	32.0 (23.0 - 50.0)	38.0 (23.0 - 54.3)	0.154
GGT (UI/l)	40.0 (28.0 - 70.0)	42.0 (30.0 - 65.5)	0.721
Platelets (G/l)	240.5 (203.0 – 283.0)	251.0 (211.0 – 295.2)	0.121
HbA1c	7.30 (6.20- 8.45)	6.95 (6.03 - 7.88)	0.064
Non-invasive tests			
FIB-4	1.34 (0.94 - 1.72)	1.31 (0.98 - 1.57)	0.563
LSM-VCTE (kPa)	6.10 (4.82 - 7.90)	6.80 (4.97 - 8.60)	0.159
ELF	9.24 (8.75 - 9.81)	9.20 (8.68 - 9.76)	0.591
XL probe (n,%)	122 (41.5%)	35 (29.2%)	0.025
LSM-2DTE-1 (kPa)	5.70 (4.50 - 7.47)	6.75 (5.38 - 9.50)	< 0.001
LSM-2DTE-2 (kPa)	NA	7.18 (6.01 - 10.09)	NA
CAP (dB/m)	305.0 (273.0 −342.0)	301.50 (265.00 - 334.25)	0.426
Risk stratification for advanced fibrosis			
LSM-VCTE ≥ 8 kPa	73 (24.8)	38 (31.7)	0.193
Composite criteria for advanced fibrosis liver biopsy/MRE/VCTE)			0.371
low risk	220 (74.8)	82 (68.3)	
Intermediate risk	42 (14.3)	23 (19.2)	
high risk	32 (10.9)	15 (12.5)	

LSM-2DTE-2 diagnostic performance for the detection of patient at risk for AF

The diagnostic performance of LSM-2DTE-2 was assessed in a subgroup of 120 participants with available data. The AUROC of LSM-2DTE-2 for the detection of LSM-VCTE ≥ 8.0 kPa was 0.81 (95% Confidence Interval (CI): 0.72–0.89) (Fig. 3A). The optimal threshold of LSM-2DTE-2 was similar 8.0 kPa (Table 2). The AUROC using the composite endpoint for the detection of patient at risk of AF was lower 0.75 (95%CI: 0.65–0.84) with a higher optimal threshold of 8.7 kPa (Fig. 3B, Table 2). Compared to LSM-2DTE-2, the AUROC of ELF™ for the detection of both LSM-VCTE ≥ 8 kPa and composite endpoint were lower: 0.64 (95% CI: 0.52–0.75) and 0.68 (95% CI: 0.58–0.79), respectively (Fig. 3A-B, Table 2).

LSM-2DTE-2 diagnostic performance for the detection of high-risk of AF

The AUROC of LSM-2DTE-2 for the detection of LSM-VCTE ≥ 12 kPa was 0.81 (95% Confidence Interval (CI): 0.66–0.96) (Fig. 3C). The optimal threshold of LSM-2DTE-2 for the detection of LSM-VCTE was 10.7 kPa with a slightly higher sensitivity compared to the pre-specified threshold of 12 kPa: 85.3% versus 54.5%, respectively (Table 3). The AUROC using the composite endpoint for the detection of high-risk of AF was higher 0.84 (95%CI: 0.73–0.95) with an optimal thresholds of 9.4 kPa (Fig. 3D, Table 3). Compared to LSM-2DTE-2, the AUROC of ELF for the detection of both LSM-VCTE ≥ 12 kPa was lower: 0.71 (95% CI: 0.51–0.92), but similar for the detection of high-risk of AF: 0.84 (95%

