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Association of MR Elastography–Derived Liver Stiffness with Prognostic Indices, Hepatocyte Function, and Cholestasis Parameters in Chronic Viral Hepatitis and Primary Biliary Cholangitis

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Abstract

Purpose.

MRE-derived liver stiffness is increasingly used to stage and prognosticate chronic liver disease, yet whether its correlates depend on aetiology is unknown. We compared the determinants of stiffness between hepatocellular (chronic viral hepatitis, CH) and cholestatic (primary biliary cholangitis, PBC) disease.

Methods.

Seventy-nine patients undergoing liver MRE between January 2023 and September 2025 were retrospectively studied (53 CH, 26 PBC). Within each group, stiffness was correlated with hepatocyte-function tests, cholestasis parameters, the neutrophil-to-lymphocyte ratio (NLR) and prognostic indices; independent determinants were identified by linear regression and prediction of a MELD score above 9 by receiver operating characteristic analysis.

Results.

Stiffness, fibrosis-stage distribution and prognostic indices were comparable between groups, yet their determinants diverged. Stiffness correlated with the NLR in CH ($r = 0.35$, $p = 0.011$) but not in PBC ($r = 0.12$, $p = 0.55$), and most strongly with MELD in CH ($r = 0.48$, $p < 0.001$). On multivariate analysis, age and AST were independent determinants in CH and AST alone in PBC, which showed higher alkaline phosphatase and cholesterol. Platelet count (AUC = 0.85) and stiffness (AUC = 0.73) both predicted MELD above 9 ($p = 0.11$); at 3.53 kPa, stiffness showed 95% sensitivity and 97% negative predictive value.

Conclusion.

Identical stiffness values carry different meaning by aetiology: in CH stiffness tracks systemic inflammation and prognosis, whereas in PBC it reflects predominantly cholestatic injury. MRE should be interpreted within an aetiology-specific framework, not with uniform thresholds, and inflammatory markers add little in cholestatic disease.

Introduction

Chronic liver disease (CLD) is a leading cause of morbidity and mortality worldwide.[1] Accurate diagnosis and staging of liver fibrosis are crucial for the management of patients with CLD.[2] Liver biopsy has long been the reference standard for staging fibrosis, but its high cost, sampling error, intra- and inter-observer variability, invasiveness and associated complications have driven the development of non-invasive methods.[2] Among these, magnetic resonance elastography (MRE) provides the most accurate non-invasive assessment of hepatic fibrosis, both for detecting fibrosis and for assigning its stage.[2–4] In an

individual-participant-data meta-analysis, MRE showed high accuracy for significant fibrosis, advanced fibrosis and cirrhosis, independent of body mass index and of the aetiology of CLD.[4]

The neutrophil-to-lymphocyte ratio (NLR) is a biomarker of systemic inflammation. It has been used widely as a prognostic marker in a range of conditions and also carries discriminative diagnostic value.[5] Because hepatic inflammation and fibrosis are driven by immune cells, including Kupffer cells, macrophages, neutrophils and lymphocytes,[6] the NLR has been proposed as a prognostic marker in CLD. The evidence, however, is inconsistent and appears to depend on aetiology. A systematic review that grouped studies by underlying disease reported a positive association between the NLR and fibrosis stage in non-alcoholic fatty liver disease, an inverse correlation in chronic hepatitis B, and no significant association in chronic hepatitis C.[7] The reason for this inconsistency is unclear, as the studies differed in both patient population and method of fibrosis assessment.

Hepatocellular (chronic viral hepatitis, CH) and cholestatic (primary biliary cholangitis, PBC) liver diseases injure the liver in different ways. In viral hepatitis the injury is hepatocellular and the inflammatory infiltrate is lobular. In PBC the small bile ducts are destroyed by a portal, lymphocyte-rich infiltrate, and the biochemical picture is cholestatic rather than cytolytic.[8] Because liver stiffness rises with inflammation and cholestasis as well as with collagen deposition,[9] the laboratory parameters that track stiffness need not be the same in the two diseases. The MELD score adds a further dimension, as it reflects synthetic failure and portal hypertension rather than fibrosis[10]; in PBC, stiffness predicts decompensation even after the MELD score and disease-specific scores are taken into account.[11]

We hypothesised that the determinants of liver stiffness, and the usefulness of individual biochemical and clinical parameters, diverge between these chronic liver diseases even when the fibrosis burden is comparable. This study therefore aimed to determine whether the relationships between MR elastography-derived liver stiffness and prognostic indices, systemic inflammatory status, hepatocellular function and cholestatic biomarkers differ between hepatocellular and cholestatic CLD, by comparatively evaluating patients with CH and PBC.

