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Original Article

Albumin ratio and liver-to-abdominal area ratio are promising prognostic indicators for patients with post-hepatitis B cirrhosis

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Abstract: Objective: To evaluate the clinical relevance of the Albumin Ratio (AR) and Liver-to-Abdominal Area Ratio (LAAR) as prognostic markers for patients with hepatitis B-related cirrhosis. Methods: A retrospective cohort study was conducted on 278 patients diagnosed with hepatitis B-associated cirrhosis at Baoji Central Hospital from January 2017 to December 2020. Clinical data, laboratory results (AR), and imaging data (LAAR) were collected. Prognostic value of AR and LAAR was assessed using Kaplan-Meier survival analysis, Cox proportional hazards regression, and receiver operating characteristic (ROC) curves. A nomogram integrating multiple variables was developed and validated to dynamically predict 6-, 12-, and 24-month survival outcomes. Results: Both AR and LAAR were significantly reduced in the deceased group compared to survivors ($P<0.05$). Cox regression analysis identified AR (HR=1.86, 95% CI: 1.40-2.45, $P<0.001$) and LAAR (HR=1.67, 95% CI: 1.25-2.22, $P=0.002$) as independent prognostic factors. Kaplan-Meier survival curves revealed significantly shorter survival in patients with lower AR and LAAR ($P<0.001$). Time-dependent ROC analysis indicated good predictive performance for AR (AUC up to 0.85), while LAAR showed relatively low discrimination, with AUCs ranging from 0.507 to 0.623. The nomogram, incorporating both AR and LAAR, exhibited excellent discrimination (C-index =0.950), and its predictive accuracy was validated through calibration curves. Conclusion: AR and LAAR are critical prognostic indicators in hepatitis B-related cirrhosis. The nomogram model, integrating these values, supports tailored treatment plans and monitoring strategies in clinical settings. Patients with lower AR and LAAR have poorer survival outcomes, and the model's robust predictive capacity has been validated, enhancing precision in patient management and supporting individualized therapeutic decisions.

Keywords: Hepatitis B, cirrhosis, prognosis, albumin ratio, liver-to-abdominal area ratio, nomogram

Introduction

Hepatitis B virus (HBV) infection remains a major global health challenge, contributing significantly to morbidity and mortality [1]. The World Health Organization reported in 2019 that approximately 296 million individuals were living with HBV, yet only 30.4 million were aware of their condition, and a mere 6.6 million received antiviral treatment. HBV-related complications, primarily cirrhosis and hepatocellular carcinoma (HCC), account for around 820,000 deaths annually [2]. In China, where HBV prevalence is among the highest globally (with an HBsAg prevalence of 5%-6%), an estimated 70 million people are chronic HBV carriers, with 20-30 million diagnosed with chronic hepatitis B (CHB) [3]. Cirrhosis, a critical consequence of HBV, worsens patients' survival and quality of life, posing a substantial challenge in liver disease management [4].

Globally, cirrhosis ranks as the 11th leading cause of death and the third most common cause of mortality in individuals aged 45-64, together with HCC, accounting for roughly 3.5% of all deaths worldwide [5]. Despite progress in antiviral therapies and HBV vaccination, which have reduced age-standardized mortality rates, the absolute number of cirrhosis-related deaths continues to rise [6]. The increasing prevalence of decompensated cirrhosis further intensifies the global healthcare burden [7]. Cirrhosis arises from multiple etiologies, including HBV, hepatitis C virus (HCV), alcoholic liver disease, and nonalcoholic fatty liver disease (NAFLD) [8]. In

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most Asian countries (except Japan), HBV remains the predominant cause of cirrhosis. Traditional prognostic tools, such as the Model for End-Stage Liver Disease (MELD) score [9] and Child-Pugh classification [10], rely on liver function tests, coagulation values, and complications to stratify patient outcomes. However, these models have limitations: they focus on a narrow set of variables, fail to provide dynamic survival predictions over time, and lack precision in individualized risk assessment [11, 12]. Recent advances in data analytics have highlighted novel biomarkers and advanced scoring systems for cirrhosis prognosis. Inflammation-based markers, such as the neutrophil-to-lymphocyte ratio (NAR) [13], and imaging-derived metrics, like the liver-to-abdominal area ratio (LAAR) [14], have emerged as valuable predictors of long-term outcomes. However, these indicators are often studied in isolation, with limited efforts to incorporate them into comprehensive predictive frameworks.

This study seeks to address these gaps by integrating clinical variables and novel biomarkers using Least Absolute Shrinkage and Selection Operator (LASSO) regression and Cox regression. We developed a dynamic nomogram for predicting 6-, 12-, and 24-month mortality in patients with post-hepatitis B cirrhosis. Unlike static models, this nomogram provides time-dependent, individualized risk assessments, thereby improving the identification of high-risk patients. Key innovations include: combining established indicators with novel biomarkers to form a multidimensional predictive model; validating its accuracy and discrimination using time-dependent receiver operating characteristic (ROC) curves and calibration plots; and developing an intuitive, dynamic nomogram to support clinicians optimizing patient care and resource allocation.

Materials and Methods

Study design

This retrospective cohort study evaluated the effect of clinical and laboratory data on the survival of patients with post-hepatitis B cirrhosis. It included patients treated between January 2017 and December 2020. This study was approved by the Baoji Central Hospital Ethics Committee.

Study population

Inclusion criteria: 1) Diagnosis of hepatitis B cirrhosis according to the *Guidelines for Prevention and Treatment of Chronic Hepatitis B* (2022 Edition) [15] and the *Guidelines for Diagnosis and Treatment of Cirrhosis* [16]; 2) Confirmed HBV infection with either compensated or decompensated cirrhosis. Decompensated cirrhosis was defined by complications such as portal hypertension (e.g., ascites, esophageal and gastric variceal bleeding, hepatic encephalopathy, or hepatorenal syndrome), or liver function deterioration; 3) Availability of complete laboratory results (e.g., blood count, coagulation tests, and biochemistry) and abdominal imaging findings (e.g., CT).