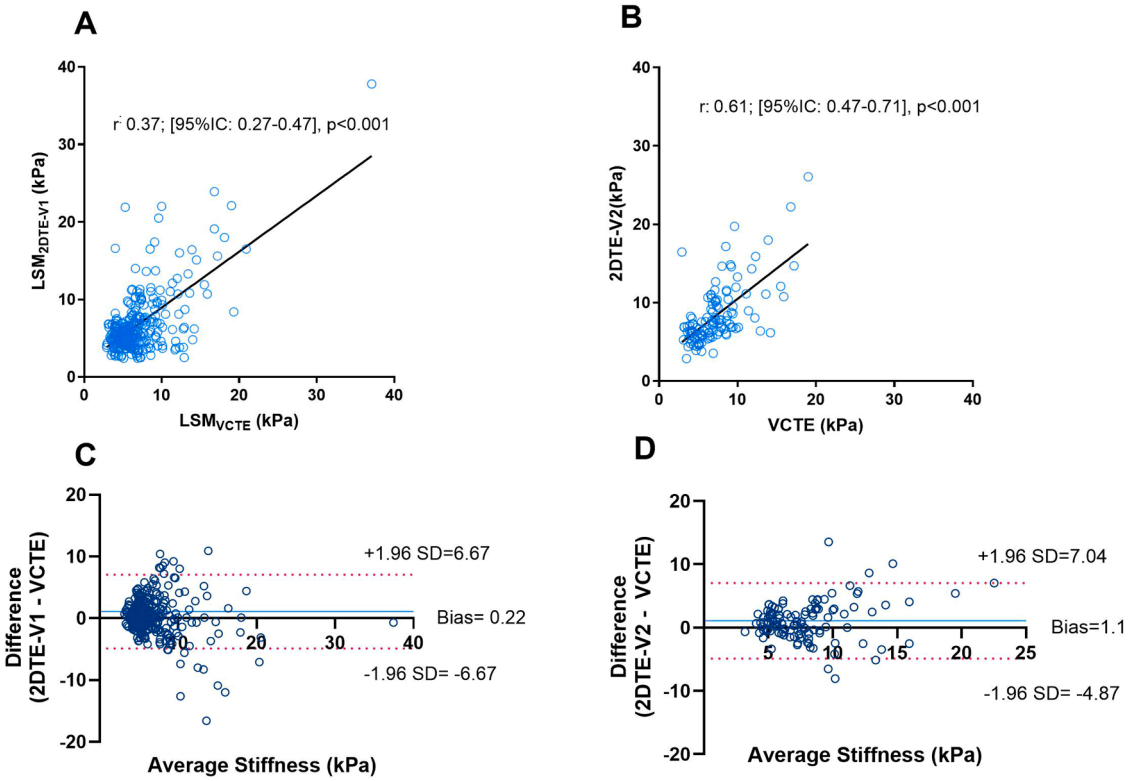

Fig. 2. Comparison between LSM using 2DTE and VCTE
Spearman correlation between LSM-VCTE and A. LSM-2DTE-1 and B. LSM-2DTE-2 in a subgroup of 120 participants. Bland-Altman plot of the difference of C. LSM-2DTE-1 and LSM-VCTE and D. LSM-2DTE-2 and LSM-VCTE.

CI: 0.72–0.95), respectively (Fig. 3C-D, Table 3).

Discussion

Main findings

In this proof-of-concept ancillary investigation of a prospective multicentre study, we report good diagnostic performance of the novel point-of-care device Hepatoscope's LSM-2DTE for identifying patient at risk for AF who require specialized care in hepatology, following a systematic screening in diabetology and nutrition clinics. This investigation of the diagnostic performance of LSM-2DTE using the Hepatoscope compared to LSM-VCTE indicates that it could be used as an alternative to LSM-VCTE in the recommended two-step screening strategy for the risk stratification of AF. In addition, LSM-2DTE exhibited a higher AUROC than ELF™ for identifying patients who require referral to hepatology for specialized care.

In context with published literature

This is the first clinical investigation assessing the use of LSM-2DTE using the Hepatoscope in patients with T2D and/or obesity and MASLD in diabetology and nutrition departments

A strong correlation between LSM-2DTE and LSM-VCTE have been previously reported in Mexican-origin adults from a variety of community-based settings in Southern Arizona [10] and in a prospective cross-sectional study performed in 100 patients with chronic liver diseases from diverse aetiologies [11]. This later study also reported a good intra- and inter-user repeatability of LSM-2DTE [11]. Interestingly, the optimal threshold of LSM-2DTE-2 in our study was 8.04 kPa for the identifying patients at risk of AF. This suggests that LSM-2DTE-2 can be used as an alternative to LSM-VCTE using the same recommended threshold of $\geq$ 8 kPa. Furthermore, LSM-2DTE-2 had a higher AUROC compared to ELF™ for the detection of patients at risk of AF which confirms previous larges studies reporting that ultrasound-based markers such as LSM-VCTE outperform ELF™ for the detection of patients at risk of advanced fibrosis [22,23]. However, the AUROC of ELF™ and LSM-2DTE-V2 were similar for the detection of high-risk for advanced fibrosis using the composite hierarchical endpoint including, liver biopsy, MRE or LSM-VCTE. This indicates that both ELF™ and LSM-2DTE have good diagnostic accuracy for identifying patient with highest risk of advanced fibrosis.