Materials and Methods

I. Study Population

The study was approved by the institutional review board (IRB no. 12.10.2025/i10-982-25) and conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was not required owing to the retrospective design of the study and the use of anonymised data obtained during routine clinical care. All patient data were de-identified before analysis, and the magnetic resonance images shown in Fig. 1 contain no identifying marks or accompanying identifying text.

Patients who underwent liver MR examination at our institution between January 2023 and September 2025 were identified from the departmental imaging archive and screened for eligibility.

Patients were eligible if they were at least 18 years old, had an established diagnosis of chronic viral hepatitis or primary biliary cholangitis, had a technically successful MRE examination, and had a complete

laboratory panel available.

Patients were excluded if they had a coexisting liver disease of another aetiology (alcohol-related liver disease, autoimmune hepatitis, primary sclerosing cholangitis, Wilson disease, haemochromatosis or drug-induced liver injury), an overlap syndrome, hepatocellular carcinoma or another hepatic malignancy, or previous hepatic resection or transplantation.

Seventy-nine patients met the clinical criteria: 53 with CH and 26 with PBC. Within the CH group, 45 patients (84.9%) had chronic hepatitis B virus infection, of whom 10 (18.9% of the group) had hepatitis delta virus co-infection; the remaining 8 patients (15.1%) had chronic hepatitis C virus infection.

II. MR elastography technique and image analysis

Patients underwent MR imaging in the supine position after fasting for 6 hours. Data were acquired on a 1.5-T system (Aera, Siemens Healthcare, Erlangen, Germany) with standard body and spine matrix coils, extending the routine liver MRI protocol to include MRE sequences. Liver MRE was performed with a motion-sensitised, phase-contrast 2D gradient-echo sequence. Four 10-mm-thick transverse slices were acquired through the largest cross-section of the liver during end-expiratory breath-holds. Elastograms, wave images and confidence maps were reconstructed with dedicated post-processing software. Each slice was acquired in 17 seconds, giving a total scan time of approximately 2 minutes including four breath-holds and rest periods.

To determine mean liver stiffness, a single reader manually delineated freehand regions of interest (ROIs) on the confidence maps, excluding large vessels, focal lesions and imaging artefacts. Parenchymal stiffness was calculated as the mean of the quantitative values obtained from each confidence map. MR elastographic stiffness thresholds were defined as < 3.0 kPa for F0, ≥ 3.0 kPa for stage F1 or higher, ≥ 3.5 kPa for stage F2 or higher, ≥ 4.0 kPa for stage F3 or higher, and ≥ 5.0 kPa for stage F4,[2] with advanced fibrosis defined as stage F3 or above.

III. Laboratory parameters and derived indices

The laboratory panel obtained closest to the MRE examination was retrieved from the hospital information system. Recorded parameters comprised markers of hepatocyte function and injury (AST, ALT, albumin, INR), cholestasis markers (alkaline phosphatase, GGT, and total, direct and indirect bilirubin), a complete blood count with differential (white cell, neutrophil, lymphocyte and platelet counts), a lipid profile (total, LDL, HDL and VLDL cholesterol), and creatinine, eGFR and sodium.

Derived indices were calculated as neutrophil-to-lymphocyte ratio (neutrophils ÷ lymphocytes), platelet-to-lymphocyte ratio and FIB-4 (age × AST ÷ [platelets × √ALT]).

The MELD score and MELD 3.0 were calculated. The MELD score was calculated as: MELD = 9.57 × ln(creatinine) + 3.78 × ln(total bilirubin) + 11.20 × ln(INR) + 6.43. MELD 3.0 was calculated as: MELD 3.0 = 1.33 × (female) + 4.56 × ln(bilirubin) + 0.82 × (137 − Na) − 0.24 × (137 − Na) × ln(bilirubin) + 9.09 × ln(INR) +

11.14 × ln(creatinine) + 1.85 × (3.5 − albumin) − 1.83 × (3.5 − albumin) × ln(creatinine) + 6. High-risk disease was defined a priori as a MELD score greater than 9.

IV. Statistical analysis

All statistical analyses were performed using the SPSS for Windows 11.5 software program (SPSS Inc., Chicago, IL). A p value below 0.05 was considered statistically significant.

The distribution of continuous variables was assessed with the Shapiro–Wilk test and by visual inspection of histograms. Normally distributed variables are presented as mean ± standard deviation and non-normally distributed variables as median with interquartile range. Categorical variables are presented as frequencies and percentages.

Baseline characteristics were compared between the chronic hepatitis and primary biliary cholangitis groups using the independent-samples t test for normally distributed variables and the Mann–Whitney U test for those not normally distributed. Categorical variables were compared using the chi-square test or Fisher's exact test where expected cell counts were below five.

