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Article

Value of APRI, FIB-4 and ALBI for Child-Pugh Stratification in Patients with Liver Cirrhosis: A Multivariable Analysis and Diagnostic Performance Study

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Abstract

Background/Objectives: The Child-Pugh system is widely used to grade cirrhosis severity but includes clinical components that may be variably documented. This study evaluated the association and diagnostic performance of the aspartate aminotransferase-to-platelet ratio index (APRI), fibrosis-4 (FIB-4) index, and albumin-bilirubin (ALBI) score for discriminating Child-Pugh classes in cirrhosis. **Methods:** We conducted a retrospective cross-sectional study using medical records from 302 adults with cirrhosis treated at Thai Binh General Hospital, Vietnam, from January to June 2025. Child-Pugh class was reconstructed from bilirubin, albumin, PT%, ascites, and hepatic encephalopathy. APRI, FIB-4, and ALBI were calculated from routine laboratory data. Group comparisons, correlation analysis, multivariable regression, receiver operating characteristic analysis with bootstrap 95% confidence intervals, optimal cut-offs, and reclassification metrics were assessed. **Results:** Among 302 patients, 48 (15.9%) were Child-Pugh A, 120 (39.7%) Child-Pugh B, and 134 (44.4%) Child-Pugh C. ALBI values differed consistently across Child-Pugh classes (-2.23 ± 0.37, -1.65 ± 0.45, and -0.80 ± 0.46; $p < 0.001$), whereas APRI and FIB-4 showed less distinct separation between classes. ALBI showed a strong correlation with the Child-Pugh score ($r = 0.853$, $p < 0.001$) and remained associated with Child-Pugh severity in multivariable linear and logistic regression models. Among the three indices, ALBI showed the highest discrimination for Child-Pugh B/C versus A in this cohort (AUC, 0.919; 95% CI, 0.884-0.950), with an estimated optimal cut-off of -1.753. **Conclusions:** In this retrospective cohort, ALBI showed closer agreement with Child-Pugh severity and higher discrimination for Child-Pugh B/C versus A than APRI and FIB-4. ALBI may be considered as a simple laboratory-based adjunct to support Child-Pugh stratification in routine cirrhosis assessment, but further prospective validation is required before broader clinical application.

Keywords: albumin-bilirubin score; diagnostic accuracy; fibrosis-4 index; liver function reserve; multivariable analysis; non-invasive indices

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1. Introduction

Liver cirrhosis represents the end stage of many chronic liver diseases and is characterized by diffuse fibrosis, regenerative nodules, and progressive portal and systemic hemodynamic dysfunction. Patients may evolve from compensated disease to decompensation with ascites, variceal bleeding, hepatic encephalopathy, renal dysfunction, and increased mortality, making timely severity assessment clinically essential [1].

The Child-Pugh system remains one of the most widely used tools for grading cirrhosis severity in daily practice [2]. However, it includes subjective clinical components such as ascites and

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encephalopathy, which may vary across observers and treatment settings. Accordingly, there is continuing interest in simple laboratory-based indices that are inexpensive, reproducible, and readily available from routine testing [3]. APRI and FIB-4 were originally developed as non-invasive fibrosis indices, whereas ALBI was proposed as a more objective marker of liver functional reserve [4–6].

The performance of APRI, FIB-4, and ALBI is not uniform across populations because it may be influenced by cirrhosis etiology, inflammatory activity, and case mix [3,7–9]. Vietnamese data directly comparing these three indices against Child-Pugh stratification remain limited [10,11]. We therefore aimed to evaluate the association, independent value, and diagnostic performance of APRI, FIB-4, and ALBI for differentiating Child-Pugh classes in a hospital-based cohort of patients with cirrhosis.

2. Materials and Methods

2.1. Study Design and Setting

This retrospective cross-sectional study used routinely collected medical records from adult patients with liver cirrhosis managed as inpatients and/or outpatients at Thai Binh General Hospital, Vietnam, between January and June 2025. The study was designed to assess the relationship between laboratory-based non-invasive indices and cirrhosis severity under real-world provincial hospital conditions.

2.2. Study Population

Eligible records were from patients aged 18 years or older with a clinical diagnosis of cirrhosis supported by clinical, laboratory, ultrasonographic, and/or other routine paraclinical findings. Records were included when sufficient information was available to reconstruct the Child-Pugh classification and to calculate at least ALBI. Cases with missing AST, ALT, or platelet count were excluded from the corresponding APRI and FIB-4 analyses only. Records with acute liver disease, primary liver cancer, poorly defined hereditary liver disorders, or severe extrahepatic conditions likely to distort liver function assessment, such as decompensated heart failure, acute kidney injury, or terminal malignancy, were excluded. The final dataset contained 302 eligible patients; APRI and FIB-4 were available in 300 complete cases.