Strengths and limitations

The main strength of our study relies on the prospective head-to-head comparison of the diagnostic performance of the novel LSM-2DTE and currently recommended LSM-VCTE and the alternative proposed patented blood-based biomarker ELF. All participants underwent a comprehensive liver assessment for the risk stratification of MASLD-related AF and the LSMs (2DTE and VCTE) were performed on the same day under identical condition. Likewise, ELF™ assessment was performed using fasting serum collected on the same day of LSMs, which limits measurement bias, temporal variability and potential confounding factors.

The use of LSM-VCTE as the reference standard in this study limits the ability to determine the diagnostic accuracy for the detection of biopsy-proven advanced fibrosis which remain the gold standard for the precise determination of liver fibrosis stages. However, it would have been unethical to perform a liver biopsy in the overall study population as the majority of the population screened in diabetology clinics exhibit low risk for advanced fibrosis including a majority (75%) of participants with low LSM-VCTE $<$ 8 kPa. However, as the LSM-VCTE can be considered as an imperfect gold standard mainly limited by potential false positive cases, we used of a secondary composite endpoint enables to provide sensitivity analyses which confirm the good diagnostic

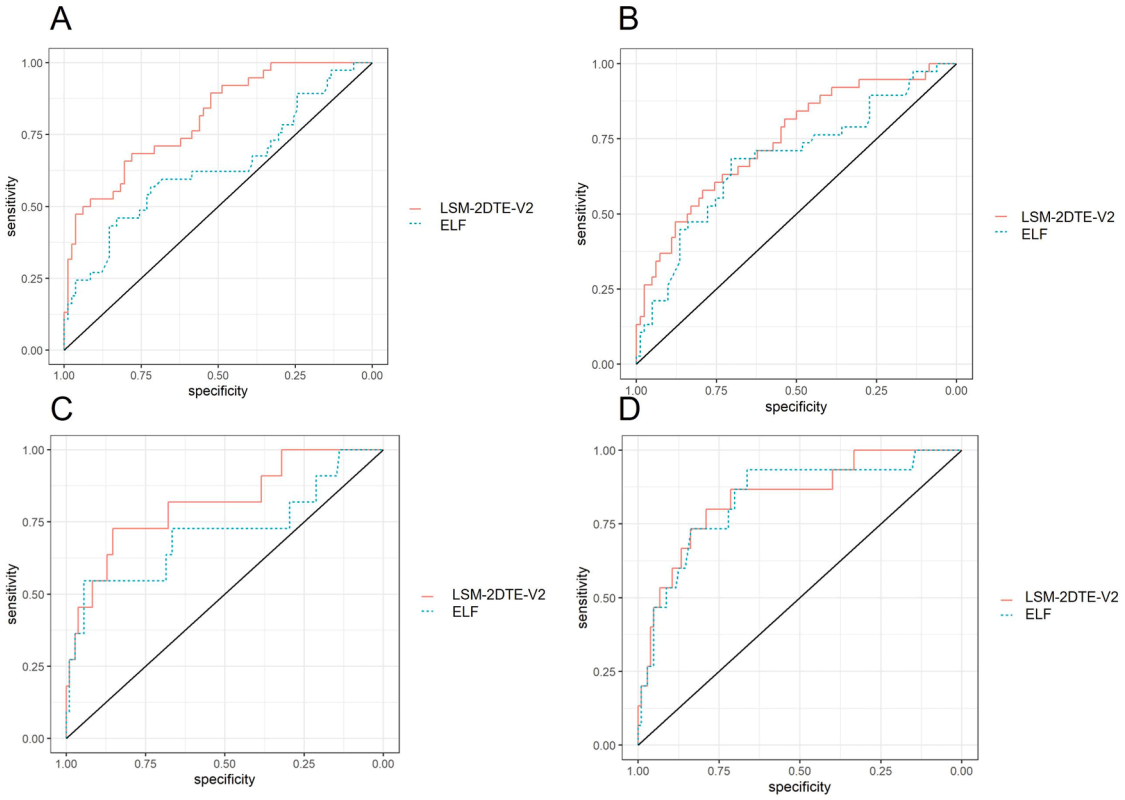

Fig. 3. AUROC of 2DTE-2 for the detection of AF

The AUROC of LSM-2DTE-2 (red) and ELF™ (blue) in the subgroup of 120 participants with available re-processing CE-marked LSM-2DTE-2 A. for the detection of VCTE ≥8 kPa, B. for the detection of patients at risk of AF using a composite endpoints C. for the detection of VCTE≥ 12 kPa D. for the detection of high risk of AF using a composite endpoint.