The relationships between liver stiffness and hepatocyte-function tests, cholestasis parameters, inflammatory markers and prognostic indices were examined with Spearman's rank correlation coefficient (r), calculated separately for each aetiological group. Correlation strength was interpreted as weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79) or very strong (≥ 0.80). Correlation coefficients were compared between the two groups using the Fisher r-to-z transformation.

Determinants of liver stiffness were identified by linear regression performed separately in each group. Variables showing a univariate association with stiffness at $p < 0.10$ were entered into the multivariable model, and backward elimination was applied until only variables with $p < 0.05$ remained. Regression coefficients are reported with 95% confidence intervals, and the explanatory power of each model is expressed as the adjusted R^2.

Receiver operating characteristic (ROC) analysis was used to evaluate the ability of liver stiffness and laboratory parameters to identify patients with high-risk disease, defined as a MELD score above 9. The area under the curve (AUC) is reported with its 95% confidence interval, and optimal cut-off values were determined with the Youden index, together with the corresponding sensitivity and specificity.

Results

Seventy-nine patients were studied, 53 with CH and 26 with PBC; their baseline characteristics are shown in Table 1. The groups did not differ in age; as expected, the PBC group was predominantly female ($p = 0.011$).

Table 1
Baseline demographic, biochemical, hematological and metabolic characteristics of study population stratified by aetiology

Parameter	Chronic viral hepatitis (n = 53)	Primary biliary cholangitis (n = 26)	p
Age (years)	61.0 [54.0–66.0]	60.0 [52.2–65.5]	0.653
MRE stiffness (kPa)	3.9 [3.1–4.9]	3.7 [2.9–4.4]	0.491
AST (U/L)	32.0 [24.0–45.0]	34.5 [25.2–53.0]	0.381
ALT (U/L)	30.0 [18.0–42.0]	29.5 [21.2–54.8]	0.605
ALP (U/L)	79.0 [65.0–98.0]	123.5 [101.8–194.2]	< 0.001
GGT (U/L)	38.0 [18.0–65.0]	50.5 [22.2–83.2]	0.238
Total bilirubin (mg/dL)	0.7 [0.4–1.0]	0.9 [0.5–1.1]	0.287
Direct bilirubin (mg/dL)	0.3 [0.2–0.4]	0.4 [0.3–0.6]	0.285
Indirect bilirubin (mg/dL)	0.4 [0.2–0.6]	0.4 [0.3–0.6]	0.979
Albumin (g/dL)	4.4 [3.9–4.6]	4.2 [3.7–4.5]	0.304
INR	1.1 [1.0–1.2]	1.0 [0.9–1.1]	0.003
WBC (×10³/μL)	6.1 [4.3–7.3]	5.1 [3.9–6.6]	0.114
Neutrophils (×10³/μL)	3.3 [2.6–4.1]	2.6 [2.1–3.6]	0.077
Lymphocytes (×10³/μL)	1.5 [1.1–2.3]	1.4 [0.9–2.2]	0.669
Platelets (×10³/μL)	163.7 ± 73.7	208.3 ± 103.6	0.057
NLR	2.0 [1.4–2.8]	1.8 [1.2–2.5]	0.164
PLR	96.8 [65.4–124.1]	121.3 [83.4–167.2]	0.054
SII	298.3 [179.0–466.2]	332.9 [221.1–457.9]	0.774
Total cholesterol (mg/dL)	161.7 ± 45.6	194.7 ± 53.6	0.006
LDL (mg/dL)	95.3 ± 34.3	112.9 ± 43.1	0.054
HDL (mg/dL)	51.5 [38.8–60.2]	59.0 [49.2–70.8]	0.029
VLDL (mg/dL)	17.0 [12.0–22.0]	17.5 [16.0–26.8]	0.166
Creatinine (mg/dL)	0.9 [0.7–1.0]	0.6 [0.6–0.8]	0.001
eGFR	92.0 [73.0–100.0]	100.5 [82.0–107.8]	0.059
Sodium (mEq/L)	139.7 ± 3.2	140.2 ± 1.9	0.378
FIB-4	1.9 [1.3–5.1]	2.0 [1.2–3.7]	0.598