Exclusion criteria: 1) Patients with liver diseases from other etiologies (e.g., alcoholic liver disease, NAFLD, autoimmune liver disease, or other viral hepatitis); 2) Negative hepatitis B surface antigen (HBsAg); 3) Coexisting liver cancer or other malignancies; 4) Acute cardiovascular events or severe renal impairment; 5) Concurrent hematologic disorders; 6) A history of chronic alcohol abuse; 7) Incomplete data (e.g., missing imaging results or insufficient follow-up), or duplicate records from readmissions during the study period.

Data collection

Clinical data: Demographic information, including age, sex, and body mass index (BMI), was collected. Clinical diagnoses, including cirrhosis staging and associated complications, were recorded. Imaging results from abdominal CT scans (e.g., liver and abdominal area measurements) and key clinical interventions during treatment were also documented.

Laboratory data: Laboratory testing followed standardized protocols. Samples were collected upon admission and analyzed by trained technicians in the hospital's laboratory.

(1) Liver Function and Enzymology: Values such as albumin (ALB), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and renal function indices (serum creatinine and urea nitrogen) were measured using a Beckman AU5800 automatic biochemical analyzer (Beckman Coulter, USA). (2) Hematology Indices: White blood cell count and neutrophil levels were measured using a Sysmex XE-2100 automated hematology analyzer (Sysmex

Corporation, Japan). (3) Coagulation Function Parameters: The international normalized ratio (INR) was determined using a Stago STA-R Evolution automated coagulation analyzer (Stago Diagnostics, France). (4) Imaging Indices: Liver area and abdominal area were quantified from abdominal CT scans using specialized imaging analysis software.

Follow-up

Follow-up began at the time of diagnosis during hospital admission. Patients were monitored for a minimum of 2 years, from January 2017 to December 2020, until death or the study endpoint (December 31, 2022). The primary endpoint was patient mortality, with detailed records of follow-up duration and survival status. Data for patients lost to follow-up were supplemented by telephone interviews, electronic medical records, and hospitalization logs to ensure comprehensive and accurate data collection.

Outcome measures

Primary outcomes: The study focused on evaluating survival and developing a dynamic nomogram for prognostic prediction. Kaplan-Meier survival analysis was employed to assess differences in survival times based on variables like INR, NAR, BAR, LAAR, MELD score, and Child-Pugh classification. Cox proportional hazards regression was employed to identify independent factors influencing mortality risk. A nomogram, built using variables selected by LASSO and Cox regression, was designed to predict survival probabilities at 6, 12, and 24 months. The model's accuracy and discriminative ability were evaluated through time-dependent ROC curves (AUC values), calibration plots, and the concordance index (C-index), ensuring robust validation of its predictive performance.

Secondary outcomes: Baseline characteristic comparisons were conducted to identify differences between the deceased and surviving groups in terms of age, gender, BMI, ALB, ALT, INR, NAR, BAR, and LAAR. Correlation analysis was performed to explore the relationship between laboratory indices, ratios, and patient prognosis. Time-dependent predictive performance of independent prognostic variables was evaluated at 6, 12, and 24 months using AUC values to identify the best predictors. Individualized survival predictions were made for typical patients using the dynamic nomogram model to assess its clinical applicability.

Statistical analysis

Categorical variables were expressed as percentages (%), and continuous variables were expressed as the mean ± standard deviation (SD) for normally distributed data or as the median (interquartile range) for non-normally distributed data. SPSS 26.0 was used for basic statistical analyses, including Kolmogorov-Smirnov (K-S) tests, independent sample t-tests, rank-sum tests, and chi-square tests. R 4.3.3 was used for advanced analyses, including LASSO-Cox regression, Kaplan-Meier (K-M) survival analysis, Cox proportional hazards regression, time-dependent ROC curve analysis, nomogram construction, and C-index calculations. The R packages "rms" and "timeROC" were employed for nomogram modeling and time-dependent analysis.

Results

Baseline characteristics analysis

Baseline characteristics showed significant differences between the deceased and surviving groups across several indicators (**Table 1**). Among general demographic characteristics, age differed significantly between the two groups (P=0.002), while gender did not show a significant difference (P=0.162). No significant differences were observed for BMI (P=0.507), history of diabetes (P=0.480), and history of hypertension (P=0.657). Although drinking history (P=0.118) and smoking history (P=0.091) approached statistical significance, they did not reach a significant level. Among disease-related indicators, splenomegaly was more prevalent in the deceased group (P=0.044), while ascites (P=0.063) and hepatic encephalopathy (P=0.485) did not show significant differences. In scoring systems, both the MELD score and Child-Pugh classification were significantly higher in the deceased group compared to the surviving group (both P<0.001), indicating more severe liver dysfunction in non-survivors.

Differences in laboratory indicators and liver area-related ratios between groups

The analysis of laboratory indicators and liver area-related ratios showed significant differences between the two groups (**Table 2**). ALB was significantly *lower* in the deceased group compared to the surviving group (*P*<0.001), while

Table 1. Comparison of baseline characteristics between death and survival groups

Variable	Total	Death Group (n=43)	Survival Group (n=235)	Statistic	*P*-value
Age					
≥55 years	93	23	70	9.172	0.002
<55 years	185	20	165		
Gender					
Male	202	35	167	1.953	0.162
Female	76	8	68		
BMI					
≥23 kg/m^2	103	14	89	0.44	0.507
<23 kg/m^2	175	29	146		
History of Diabetes					
Yes	35	4	31	0.5	0.48
No	243	39	204		
History of Hypertension					
Yes	52	7	45	0.197	0.657
No	226	36	190		
History of Alcohol Consumption					
Yes	94	19	75	2.446	0.118
No	184	24	160		
History of Smoking					
Yes	211	37	174	2.863	0.091
No	67	6	61		
Family History					
Yes	103	14	89	0.44	0.507
No	175	29	146		
Enlarged Spleen					0.044
Yes	155	30	125	4.049	
No	123	13	110		
Ascites					0.063
Yes	107	22	85	3.451	
No	171	21	150		
Hepatic Encephalopathy					0.485
Yes	70	9	61	0.488	
No	208	34	174		
MELD Score	11.00 [8.00, 13.00]	15.00 [12.50, 18.00]	10.00 [8.00, 12.00]	8.257	<0.001
Child-Pugh Classification	8.00 [6.00, 9.00]	10.00 [9.00, 12.00]	7.00 [6.00, 8.00]	8.484	<0.001

Note: BMI: Body Mass Index, MELD: Model for End-Stage Liver Disease.