Table 2

Diagnostic performance of 2DTE-V2 and ELF for the detection of intermediate to high risk of AF requiring referral in hepatology.

	AUROC	(95%CI)	Threshold	Sensitivity % (95%CI)	Specificity % (95%CI)
VCTE ≥ 8kPa					
2DTE-V2	0.81	0.72–0.89	Optimal: 8.04 kPa	68.4 (NA)	78.0 (NA)
			Fixed sensitivity 80%: 6.8 kPa	80.0 (NA)	56.1 (41.5–78.0)
			Fixed specificity 80%: 8.3 kPa	65.8 (47.4–84.2)	80.0 (NA)
			≥ 8kPa	68.4 (51.3–82.5)	75.6 (64.9 - 84.4)
ELF™	0.64	0.52- 0.75	≥ 9.8	43.2 (27.1–60.5)	84.1 (74.4–91.3)
Composite criteria : (liver biopsy/MRE/VCTE)					
2DTE-V2	0.75	0.65 - 0.84	Optimal: 8.7 kPa	57.9 (NA)	79.3 (NA)
			Fixed sensitivity 80%: 6.8	80.0 (NA)	53.7 (39.0–71.9)
			Fixed specificity 80%: 8.9 kPa	55.3 (36.8–71.0)	80.0 (NA)
			≥ 8kPa	63.2 (46,0–78,2)	73.2 (62.2-82.4)
ELF™	0.68	0.57–0.79	≥ 9.8	44.7 (28.6–61.7)	85.2 (75.6–92.1)

Table 3

Diagnostic performance of 2DTE-V2 and ELF for the detection of high-risk of AF.

	AUROC	(95%CI)	Threshold	Sensitivity % (95%CI)	Specificity % (95%CI)
VCTE ≥ 12kPa					
2DTE-V2	0.81	0.66–0.96	Optimal: 10.7 kPa	85.3 (NA)	72.7 (NA)
			Fixed sensitivity 80%: 8.0 kPa	80% (NA)	67.9 (25.7–90.8)
			Fixed specificity 80%: 10.2 kPA	72.7 (41.8–90.9)	80% (NA)
			≥ 12kPa	54.5 (23.4–83.3)	91.7 (84.9–96.2)
ELF™	0.71	0.51 - 0.92	≥ 11.3	9.1 (0.2–41.3)	100 (96.6–100)
Composite criteria: (liver biopsy/MRE/VCTE)					
2DTE-V2	0.84	0.73–0.95	Optimal: 9.4 kPa	80.0 (NA)	79.0 (NA)
			Fixed sensitivity 80%: 9.4 kPa	80.0 (NA)	79.0 (35.2–94.3)
			Fixed specificity 80%: 9.6 kPa	73.3 (40.0–93.3)	80 (NA)
			≥ 12.0 kPa	53.3 (26.6–78.7)	93.3 (86.7–97.3)
ELF™	0.84	0.71- 0.95	≥ 11.3	6.7 (0.2–31.9)	100 (96.5–100)

performance of LSM-2DTE for the identification of patient at risk of AF while minimizing potential false positive cases with VCTE ≥ 8 kPa. Importantly, as clinical practice may differ according to different

centres, the study centre agreed to follow a standardized clinical algorithm across all study centres specified in the study protocol using and LSM-VCTE threshold fixed at 7 kPa which further limits selection bias [9].