2.3. Sample Size and Sampling

The minimum sample size was estimated for a single proportion with 95% confidence and a desired precision of 5%, assuming a prevalence of 20% for Child-Pugh class C in the source population. This yielded a minimum requirement of 246 participants. Consecutive eligible records during the study period were then included, resulting in 302 analyzed cases, which exceeded the minimum sample size.

2.4. Data Collection and Measurements

Data were extracted retrospectively using a standardized abstraction form. Variables included age, sex, cirrhosis etiology, routine hematology and biochemistry results, and clinical findings required to reconstruct Child-Pugh class, namely ascites and hepatic encephalopathy. Laboratory variables collected were albumin, total bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), platelet count, and PT%. Data quality was checked before analysis, implausible values were reviewed, and measurement units were standardized before index calculation.

2.5. Variables and Definitions

The main study variables were APRI, FIB-4, and ALBI. APRI was calculated as [(AST/upper limit of normal AST) × 100]/platelet count according to Wai et al. [4]. FIB-4 was calculated as age × AST/[platelet count × √ALT] according to Sterling et al. [5]. ALBI was calculated as 0.66 x log10 bilirubin (μmol/L) − 0.085 x albumin (g/L) according to Johnson et al. [6]. Because the upper reference

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limit for AST was not stored separately for each laboratory time point in this retrospective dataset, a uniform AST upper limit was used transparently for APRI calculation.

The primary dependent variable was Child-Pugh classification. Since INR values were not stored consistently in the source dataset, Child-Pugh class was reconstructed from the five conventional components: bilirubin, albumin, coagulation represented by PT%, ascites, and hepatic encephalopathy, following the classical Child-Pugh framework [2]. Cirrhosis etiology was categorized as hepatitis B virus (HBV), hepatitis C virus (HCV), alcohol-related liver disease, MASLD/NAFLD, or other/undetermined causes. Index interpretation followed commonly used thresholds and recent non-invasive liver disease guidance [3].

2.6. Statistical Analysis

Distributional assumptions were checked using histograms, Q-Q plots, and the Shapiro-Wilk test. Normally distributed continuous variables are presented as mean ± standard deviation, non-normally distributed variables as median and interquartile range, and categorical variables as counts and percentages. Comparisons across the three Child-Pugh groups used one-way analysis of variance or the Kruskal-Wallis test as appropriate, with Bonferroni-adjusted pairwise comparisons when required. Categorical variables were compared with the χ^2 test or Fisher exact test.

Associations between non-invasive indices and Child-Pugh score were assessed with Spearman correlation. Independent associations were evaluated using multivariable linear regression with continuous Child-Pugh score as the outcome and multivariable logistic regression with Child-Pugh B/C versus A as the binary outcome. Diagnostic performance was assessed by the area under the receiver operating characteristic curve (AUC) with bootstrap-derived 95% confidence intervals (CIs). Optimal thresholds were selected using the Youden index, and sensitivity, specificity, positive predictive value, and negative predictive value were calculated. The incremental value of ALBI beyond APRI and FIB-4 was explored with continuous net reclassification improvement (NRI) and integrated discrimination improvement (IDI). All tests were two-sided, and $p < 0.05$ was considered statistically significant. The manuscript was prepared with consideration of the STARD 2015 recommendations for diagnostic accuracy studies.

2.7. Ethical Considerations

The study used retrospective medical records, did not interfere with patient management, and did not introduce additional risk to participants. The study was implemented in accordance with institutional regulations of Thai Binh University of Medicine and Pharmacy and with the permission of Thai Binh General Hospital. All personal data were de-identified before analysis and used solely for research purposes.

3. Results

3.1. Patient Characteristics

Of the 302 included patients, 48 (15.9%) were classified as Child-Pugh A, 120 (39.7%) as Child-Pugh B, and 134 (44.4%) as Child-Pugh C. Age and sex did not differ significantly across Child-Pugh groups. The distributions of HBV, HCV, and alcohol-related cirrhosis were broadly comparable, and no MASLD/NAFLD cases were recorded in this dataset. Albumin and PT% decreased markedly, whereas total bilirubin increased substantially with increasing Child-Pugh severity (all $p < 0.001$; Table 1).