INR was significantly *higher* (*P*<0.001). Other laboratory indicators, including ALT (*P*=0.173), AST (*P*=0.550), WBC count (*P*=0.806), neutrophils (*P*=0.369), GGT (*P*=0.430), creatinine (*P*=0.213), urea nitrogen (*P*=0.839), and D-dimer (*P*=0.125), did not show significant differences. Among liver area-related ratios, NAR (*P*=0.014), PTAR (*P*<0.001), DAR (*P*=0.003), and BAR (*P*=0.023) was significantly *higher*, while LAAR (*P*=0.027) was significantly *lower* in the deceased group. No significant differences were observed in liver area (*P*=0.113), abdominal area (*P*=0.084), or GAR (*P*=0.435) between the two groups.

Application of LASSO regression model in prognostic indicator selection

LASSO regression analysis was employed to identify prognostic indicators in patients with post-hepatitis B cirrhosis (**Figure 1**). Using 10-fold cross-validation and a seed number of 2022, the optimal penalty parameter (λ=0.022-255) was determined. At this λ value, the partial likelihood deviance was minimized, and 8 non-zero coefficient variables were selected. In contrast, at a larger λ value (λ=0.074591), only 4 non-zero coefficient variables were identified, but the partial likelihood deviance increased,

Table 2. Comparison of laboratory indicators and liver area-related ratios between death and survival groups

Variable	Total	Death Group (n=43)	Survival Group (n=235)	Statistic	*P*-value
ALB (g/dL)	3.16 ± 0.70	2.72 ± 0.71	3.24 ± 0.67	4.614	<0.001
ALT (U/L)	26.32 [14.38, 38.33]	27.63 [16.21, 52.31]	25.79 [14.16, 37.38]	1.363	0.173
AST (U/L)	39.05 [24.74, 51.65]	41.84 [21.04, 61.08]	38.59 [25.08, 50.98]	0.598	0.55
White Blood Cell Count ($\times 10^9$/L)	4.25 [2.46, 6.57]	4.17 [2.56, 6.49]	4.26 [2.42, 6.56]	0.246	0.806
Neutrophils	2.24 [1.20, 3.27]	2.39 [1.62, 3.45]	2.23 [1.19, 3.21]	0.897	0.369
Gamma-Glutamyl Transferase (U/L)	32.08 ± 10.55	33.25 ± 13.64	31.86 ± 9.90	-0.79	0.43
Serum Creatinine (mmol/L)	73.23 ± 13.29	75.55 ± 17.30	72.80 ± 12.42	-1.248	0.213
Blood Urea Nitrogen (mmol/L)	5.01 ± 1.58	5.05 ± 1.71	5.00 ± 1.56	-0.203	0.839
International Normalized Ratio (INR)	1.27 ± 0.27	1.42 ± 0.25	1.24 ± 0.27	-3.951	<0.001
D-Dimer	1.54 [0.86, 2.41]	1.76 [1.39, 2.35]	1.44 [0.76, 2.41]	1.534	0.125
Liver Area (1000 mm^2)	14.97 [12.98, 17.12]	14.38 [12.64, 16.84]	14.99 [13.02, 17.18]	1.584	0.113
Abdominal Cavity Area (1000 mm^2)	39.05 ± 4.85	40.23 ± 4.72	38.83 ± 4.85	-1.736	0.084
NAR	0.73 [0.38, 1.02]	0.92 [0.61, 1.27]	0.71 [0.36, 0.97]	2.454	0.014
PTAR	0.39 [0.32, 0.50]	0.50 [0.43, 0.62]	0.38 [0.32, 0.47]	5.386	<0.001
DAR	0.51 [0.26, 0.80]	0.72 [0.56, 0.92]	0.45 [0.24, 0.79]	2.979	0.003
BAR	1.56 [1.20, 2.04]	1.88 [1.24, 2.68]	1.53 [1.19, 2.02]	2.265	0.023
GAR	12.28 ± 5.86	12.93 ± 6.46	12.17 ± 5.75	-0.782	0.435
LAAR	0.37 [0.35, 0.39]	0.33 [0.29, 0.46]	0.37 [0.36, 0.38]	2.205	0.027

Note: ALB: Albumin, ALT: Alanine Aminotransferase, AST: Aspartate Aminotransferase, NAR: Neutrophil-to-Albumin Ratio, PTAR: Platelet-to-Albumin Ratio, DAR: D-Dimer-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, GAR: Gamma-Glutamyl Transferase-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio.

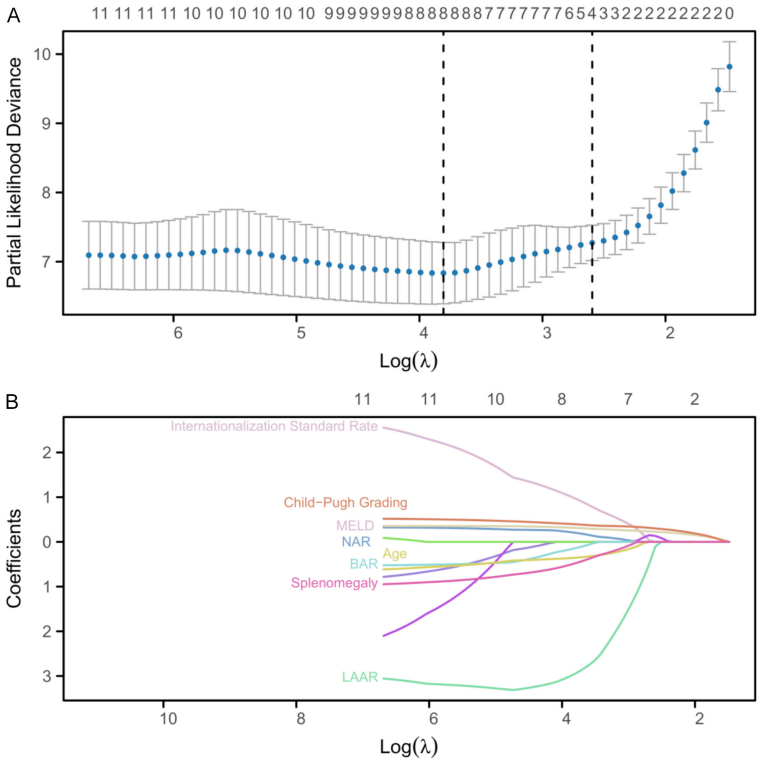

Figure 1. Selection of penalty parameter λ and variable regularization path in the LASSO regression model. A. Relationship between penalty parameter λ and partial likelihood deviance. B. Regularization path of LASSO regression. The x-axis represents log(λ), and the y-axis represents the regression coefficients of variables. Note: LASSO: Least Absolute Shrinkage and Selection Operator, MELD: Model for End-Stage Liver Disease, NAR: Neutrophil-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio.