Parameter	Chronic viral hepatitis (n = 53)	Primary biliary cholangitis (n = 26)	p
APRI	0.5 [0.3–1.1]	0.5 [0.3–0.8]	0.766
AST/ALT ratio	1.1 [0.9–1.5]	1.2 [1.0–1.3]	0.719
MELD	8.0 [7.0–10.0]	7.0 [6.0–8.8]	0.090
MELD 3.0	7.0 [7.0–10.0]	7.0 [7.0–8.0]	0.491
Female sex, n (%)	21 (39.6)	19 (73.1)	0.011
Fibrosis stage, n (%)			0.927
F0 (< 3.0 kPa)	12 (22.6)	8 (30.8)	
F1 (3.0–3.5 kPa)	8 (15.1)	3 (11.5)	
F2 (3.5–4.0 kPa)	8 (15.1)	4 (15.4)	
F3 (4.0–5.0 kPa)	14 (26.4)	7 (26.9)	
F4 (≥ 5.0 kPa)	11 (20.8)	4 (15.4)	
Significant fibrosis (≥ F2), n (%)	33 (62.3)	15 (57.7)	0.884
Advanced fibrosis (≥ F3), n (%)	25 (47.2)	11 (42.3)	0.867
Cirrhosis (F4), n (%)	11 (20.8)	4 (15.4)	0.762

ALP, alkaline phosphatase; ALT, alanine aminotransferase; APRI, AST-to-platelet ratio index; AST, aspartate aminotransferase; eGFR, estimated glomerular filtration rate; GGT, gamma-glutamyl transferase; HDL, high-density lipoprotein; INR, international normalised ratio; LDL, low-density lipoprotein; MELD, Model for End-Stage Liver Disease; MRE, magnetic resonance elastography; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; VLDL, very-low-density lipoprotein; WBC, white blood cell count.

Liver stiffness did not differ between the two groups ($p = 0.49$), nor did the distribution of fibrosis stages or the proportion of patients with advanced fibrosis ($p = 0.86$). Because the fibrosis burden was comparable, any difference in the laboratory correlates of stiffness could not be attributed to a difference in disease severity.

Transaminases were similar in the two groups, as were GGT, all three bilirubin fractions and albumin. Alkaline phosphatase separated the groups clearly, being markedly higher in PBC ($p < 0.001$), whereas INR was higher in CH ($p = 0.003$). The neutrophil count was slightly higher in CH but the difference was not significant ($p = 0.077$); the white cell count, lymphocyte count, platelet count and the NLR itself also did not differ. The two cohorts therefore entered the correlation analysis with a comparable degree of systemic inflammation.

Compared with the CH group, patients with PBC had significantly higher total cholesterol (p = 0.006) and HDL cholesterol (p = 0.029), with a similar trend for LDL cholesterol (p = 0.054), whereas VLDL cholesterol did not differ significantly. Creatinine was significantly lower in the PBC group (p = 0.001). None of the prognostic indices differed between the groups.

Correlations were examined separately in each group. A significant positive correlation between liver stiffness and the NLR was observed in the CH group (r = 0.35, p = 0.011) but not in the PBC group (r = 0.12, p = 0.55); the between-group difference was not statistically significant (Fisher r-to-z, p = 0.22). Figure 1 shows representative examples of the MRE and NLR values obtained in our cases. Among the prognostic indices, the MELD score gave the strongest correlation with stiffness in the CH cohort (r = 0.48, p < 0.001).

In CH, univariate analysis showed liver stiffness to be associated with age, AST, the NLR, platelet count, alkaline phosphatase, LDL cholesterol and albumin, but not with total bilirubin, ALT or MELD 3.0. Only age and AST remained significant on multivariate analysis (Table 2). The NLR lost significance once AST was included in the model, suggesting that the two carry overlapping information about hepatic inflammation.

Table 2
Univariate and multivariable linear regression analysis of the determinants of liver stiffness in chronic viral hepatitis (n = 53)

Variable	**β**	**95% CI**	**p**	**β**	**95% CI**	**p**
Age	0.055	0.015 to 0.094	0.007	0.053	0.019 to 0.087	0.003
AST	0.038	0.019 to 0.056	< 0.001	0.037	0.020 to 0.054	< 0.001
ALT	0.014	-0.005 to 0.034	0.152			
ALP	0.008	0.002 to 0.014	0.014			
GGT	0.006	-0.002 to 0.014	0.167			
Total bilirubin	0.553	-0.063 to 1.168	0.077			
Albumin	-0.822	-1.583 to -0.061	0.035			
Platelet count	-0.008	-0.013 to -0.003	0.002			
NLR	0.247	0.060 to 0.434	0.011			
LDL	-0.014	-0.025 to -0.002	0.019			
MELD 3.0	0.076	-0.047 to 0.198	0.219			

Columns 2–4 give the univariate estimates and columns 5–7 the multivariable estimates. CI, confidence interval; other abbreviations as in Table 1.