However, the study population excluded patients with class III obesity in which LSM-VCTE has been reported to be difficult to perform and less reliable [13,24]. Whether LSM-2DTE encounters the same limitation is unknown and would need to be assessed in a dedicated investigation. In addition, due to a technical issue with data transfer, the re-processing of LSM-2DTE-1 into LSM-2DTE-2, currently implemented in the commercial CE-marked version of the Hepatoscope, was available only for a subset of the initial study population. However, there were no statistical differences in the baseline characteristics between the 2DTE-1 and 2DTE-2 groups except for the median LSM-2DTE-1, suggesting that the LSM-2DTE-2 subset remains representative of the population enrolled in the study and is potentially generalizable to the usual population screened in diabetology and nutrition clinics. However, we acknowledge that we cannot exclude non-random selection bias and that the analysis performed in the LSM-2DTE-2 population may lack of statistical power to determine to precise diagnostic performance of LSM-2DTE-2 for the risk stratification for AF. Hence, larger independent studies are needed to further validate this proof-of-concept findings.

We also acknowledged some limitation in the analyses of the optimal threshold of LSM-2DTE. The Youden index identifies the threshold that maximizes sensitivity and specificity by assuming equal weighting of false positives and false negatives. Because it does not account for disease prevalence, it effectively optimizes performance in a context where the two outcome classes are balanced. Therefore, the thresholds for fixed specificity or sensitivity at 80% were also provided in order to better inform the clinicians on the use of LSM-2DTE depending on the clinical context and desired sensitivity or specificity. However, further studies, in larger population are needed to better define the optimal threshold of LSM-2DTE for the detection of AF.

Clinical impact and future direction

Given the large population affected by MASLD worldwide, including its high prevalence among patients with T2D or obesity, wide availability of non-invasive tests for detecting patients at risk for advanced fibrosis is crucial for implementing care pathways and ensuring optimal patient management. This is all the more important as patients can benefit from optimization of anti-diabetes, or anti-obesity medication which improves MASLD [1,5,6]. Patients may also benefit from approved therapies for fibrotic MASH, such as resmetirom or semaglutide 2.4 mg weekly [25,26]. In addition, initiation and monitoring of these approved therapies rely on LSM-VCTE, which further reinforces the clinical need for widely available and affordable LSM within healthcare systems [25,26]. LSM-2DTE using the Hepatoscope could represents a reliable alternative to LSM-VCTE as it combines the 50 Hz vibration for shear wave generation similarly to VCTE, with the two-dimensional estimation of the propagation, enabling liver stiffness imaging with the advantage of a real-time assessment of the quality of each individual measurement. Finally, it can be processed by off-the-shelf mobile platforms, making this technology affordable and easily deployable anywhere, thereby ensuring broad availability and supporting the implementation of effective care pathways. The Hepatoscope can also provide quantitative ultrasound measurements for the assessment of steatosis-related parameters, and further investigations are needed to evaluate the diagnostic performance of these non-invasive tests for hepatic steatosis and cost-effectiveness compared to LSM-VCTE or ELF, which are beyond the scope of this study.

In conclusion, the study provides evidence that LSM measured with 2DTE, available on a novel point of care device the Hepatoscope has an utility for the risk stratification of AF in diabetology setting. Hence, LSM-2DTE represent an interesting alternative to LSM-VCTE and its diagnostic performance will need to be further confirmed in larger prospective studies in order to determine the optimal thresholds and validate its clinical utility in various clinical settings.

Appendix supplementary material

Supplementary materials (Figs. S1-S2 and Table S1) associated with this article can be found at http://www.scincedirect.com at doi …

Funding declaration

The NAFLD-Care study is funded by an investigator initiated research grant from GILEAD Inc. , the current ancillary NAFLD-Screen study benefited from financial support of E-Scopics.

Data availability

The data that support the findings of this study are owned by the Hospices Civils de Lyon. Due to legal and ethical restrictions, the data are not publicly available. However, the data may be made available from the corresponding author upon reasonable request, subject to review and approval by the legal department of the Hospices Civils de Lyon.