indicating that the smaller λ value provided a more comprehensive set of predictive variables. Therefore, λ=0.022255 was chosen as the final penalty parameter. The 8 selected variables included INR (coefficient =0.9739), NAR (coefficient =0.2050), BAR (coefficient =0.1430), LAAR (coefficient =-2.9485), MELD (coefficient =0.3133), Child-Pugh classification (coefficient =0.3951), age (coefficient =0.3544), and splenomegaly (coefficient =0.4802). Other variables, such as ALB, PTAR, and DAR, were excluded from the model with coefficients of 0.

Kaplan-Meier survival curve analysis of prognostic variables

Kaplan-Meier survival curve analysis was performed on the 8 prognostic variables identified by LASSO regression (**Figure 2**). Results revealed significant survival differences for all variables. INR (P< 0.001), NAR (P<0.001), BAR

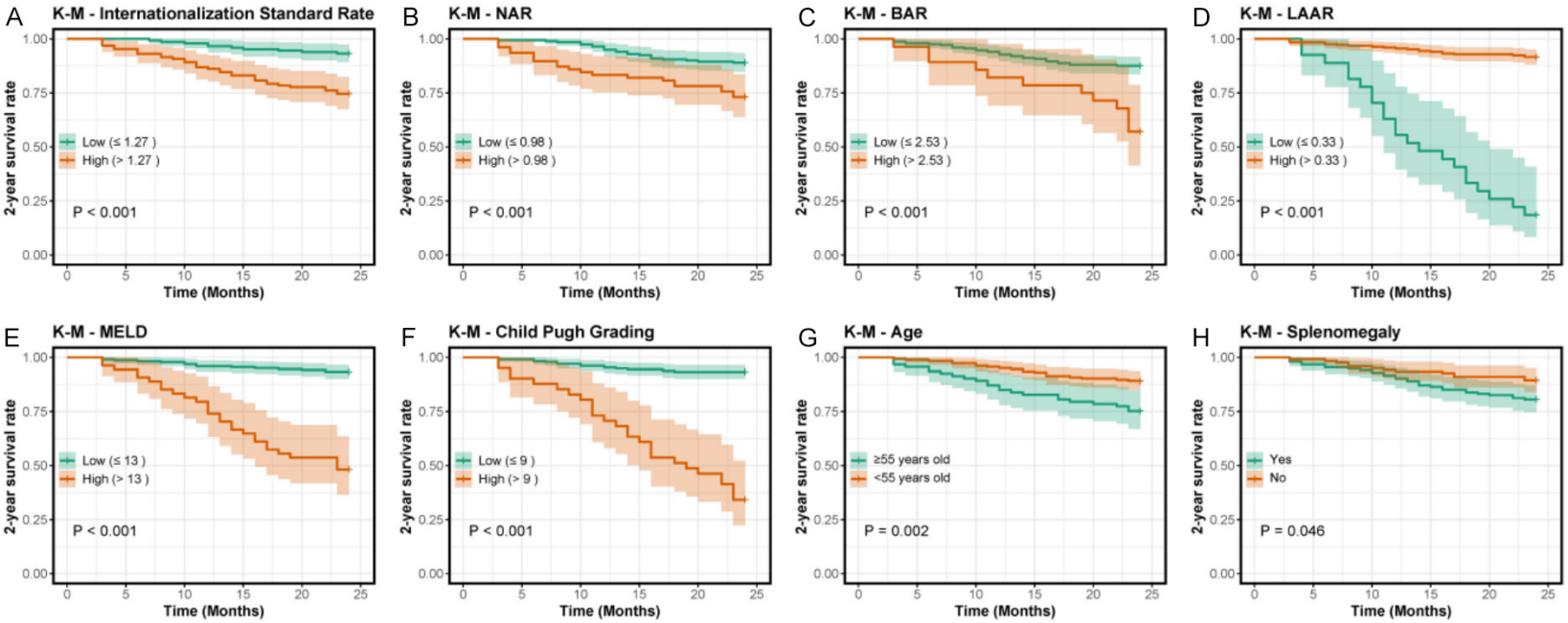

Figure 2. Kaplan-Meier survival curves for prognosis-related variables selected by LASSO. A. Survival curves for different INR groups. B. Survival curves for different NAR groups. C. Survival curves for different BAR groups. D. Survival curves for different LAAR groups. E. Survival curves for different MELD score groups. F. Survival curves for different Child-Pugh Classification groups. G. Survival curves for different age groups (<55 years vs. ≥55 years). H. Survival curves for Enlarged Spleen (Yes/No) groups. Note: LASSO: Least Absolute Shrinkage and Selection Operator, INR: International Normalized Ratio, NAR: Neutrophil-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio, MELD: Model for End-Stage Liver Disease.

Table 3. Independent prognostic variables selected by cox proportional hazards regression model

Variable	β	SE	Chi-square	*P*-value	HR	95.0% Exp(B) CI
International Normalized Ratio (INR)	1.914	0.654	8.565	0.003	6.777	1.881-24.411
NAR	0.477	0.235	4.111	0.043	1.611	1.016-2.554
BAR	0.536	0.196	7.487	0.006	1.709	1.164-2.510
LAAR	-4.118	1.705	5.835	0.016	0.016	0.001-0.460
MELD Score	0.396	0.06	43.783	<0.001	1.486	1.321-1.671
Child-Pugh Classification	0.495	0.1	24.526	<0.001	1.641	1.349-1.996
Age	-0.424	0.346	1.497	0.221	0.655	0.332-1.290
Splenomegaly	-1.018	0.354	8.269	0.004	0.361	0.180-0.723

Note: NAR: Neutrophil-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio, MELD: Model for End-Stage Liver Disease, HR: Hazard Ratio, CI: Confidence Interval.