In PBC, stiffness was associated on univariate analysis with AST, ALT, total bilirubin, MELD 3.0 and albumin. Alkaline phosphatase, despite being the abnormality that defines the disease, reached only borderline significance, and age, LDL cholesterol and the NLR showed no association at all. AST was the only variable to survive multivariate analysis (Table 3).

Table 3
Univariate and multivariable linear regression analysis of the determinants of liver stiffness in primary biliary cholangitis (n = 26)

Variable	β	95% CI	p	β	95% CI	p
Age	-0.079	-0.167 to 0.010	0.080			
AST	0.056	0.044 to 0.067	< 0.001	0.056	0.044 to 0.067	< 0.001
ALT	0.056	0.036 to 0.076	< 0.001			
ALP	0.005	-0.000 to 0.011	0.053			
GGT	0.010	-0.000 to 0.021	0.051			
Total bilirubin	1.509	1.141 to 1.876	< 0.001			
Albumin	-1.585	-3.048 to -0.123	0.035			
Platelet count	-0.008	-0.017 to 0.001	0.065			
NLR	0.261	-0.633 to 1.155	0.552			
LDL	0.018	-0.004 to 0.040	0.104			
MELD 3.0	0.410	0.117 to 0.703	0.008			

Columns 2–4 give the univariate estimates and columns 5–7 the multivariable estimates. CI, confidence interval; other abbreviations as in Table 1.

With both groups combined, ROC analysis showed that platelet count (AUC = 0.85, 95% CI 0.76–0.93) and liver stiffness (AUC = 0.73, 95% CI 0.62–0.85) were both significant predictors of a MELD score above 9, with no significant difference between them (p = 0.11; Fig. 2). At its optimal cut-off of 3.53 kPa, liver stiffness had a sensitivity of 95% and a negative predictive value of 97%, but a specificity of only 50%. These ROC results are presented in Table 4.

Table 4
Receiver operating characteristic analysis of platelet count and MR elastography liver stiffness for the prediction of a MELD score above 9

Predictor	AUC	95% CI	p	Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Whole cohort (n = 79)									
Platelet count	0.846	0.760–0.932	< 0.001	152	89	77	55	96	80
MRE stiffness	0.733	0.615–0.851	< 0.001	3.53	95	50	38	97	61
Chronic viral hepatitis (n = 53)									
Platelet count	0.810	0.690–0.929	< 0.001	152	86	77	57	94	79
MRE stiffness	0.705	0.562–0.848	0.005	3.53	100	51	42	100	64
Primary biliary cholangitis (n = 26)									
Platelet count	0.905	0.783–1.000	< 0.001	147	100	81	56	100	85
MRE stiffness	0.800	0.555–1.000	0.016	4.26	80	71	40	94	73

AUC, area under the curve; CI, confidence interval; MELD, Model for End-Stage Liver Disease; MRE, magnetic resonance elastography; NPV, negative predictive value; PPV, positive predictive value.

Discussion

To our knowledge, this is one of the few studies to compare how MRE-derived liver stiffness relates to prognostic indices, systemic inflammation, hepatocellular function and cholestatic biomarkers across chronic liver diseases with distinct underlying mechanisms. Two findings stand out. First, liver stiffness correlated with the NLR in the CH group but not in the PBC group. Second, the laboratory parameters associated with stiffness differed by aetiology. Together these results indicate that MRE reflects more than fibrosis, and that what it reflects is not the same in hepatocellular and cholestatic disease.

Unlike hepatocellular CLD, the increased liver stiffness seen in PBC cannot be attributed to fibrosis alone. PBC is characterised by chronic immune-mediated destruction of the small intrahepatic bile ducts, resulting in persistent cholestasis, ductular reaction and progressive extracellular matrix remodelling. Dysregulated

matrix metalloproteinases (MMPs), particularly MMP-7, together with altered tissue inhibitors of metalloproteinases, may contribute to fibrogenesis and increased stiffness in PBC. Circulating MMP-7 levels correlate closely with liver stiffness measured by point shear-wave elastography in early-stage PBC, suggesting that matrix remodelling, rather than systemic inflammatory activity, is a major determinant of increased stiffness in this disease.[12]

Ultrasound-based elastography not only stages liver fibrosis accurately but also provides clinically meaningful prognostic information in PBC.[13] It does, however, have inherent limitations, including sampling of only a small portion of the liver and a lower technical success rate than MRE.[2–4] Osman et al. [11] found that MRE-derived liver stiffness independently predicts histological fibrosis, clinical decompensation and long-term mortality in PBC, and that it did so regardless of the biochemical response to ursodeoxycholic acid (UDCA) or the baseline GLOBE score. This points to stiffness on MRE tracking fibrogenesis itself rather than cholestatic inflammation, and argues for its use in routine risk stratification. [11]