CRediT authorship contribution statement

Cyrielle Caussy: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Bruno Vergès:** Writing – review & editing, Investigation. **Fabien Subtil:** Writing – review & editing, Formal analysis. **Amna Abichou-Klich:** Writing – review & editing, Formal analysis. **Valérie Hervieu:** Writing – review & editing, Investigation. **Damien Leleu:** Writing – review & editing, Investigation. **Laurent Milot:** Writing – review & editing, Investigation. **Bérénice Ségrestin:** Writing – review & editing, Investigation. **Sylvie Bin:** Writing – review & editing, Methodology. **Julien Berthiller:** Writing – review & editing, Methodology. **Alexia Rouland:** Writing – review & editing, Investigation. **Dominique Delaunay:** Writing – review & editing, Project administration. **Claire Primot:** Writing – review & editing, Investigation. **Samy Hadjadj:** Writing – review & editing, Investigation. **Bertrand Cariou:** Writing – review & editing, Investigation. **Philippe Moulin:** Writing – review & editing, Investigation. **Sybil Charrière:** Writing – review & editing, Investigation. **Emmanuel Disse:** Writing – review & editing, Investigation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Cyrielle Caussy reports financial support was provided by E-scopics. Cyrielle Caussy reports financial support was provided by Gilead Sciences Inc. Cyrielle Caussy reports a relationship with Gilead Sciences Inc that includes: consulting or advisory. Cyrielle Caussy reports a relationship with NovoNordisk that includes: consulting or advisory, funding grants, speaking and lecture fees, and travel reimbursement. Cyrielle Caussy reports a relationship with AstraZenecca that includes: consulting or advisory, speaking and lecture fees, and travel reimbursement. Cyrielle Caussy reports a relationship with Eli Lilly and Company that includes: consulting or advisory, speaking and lecture fees, and travel reimbursement. Cyrielle Caussy reports a relationship with E-scopics that includes: consulting or advisory. Cyrielle Caussy reports a relationship with MSD France SAS that includes: consulting or advisory. Cyrielle Caussy reports a relationship with Bayer HealthCare AG that includes: consulting or advisory. Cyrielle Caussy reports a relationship with Madrigal Pharmaceuticals Inc that includes: consulting or advisory and speaking and lecture fees. Cyrielle Caussy reports a relationship with Echosens SA that includes: consulting or advisory and speaking and lecture fees. C Caussy reports a relationship with Boehringer Ingelheim GmbH that includes: consulting or advisory. Bruno Verges reports a relationship with Amgen SA that includes: consulting or advisory. Bruno

Verges reports a relationship with AstraZenecca that includes: consulting or advisory and funding grants. Bruno verges reports a relationship with Eli Lilly and Company that includes: consulting or advisory and funding grants. Bruno Verges reports a relationship with Novartis that includes: consulting or advisory. Bruno Verges reports a relationship with NovoNordisk that includes: consulting or advisory and funding grants. Bruno Verges reports a relationship with Recordati Pharma GmbH that includes: consulting or advisory. Bruno verges reports a relationship with Sanofi that includes: consulting or advisory. Bruno Verges reports a relationship with Timkl that includes: consulting or advisory. B Segrestin reports a relationship with NovoNordisk that includes: consulting or advisory. B Segrestin reports a relationship with Eli Lilly and Company that includes: consulting or advisory. B Segrestin reports a relationship with Rythm that includes: consulting or advisory. P Moulin reports a relationship with Amarin Pharma Inc that includes: consulting or advisory. P Moulin reports a relationship with Amryt Pharmaceuticals Inc that includes: consulting or advisory. B Cariou reports a relationship with Amgen Inc that includes: consulting or advisory. B Cariou reports a relationship with Abbott that includes: consulting or advisory. B Cariou reports a relationship with AstraZeneca Pharmaceuticals LP that includes: consulting or advisory. B Cariou reports a relationship with Gilead Sciences Inc that includes: consulting or advisory. B Cariou reports a relationship with Eli Lilly that includes: consulting or advisory. B Cariou reports a relationship with Merck Sharp & Dohme UK Ltd that includes: consulting or advisory. B Cariou reports a relationship with Novartis that includes: consulting or advisory. B Cariou reports a relationship with NovoNordisk that includes: consulting or advisory. B Cariou reports a relationship with Sanofi that includes: consulting or advisory. B Cariou reports a relationship with Ultragenyx Pharmaceutical Inc that includes: consulting or advisory. S Charriere reports a relationship with Amarin Pharma Inc that includes: consulting or advisory. S Charriere reports a relationship with Amgen Inc that includes: consulting or advisory. S Charriere reports a relationship with AstraZenecca that includes: consulting or advisory. S Charriere reports a relationship with BioMarin Pharmaceutical Inc that includes: consulting or advisory. S Charriere reports a relationship with Boehringer Ingelheim GmbH that includes: consulting or advisory. S Charriere reports a relationship with Ionis Pharmaceuticals Inc that includes: consulting or advisory. S Charriere reports a relationship with Eli Lilly and Company that includes: consulting or advisory. S Charriere reports a relationship with MSD that includes: consulting or advisory. S Charriere reports a relationship with Novartis that includes: consulting or advisory. S Charriere reports a relationship with NovoNordisk that includes: consulting or advisory. S Charriere reports a relationship with PTC Therapeutics Inc that includes: consulting or advisory. S Charriere reports a relationship with Ultragenix that includes: consulting or advisory. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.diabet.2026.101766.