(P<0.001), LAAR (P<0.001), MELD score (P< 0.001), and Child-Pugh classification (P<0.001) all showed significant survival differences between high and low groups. Age (P=0.032) and splenomegaly (P=0.046) also demonstrated significant survival differences. Specifically, patients with higher INR, NAR, BAR, and MELD scores had lower survival rates, while those with lower LAAR exhibited significantly reduced survival. Patients with higher Child-Pugh classifications also had lower survival rates compared to those with lower classifications. Patients aged ≥55 years and those with splenomegaly had significantly lower survival rates.

Independent prognostic variables identified by cox regression model

Cox proportional hazards regression analysis was performed on the 8 variables selected-by LASSO regression, resulting in 7 independent prognostic variables (**Table 3**). International Normalized Ratio (INR, P=0.003), Neutrophil-to-Albumin Ratio (NAR, P=0.043), Bilirubin-to-Albumin Ratio (BAR, P=0.006), Liver-to-Abdominal Area Ratio (LAAR, P=0.016), Model for End-Stage Liver Disease (MELD) score (P<0.001), Child-Pugh classification (P<0.001), and splenomegaly (P=0.004) were significantly associated with prognosis. In contrast, age (P=0.221) was not significant and therefore excluded from the final independent prognostic model. The specific results showed that INR (HR=6.777, 95% CI: 1.881-24.411), NAR (HR= 1.611, 95% CI: 1.016-2.554), BAR (HR=1.709, 95% CI: 1.164-2.510), MELD score (HR=1.486, 95% CI: 1.321-1.671), and Child-Pugh classification (HR=1.641, 95% CI: 1.349-1.996) were significant risk factors for increased mortality, indicating that their elevation was associated with higher mortality risk. In contrast, higher levels of LAAR (HR=0.016, 95% CI: 0.001-0.460) and absence of splenomegaly (HR= 0.361, 95% CI: 0.180-0.723) were associated with lower mortality risk, identified as protective factors.

Time-dependent ROC analysis of independent prognostic variables at 6, 12, and 24 months

Time-dependent ROC curve analysis was used to evaluate the predictive ability of the independent prognostic variables identified by Cox regression for survival at 6, 12, and 24 months (**Figure 3**). The results showed varying AUC values for different variables at each time point. Child-Pugh classification exhibited the best overall predictive performance, with AUCs ranging from 0.834 to 0.895, followed by MELD score, with AUCs ranging from 0.766 to 0.886. NAR (AUC up to 0.822) and INR (AUC up to 0.786) showed moderate to good predictive ability. In contrast, LAAR showed the lowest predictive performance, with AUCs ranging from 0.507 to 0.623. Other variables such as BAR and splenomegaly demonstrated relatively low and less stable predictive values.

Nomogram model construction and performance evaluation

A nomogram model was constructed based on the independent prognostic variables identified by Cox regression to predict 6-, 12-, and 24-month survival probabilities for patients with post-hepatitis B cirrhosis (**Figure 4**). The model incorporated variables such as INR, NAR, BAR, LAAR, MELD score, Child-Pugh classification, and splenomegaly. The scoring system demonstrated that higher INR values, MELD scores, and Child-Pugh classifications were strongly associated with worse prognosis and had the