One clear difference was that liver stiffness correlated with the NLR in CH but showed no such association in PBC. In CH, persistent virus-induced inflammation drives hepatic fibrogenesis through activation of inflammatory pathways, which makes the NLR a plausible surrogate for disease activity and fibrosis. In PBC, by contrast, fibrosis arises mainly from chronic autoimmune-mediated bile duct injury and cholestasis rather than from systemic inflammation.[14, 15] Widespread UDCA use may further dampen systemic inflammation and weaken any link between the NLR and stiffness. The value of the NLR as a fibrosis marker therefore appears to depend on the disease and should be read in light of the underlying aetiology.

This disease-dependent behaviour may help explain why the relationship between the NLR and fibrosis progression in CH is still debated. Kalra et al. linked an elevated NLR to advanced cirrhosis in mixed-aetiology cohorts,[16] and Gong et al. reported a positive association and validated the NLR as an independent predictor of mortality in HBV-infected individuals.[17] Other studies, however, describe a negative correlation between the NLR and liver fibrosis scores in chronic hepatitis B.[7, 18, 19] With the published results in conflict and data on PBC still scarce, direct comparisons between diseases are needed, particularly as outcomes differ widely across CLD types.

The studies cited above assessed fibrosis histologically by biopsy or relied on clinical background data. Few have looked directly at stiffness measured by MRE, which samples a far larger volume of liver with high sensitivity and specificity. This difference in method may be why our results diverge from the earlier reports, as MRE is likely to capture the fibrosis burden in CH more faithfully than biopsy-based staging.

Compared with CH, patients with PBC had significantly higher alkaline phosphatase and a more pronounced cholestatic lipid profile, with significantly higher total and HDL cholesterol and a similar trend for LDL, whereas VLDL cholesterol was comparable. Similar biochemical features have been consistently reported in current clinical practice guidelines for PBC.[14, 20] The lower creatinine in PBC may reflect differences in muscle mass or nutritional status rather than impaired renal function and should be interpreted with caution.

A strong positive correlation was found between MRE liver stiffness and the MELD score ($r = 0.48$, $p < 0.001$). Both predict disease severity and prognosis, but they capture different things: stiffness mainly reflects fibrosis, whereas the MELD score reflects hepatic synthetic function and renal function. In CH, the shift from compensated to decompensated disease brings a marked rise in portal pressure and functional impairment, which shows up in MELD components such as bilirubin and INR; timely antiviral treatment lowers MELD scores over time in these patients.[21] That stiffness correlated more closely with MELD than with any other index fits the idea that high parenchymal stiffness on MRE accompanies the haemodynamic and metabolic changes of late-stage viral liver disease, and that it might be used to monitor the risk of decompensation.

In CH, liver stiffness was associated with several biochemical and inflammatory parameters on univariate analysis, but only age and AST remained independent after multivariable adjustment. Once AST was in the model the NLR lost significance, which suggests that its link with stiffness mostly reflects hepatic inflammatory activity (captured by AST) rather than an independent effect on fibrosis. In PBC, stiffness was associated with markers of liver injury and disease severity on univariate analysis, yet AST was again the only independent predictor. That the NLR showed no independent association fits the view that fibrosis in PBC is driven mainly by cholestatic and immune-mediated biliary injury rather than by systemic inflammation.[14]

ROC analysis showed that liver stiffness performed much like platelet count in identifying patients with a MELD score above 9. Its specificity was only moderate, but its high sensitivity and excellent negative predictive value make it most useful for ruling out advanced disease: patients with values below the proposed cut-off (< 3.53 kPa) are unlikely to have clinically significant hepatic dysfunction, as reflected by a MELD score above 9. Liver stiffness may therefore work well as a simple, non-invasive screen that adds to, rather than replaces, conventional laboratory-based prognostic markers.

This study has several limitations. It was retrospective and single-centre. Stiffness was measured by a single reader, so inter-observer agreement was not assessed. The PBC group was relatively small, which limits statistical power. Antiviral and UDCA treatment status, viral load and disease duration were not available and may have influenced both the inflammatory markers and stiffness.

In conclusion, CH and PBC have distinct biochemical and inflammatory profiles, and these are reflected in different determinants of liver stiffness. Stiffness in CH was associated with systemic inflammatory markers, whereas in PBC it was not, which points to different mechanisms of fibrosis in viral and cholestatic disease. In both cohorts AST was the only independent predictor of stiffness, in keeping with the close link between hepatocellular injury and fibrosis. Stiffness also had high sensitivity and an excellent negative predictive value for a MELD score above 9, so it may help to exclude advanced liver dysfunction. Overall, liver stiffness should be interpreted in light of the underlying aetiology rather than against a single uniform threshold.