References

[1] European Association for the Study of the L. European Association for the Study of D, European Association for the Study of O. EASL-EASD-EASO Clinical Practice Guidelines on the management of metabolic dysfunction-associated steatotic liver disease (MASLD). J Hepatol 2024;81(3):492–542. https://doi.org/10.1016/j.jhep.2024.04.031.

[2] Simon TG, Roelstraete B, Khalili H, Hagstrom H, Ludvigsson JF. Mortality in biopsy-confirmed nonalcoholic fatty liver disease: results from a nationwide cohort. Gut 2021;70:1375–82. https://doi.org/10.1136/gutjnl-2020-322786.

[3] Rinella ME, Neuschwander-Tetri BA, Siddiqui MS, Abdelmalek MF, Caldwell S, Barb D, et al. AASLD practice guidance on the clinical assessment and management of nonalcoholic fatty liver disease. Hepatology 2023;77(5):1797–835. https://doi.org/10.1097/HEP.0000000000000323.

[4] Kanwal F, Shubrook JH, Adams LA, Pfotenhauer K, Wai-Sun Wong V, Wright E, et al. Clinical care pathway for the risk stratification and management of patients with nonalcoholic fatty liver disease. Gastroenterology 2021;161:1657–69. https://doi.org/10.1053/j.gastro.2021.07.049.

[5] Cusi K, Abdelmalek MF, Apovian CM, Balapattabi K, Bannuru RR, Barb D, et al. Metabolic dysfunction-associated steatotic liver disease (MASLD) in people with diabetes: the need for screening and early intervention. A consensus report of the American Diabetes Association. Diabetes Care 2025;48:1057–82. https://doi.org/10.2337/dci24-0094.

[6] Chouik Y, Canivet CM, Julla JB, Mouillot T, Parlati L, Rouland A, et al. Management of patients with type 2 diabetes and MASLD: an overview and joint statement. Diabetes Metab 2025;51:101709. https://doi.org/10.1016/j.diabet.2025.101709.

[7] Younossi ZM, Zelber-Sagi S, Lazarus JV, Wong VW, Yilmaz Y, Duseja A, et al. Global consensus recommendations for metabolic dysfunction-associated steatotic liver disease and steatohepatitis. Gastroenterology 2025;169:1017–1032.e2. https://doi.org/10.1053/j.gastro.2025.02.044. 1017–32 e2.

[8] European Association for the Study of the L. EASL clinical practice guidelines on non-invasive tests for evaluation of liver disease severity and prognosis - 2021 update. J Hepatol 2021;75:659–89. https://doi.org/10.1016/j.jhep.2021.05.025.

[9] Caussy C, Verges B, Leleu D, Duvillard L, Subtil F, Abichou-Klich A, et al. Screening for metabolic dysfunction-associated steatotic liver disease-related advanced fibrosis in diabetology: a prospective multicenter study. Diabetes Care 2025;48:877–86. https://doi.org/10.2337/dc24-2075.

[10] Villavicencio EA, Serdjebi C, Maldonado A, Ochoa Mora E, Besson A, Alkhouri N, et al. Use of Hepatoscope 2DTE for non-invasive assessment of liver stiffness among Mexican immigrant adults in a community-based setting. Clin Res Hepatol Gastroenterol 2025;49:102581. https://doi.org/10.1016/j.clinre.2025.102581.

[11] Serdjebi C, Foucher J, Besson A, Gay J, Delamarre A, Cohen-Bacrie C. Hepatoscope 2DTE's image-based quality index enhances applicability and repeatability of liver stiffness measurement. Clin Res Hepatol Gastroenterol 2025;49:102532. https://doi.org/10.1016/j.clinre.2025.102532.

[12] Younossi ZM, Felix S, Jeffers T, Younossi E, Nader F, Pham H, et al. Performance of the enhanced liver fibrosis test to estimate advanced fibrosis among patients with nonalcoholic fatty liver disease. JAMA Netw Open 2021;4:e2123923. https://doi.org/10.1001/jamanetworkopen.2021.23923.