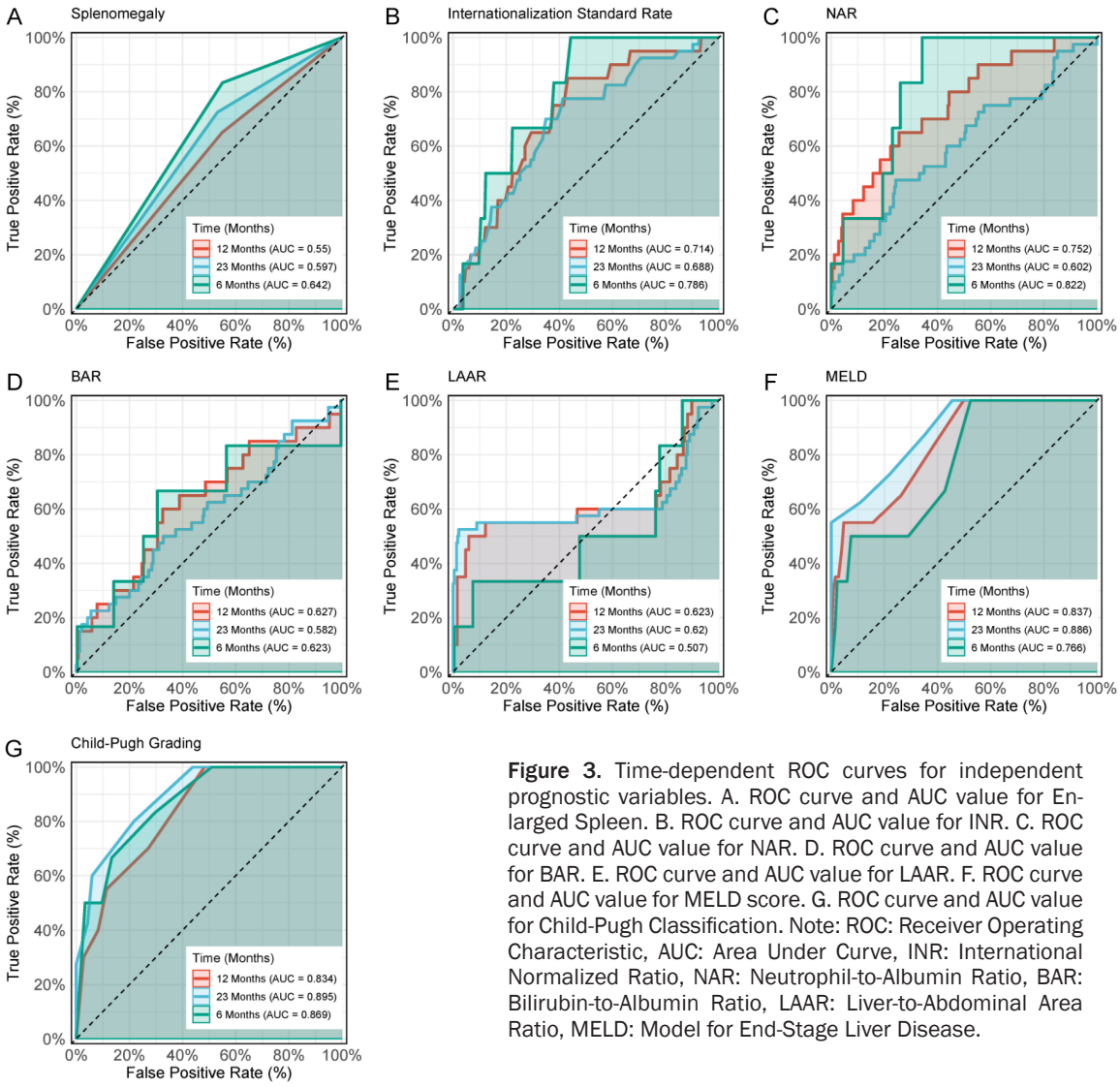

Figure 3. Time-dependent ROC curves for independent prognostic variables. A. ROC curve and AUC value for Enlarged Spleen. B. ROC curve and AUC value for INR. C. ROC curve and AUC value for NAR. D. ROC curve and AUC value for BAR. E. ROC curve and AUC value for LAAR. F. ROC curve and AUC value for MELD score. G. ROC curve and AUC value for Child-Pugh Classification. Note: ROC: Receiver Operating Characteristic, AUC: Area Under Curve, INR: International Normalized Ratio, NAR: Neutrophil-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio, MELD: Model for End-Stage Liver Disease.

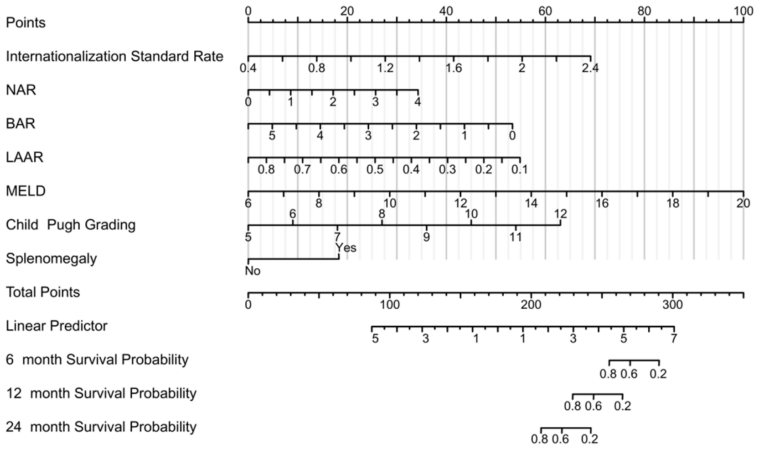

Figure 4. Nomogram model for predicting survival probability in patients with liver cirrhosis following hepatitis B infection. Note: NAR: Neutrophil-to-Albumin Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio, MELD: Model for End-Stage Liver Disease.

greatest impact on patient survival. NAR and LAAR were moderately associated with prognosis, while BAR and splenomegaly contributed less to the total score but still had predictive value. The nomogram exhibited good discriminatory ability and accurately predicted survival probabilities at different time points.

Time-dependent ROC and calibration curve analysis of the nomogram model

Time-dependent ROC analysis of the nomogram showed AUC values of 0.939, 0.942, and

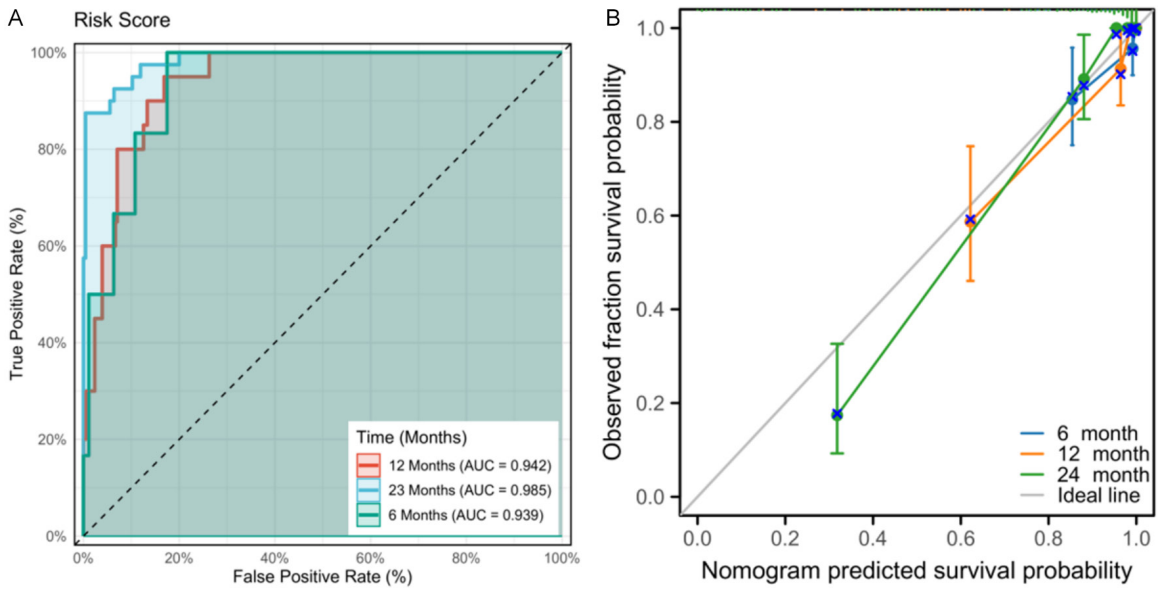

Figure 5. Time-dependent ROC curves and calibration curves based on the nomogram model. A. Time-dependent ROC curve of the nomogram model. B. Calibration curve showing the predictions of the nomogram model.

0.958 for predicting 6-, 12-, and 24-month survival probabilities, respectively, indicating high discriminative power at all time points (**Figure 5A**). Calibration curves confirmed that the predicted survival probabilities closely matched the observed probabilities at all time points, demonstrating high predictive accuracy (**Figure 5B**). The overall model performance, as measured by the concordance index (C-index), was 0.948 (95% CI: 0.937-0.958), indicating excellent discrimination.