Declarations

Competing interests:

The authors have no relevant financial or non-financial interests to disclose.

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Author Contribution

İrem Gürcan Eriş: Conceptualization, Investigation, Formal analysis, Writing – original draft. Emre Atak: Data curation, Investigation Diğdem Kuru Öz: Supervision, Validation, Writing – review and editing.Ayşe Erden: Conceptualization, Supervision, Validation, Writing – review and editing.

Data availability:

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

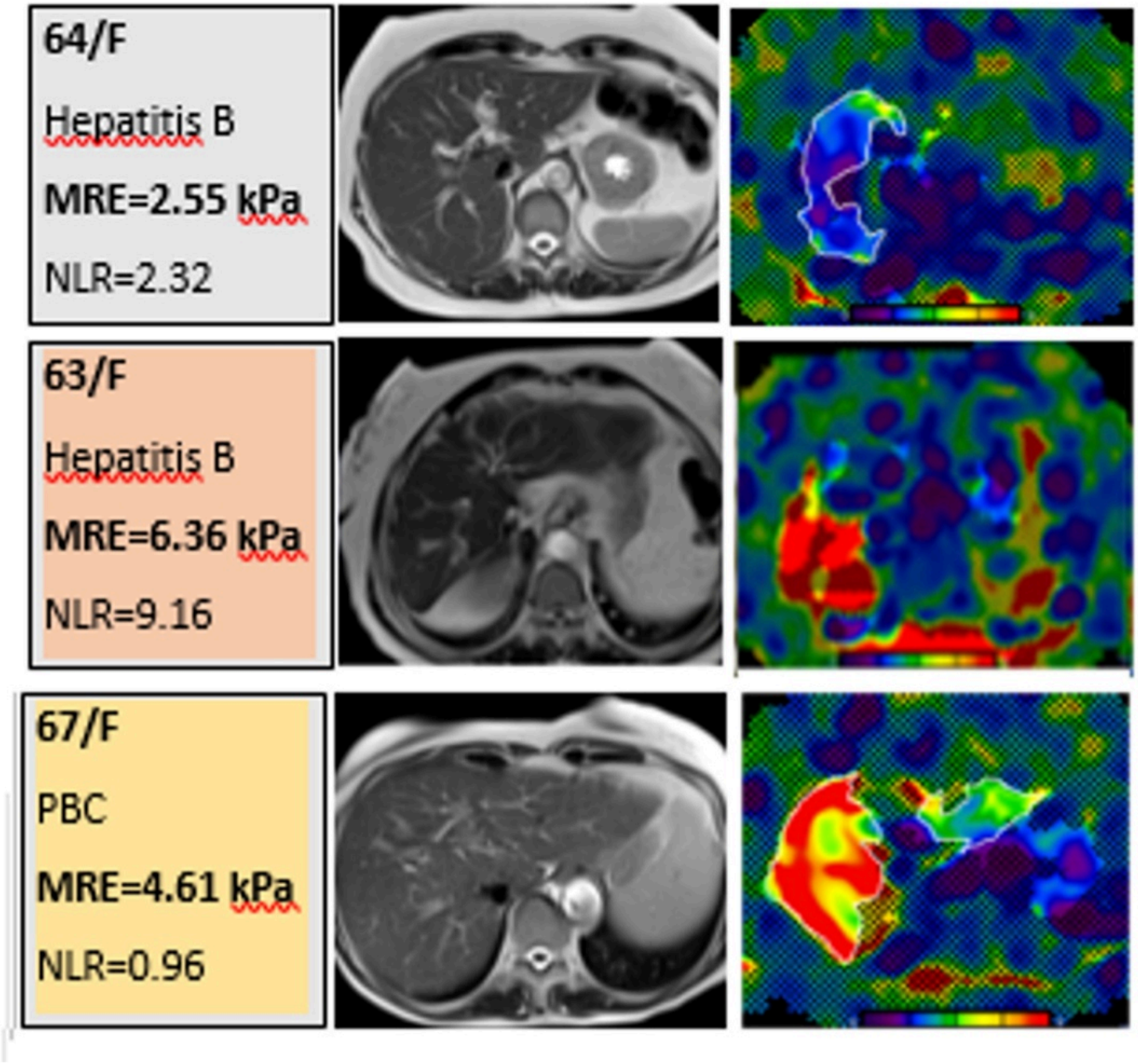


Figure 1

Representative cases from our study cohort. Examples of T2-weighted images (middle column) and MRE confidence maps (right column) illustrating patients with chronic hepatitis B and PBC, along with their liver stiffness and NLR values

Top row: A patient with chronic hepatitis B demonstrating normal liver parenchymal stiffness on MRE and a NLR within the normal range.