[13] Chouik Y, Aubin A, Maynard-Muet M, Segrestin B, Milot L, Hervieu V, et al. The grade of obesity affects the noninvasive diagnosis of advanced fibrosis in individuals with MASLD. Obesity 2024;32:1114–24. https://doi.org/10.1002/oby.24033 (Silver Spring).

[14] Caussy C, Telliam C, Al-Nuaimi B, Maynard-Muet M, Dumortier J, Zoulim F, et al. Comparison of pathway referrals for liver fibrosis risk stratification performed in diabetology and nutrition clinics. Diabetes Metab Syndr Obes 2023;Volume 16:1721–9. https://doi.org/10.2147/DMSO.S407511.

[15] Castera L, Forns X, Alberti A. Non-invasive evaluation of liver fibrosis using transient elastography. J Hepatol 2008;48:835–47. https://doi.org/10.1016/j.jhep.2008.02.008.

[16] Cusi K, Isaacs S, Barb D, Basu R, Caprio S, Garvey WT, et al. American association of clinical endocrinology clinical practice guideline for the diagnosis and management of nonalcoholic fatty liver disease in primary care and endocrinology clinical settings: co-sponsored by the American Association for the Study of Liver Diseases (AASLD). Endocr Pract 2022;28:528–62. https://doi.org/10.1016/j.eprac.2022.03.010.

[17] Comprehensive Medical Evaluation and Assessment of Comorbidities. Standards of medical care in diabetes-2022. Diabetes Care 2022;45(Suppl 1):S46–59.

[18] Ito K, Mitchell DG, Gabata T, Hussain SM. Expanded gallbladder fossa: simple MR imaging sign of cirrhosis. Radiology 1999;211:723–6. https://doi.org/10.1148/radiology.211.3.r99ma31723.

[19] Harbin WP, Robert NJ, Ferrucci Jr JT. Diagnosis of cirrhosis based on regional changes in hepatic morphology: a radiological and pathological analysis. Radiology 1980;135:273–83. https://doi.org/10.1148/radiology.135.2.7367613.

[20] Hsu C, Caussy C, Imajo K, Chen J, Singh S, Kaulback K, et al. Magnetic resonance vs transient elastography analysis of patients with nonalcoholic fatty liver disease: a systematic review and pooled analysis of individual participants. Clin Gastroenterol Hepatol 2019;17:630–637.e8. https://doi.org/10.1016/j.cgh.2018.05.059. 630–7 e8.

[21] Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig L, et al. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. Clin Chem 2015;61:1446–52. England.

[22] Vali Y, Lee J, Boursier J, Petta S, Wonders K, Tiniakos D, et al. Biomarkers for staging fibrosis and non-alcoholic steatohepatitis in non-alcoholic fatty liver disease (the LITMUS project): a comparative diagnostic accuracy study. Lancet Gastroenterol Hepatol 2023;8:714–25. https://doi.org/10.1016/S2468-1253(23)00017-1.

[23] Younossi ZM, de Avila L, Petta S, Hagstrom H, Kim SU, Nakajima A, et al., Global NASH/MASH Council (GNC). Global performance of non-invasive tests in MASLD: insights from the G-MASLD study. Hepatology 2025. https://doi.org/10.1097/HEP.0000000000001564. Epub ahead of print.

[24] Caussy C, Chen J, Alquiraish MH, Cepin S, Nguyen P, Hernandez C, et al. Association between obesity and discordance in fibrosis stage determination by magnetic resonance vs transient elastography in patients with nonalcoholic liver

disease. Clin Gastroenterol Hepatol 2018;16(e7):1974–1982.e7. https://doi.org/10.1016/j.cgh.2017.10.037.
[25] Chen VL, Morgan TR, Rotman Y, Patton HM, Cusi K, Kanwal F, et al. Resmetirom therapy for metabolic dysfunction-associated steatotic liver disease: October 2024 updates to AASLD practice guidance. Hepatology 2025;81:312–20. https://doi.org/10.1097/HEP.0000000000001112.
[26] Bansal MB, Patton H, Morgan TR, Carr RM, Dranoff JA, Allen AM. Semaglutide therapy for metabolic dysfunction-associated steatohepatitis: November 2025 updates to AASLD practice guidance. Hepatology 2026;83:1326–40.