Individualized survival prediction using the dynamic nomogram model

The dynamic nomogram model was used to predict individualized mortality probabilities for two patients (**Figure 6**). Patient A (ID 4, deceased) had a total score of 277 points, with 6-month, 12-month, and 24-month mortality probabilities of 3.2%, 14.5%, and 61.1%, respectively, indicating high risk consistent with the actual outcome. High INR, NAR, and MELD scores contributed to the elevated risk. In contrast, Patient B (ID 44, surviving) had a total score of 192 points, with 6-month, 12-month, and 24-month mortality probabilities of 0.4%, 0.1%, and <0.1%, respectively, indicating low risk consistent with the actual outcome. Low BAR and high LAAR values provided protective effects against mortality risk. These results show that the dynamic nomogram model's could accurately predict both short-term and long-term individualized mortality risks.

Discussion

This study concerning patients with liver cirrhosis following hepatitis B infection suggested an association between AR, LAAR and prognosis. Cox regression analysis identifieed AR and LAAR as independent risk factors for the prognosis of hepatitis B-related liver cirrhosis patients, although the specific mechanisms remain unclear. Kaplan-Meier survival curves indicated shorter survival periods for patients with high AR and low LAAR, but this result needs confirmation. ROC curve analysis revealed a certain predictive performance for AR and LAAR, but again the practical application value warrants further evaluation. Furthermore, the nomogram model constructed by integrating AR and LAAR exhibited good discriminatory ability and predictive accuracy, but its actual significance for clinical practice will need more in-depth validation. Eventually, it may offer a reference for the formulation of individualized management strategies.

AR, crucial for liver function, appears linked to nutritional status, inflammatory response, and liver metabolic capacity, although the exact nature of this link remains somewhat unclear. While a low AR may suggest impaired liver func-

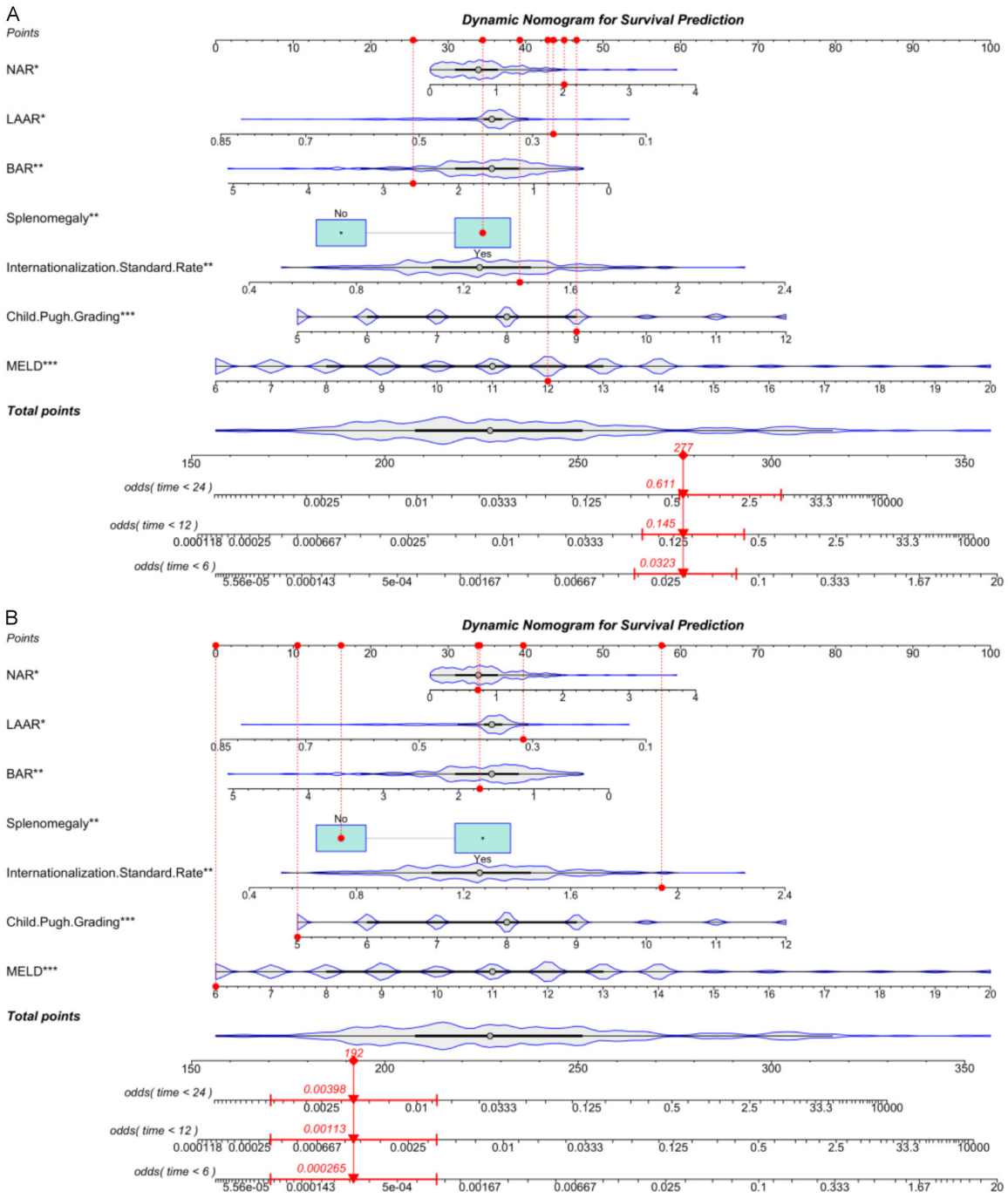

Figure 6. Individualized survival prediction analysis of patients based on the dynamic nomogram model. A. Dynamic nomogram analysis result for Patient A (ID 4, deceased). B. Dynamic nomogram analysis result for Patient B (ID 44, survived). Note: NAR: Dynamic nomogram, Neutrophil-to-Lymphocyte Ratio, BAR: Bilirubin-to-Albumin Ratio, LAAR: Liver-to-Abdominal Area Ratio, MELD: Model for End-Stage Liver Disease.