Middle row: A patient with chronic hepatitis B showing increased liver stiffness on MRE. At the time of MRE examination, the patient also had an elevated NLR.

Bottom row: A patient with PBC demonstrating increased liver stiffness on MRE, while the NLR remained within normal limits.

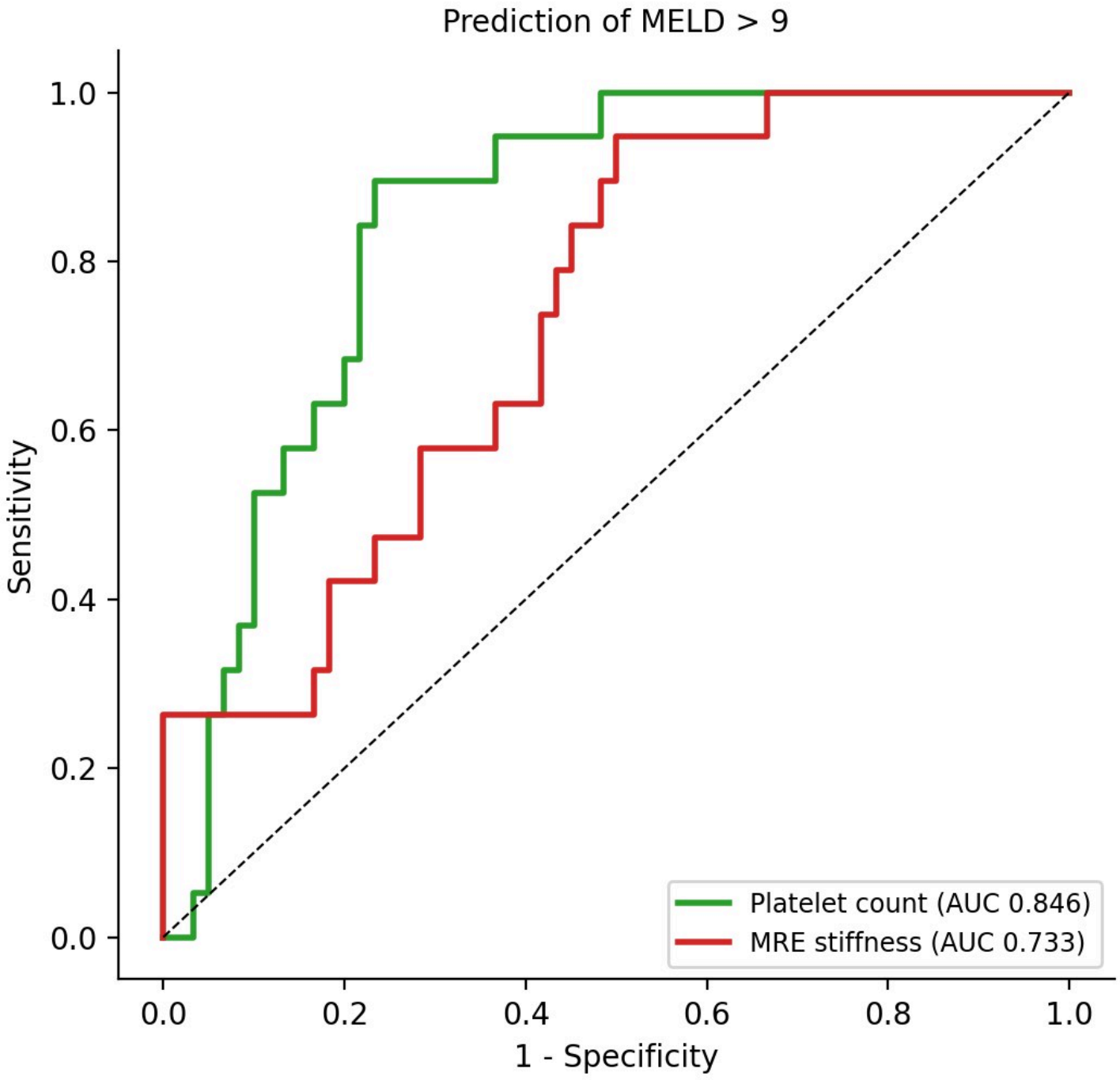


Figure 2

ROC analysis demonstrated that platelet count (AUC = 0.85) and liver stiffness (AUC = 0.73) were both significant predictors of a MELD score above 9, with no significant difference between them.