tion and decreased albumin synthesis, particularly in decompensated liver cirrhosis, its isolated effect on prognosis is debatable. For example, Zhang et al. [17] proposed NLR/Albumin Ratio (NLA) as a possible short-term mortality predictor in male alcoholic liver cirrhosis, yet its applicability across broader demographics warrants scrutiny. Their ROC analysis suggested the NLA's predictive ability (AUC=0.72) is somewhat comparable to the MELD score, though any accuracy improvement remains open to interpretation. Han et al. [18] further posited that

the NAR might exhibit predictive performance in HBV-related decompensated liver cirrhosis, though its clinical significance in non-survivors was not definitively established. Yao et al. [19] suggested that NAR is a strong independent predictor of 90-day mortality in decompensated liver cirrhosis, yet causality remains elusive. The iMELD-NAR model has been reported to enhance mortality risk prediction (AUC=0.872), although its practical impact may be marginal. Compared to albumin levels, ARs are believed to provide a more comprehensive assessment of cirrhotic patients by factoring in inflammatory responses and other clinical factors, like bilirubin, although the precise weighting of these factors is uncertain. Yuan et al. [20] validated the Monocyte-to-Albumin Ratio (MAR) as a potential mortality risk predictor in HBV decompensated liver cirrhosis, yet the overlap with the MELD score's predictions requires careful consideration. Ultimately, however, this combined assessment method, based on albumin and inflammatory indicators, may contribute to dynamic risk prediction and individualized treatment.

LAAR, primarily considered an imaging indicator, is thought to reflect pathophysiological changes like liver atrophy, ascites, and abdominal effusion, though the exact interpretation is often debated. Gao et al. [21] suggested LAAR is reduced in cirrhotic patients, implying a link between the severity of liver atrophy/abdominal effusion and prognosis. Their study also examined the Prothrombin Time Activity Ratio (PTAR) in critically ill cirrhotic patients, but its relevance to LAAR was not fully clarified. Chen et al. [22] explored LAAR's prognostic value in alcoholic acute-on-chronic liver failure (ACLF), finding LAAR is vaguely correlated with liver volume. Cox regression analysis allegedly validated LAAR's independent value for predicting 3-month survival, with an AUC of 0.747. These findings suggest LAAR's potential for predicting short-term mortality, but more evidence is needed. Fan et al. [23] analyzed LAAR changes in 128 Child-Pugh class B/C liver cirrhosis patients, finding a weak correlation between LAAR and inpatient mortality. For Child-Pugh class C patients, LAAR's predictive ability was slightly more pronounced, with an AUC of 0.821, though the improvement is marginal. These studies suggest LAAR has clinical potential.

Compared to other imaging indicators, LAAR offers a more direct basis for condition assessment, though the advantage is minimal. This study claims that low LAAR correlates with a slightly increased mortality risk, but the effect size is small, particularly in decompensated liver cirrhosis. While LAAR is said to have high predictive capability, especially in decompensated cases, this assertion is likely overstated. Combined with clinical observations, LAAR, as an allegedly easily measurable and quantifiable indicator, has limited clinical practicality. Traditional prognostic assessment tools like the MELD score and Child-Pugh classification, while imperfect, are still widely used. This study tried to expand these models by including AR and LAAR, but the incremental value was debatable. While AR and LAAR may better reflect liver function and inflammation than MELD and Child-Pugh, this is not certain, and their addition of imaging information provides only minimal benefit. Previous studies focused heavily on inflammatory indicators (e.g., NAR) and liver metabolism (e.g., BAR), often overlooking other useful indicators. This study attempted to incorporate AR and LAAR as core indicators to enhance systematic prognosis evaluation, but whether this truly improves accuracy is uncertain. Additionally, the use of LASSO regression to systematically integrate multiple variables may have introduced bias, making the results somewhat reliable yet not entirely conclusive for the predictive ability of the nomogram model.

The nomogram model, an intuitive and user-friendly predictive tool, has been increasingly applied in medical research. This study constructed a nomogram model based on AR, LAAR, and other independent prognostic variables (e.g., the MELD score and Child-Pugh classification) to predict the 6-month, 12-month, and 24-month mortality risks of patients with liver cirrhosis following hepatitis B infection. Similar studies have shown that nomogram models incorporating multidimensional clinical indicators can significantly enhance predictive accuracy. For example, Xu et al. [24] developed a postoperative Nomogram model by combining AFP, tumor size, and microvascular invasion (MVI) indicators, successfully improving individualized risk prediction for HBV-related liver cirrhosis patients with HCC, with a C-index of 0.813. Liu et al. [25] proposed the AIAG scoring model (based on age, INR, albumin, and GGT),

which, when combined with the Nomogram, significantly improved survival prediction for HBV-related HCC patients, with a C-index of 0.710. The nomogram model constructed in this study exhibited high discriminatory ability (C-index =0.950) and predictive accuracy, validated by time-dependent ROC curve AUC values at different time points. Calibration curve analysis showed high consistency between predicted and actual survival probabilities, further proving its clinical applicability.

Despite validating the prognostic value of AR and LAAR in patients with liver cirrhosis following hepatitis B infection, this study has limitations. First, the single-center retrospective design and small sample size limited the generalizability of the results. Multi-center, large-scale prospective studies are needed for further validation. Secondly, AR and LAAR detection may have been influenced by technical conditions, and results may vary between hospitals, requiring enhanced standardization. Furthermore, although the nomogram model demonstrated good predictive efficacy, it lacks independent cohort validation, and its generalizability should be assessed. Future research should expand the sample size, explore the effect of dynamic changes in AR and LAAR on long-term prognosis through longitudinal follow-up data, integrate novel biomarkers to optimize the predictive model, and develop nomogram-based clinical decision support tools to enhance individualized management and practical application.

Conclusion

This study systematically validated the significant role of AR and LAAR for prognostic assessment of patients with liver cirrhosis following hepatitis B infection. As simple and practical clinical indicators, AR and LAAR not only reflect liver function, inflammatory status, and imaging characteristics but also provide essential guidance for prognostic management. Combined with a dynamic nomogram model, these indicators offer clinicians a comprehensive and intuitive risk assessment tool, optimizing individualized treatment and follow-up strategies. In the future, large-scale, multi-center studies will likely expand the application of this evaluation system formanagement of liver cirrhosis.

Disclosure of conflict of interest

None.

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