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Table 1. Baseline characteristics according to Child-Pugh class.

Variable	Overall (n = 302)	Child-Pugh A (n = 48)	Child-Pugh B (n = 120)	Child-Pugh C (n = 134)	p-value
Age, years (mean ± SD)	57.2 ± 10.1	56.6 ± 7.2	58.6 ± 10.3	56.3 ± 10.8	0.161
Male sex, n (%)	280 (92.7)	46 (95.8)	110 (91.7)	124 (92.5)	0.640
HBV, n (%)	36 (11.9)	3 (6.2)	12 (10.0)	21 (15.7)	0.158
HCV, n (%)	32 (10.6)	4 (8.3)	15 (12.5)	13 (9.7)	0.645
Alcohol-related, n (%)	174 (57.6)	28 (58.3)	73 (60.8)	73 (54.5)	0.589
MASLD/NAFLD, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.000
Albumin, g/L	28.9 ± 6.3	36.1 ± 4.0	31.2 ± 5.0	24.4 ± 4.2	<0.001
Total bilirubin, µmol/L	78.3 ± 95.8	20.7 ± 9.4	51.1 ± 62.6	123.2 ± 115.6	<0.001
PT%, used instead of INR	70.5 ± 22.2	89.8 ± 18.8	80.2 ± 17.4	54.8 ± 16.0	<0.001

Data are presented as mean ± standard deviation or number (%). HBV, hepatitis B virus; HCV, hepatitis C virus; MASLD, metabolic dysfunction-associated steatotic liver disease; NAFLD, non-alcoholic fatty liver disease; PT%, prothrombin time percentage.

3.2. Distribution of APRI, FIB-4 and ALBI Across Child-Pugh Classes

ALBI values differed progressively across Child-Pugh classes, from -2.23 ± 0.37 in class A to -0.80 ± 0.46 in class C ($p < 0.001$). FIB-4 also increased with worsening class, although the separation was less pronounced. APRI differed across classes but with substantial overlap and a less consistent gradient (Table 2).

Table 2. Distribution of APRI, FIB-4 and ALBI according to Child-Pugh class.

Index	Child-Pugh A (n = 48)	Child-Pugh B (n = 120)	Child-Pugh C (n = 134)	p-value
APRI, median (IQR)	2.50 (0.97-3.62)	1.86 (0.89-4.01)	2.59 (1.51-5.30)	0.020
FIB-4, median (IQR)	7.12 (3.69-10.68)	6.26 (3.60-12.07)	9.68 (5.38-15.36)	<0.001
ALBI, mean ± SD	-2.23 ± 0.37	-1.65 ± 0.45	-0.80 ± 0.46	<0.001

APRI and FIB-4 were calculated in 300 complete cases. IQR, interquartile range; ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

3.3. Correlations with Child-Pugh Score

ALBI showed a strong positive correlation with Child-Pugh score ($r = 0.853$, $p < 0.001$), whereas APRI ($r = 0.162$, $p = 0.005$) and FIB-4 ($r = 0.216$, $p < 0.001$) showed weaker correlations (Table 3).

Table 3. Spearman correlations between non-invasive indices and Child-Pugh score.

Variable	Spearman correlation coefficient (r)	p-value
APRI and Child-Pugh score	0.162	0.005
FIB-4 and Child-Pugh score	0.216	<0.001
ALBI and Child-Pugh score	0.853	<0.001

ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

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3.4. Multivariable Linear Regression

In a multivariable linear regression model including APRI, FIB-4, and ALBI simultaneously, ALBI remained associated with Child-Pugh score, whereas APRI and FIB-4 were not statistically significant in the same model (B = 2.826, p < 0.001). Neither APRI nor FIB-4 retained statistical significance after adjustment (Table 4).

Table 4. Multivariable linear regression for factors associated with Child-Pugh score.

Variable	Regression coefficient (B)	SE	p-value	95% CI
APRI	-0.028	0.021	0.193	-0.070–0.014
FIB-4	0.008	0.013	0.515	-0.017–0.033
ALBI	2.826	0.104	<0.001	2.620–3.031

SE, standard error; CI, confidence interval; ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

3.5. Multivariable Logistic Regression for Child-Pugh B/C Versus A

When Child-Pugh B/C was contrasted against Child-Pugh A, ALBI was the only index that remained statistically associated with Child-Pugh B/C status in the multivariable logistic model (odds ratio, 39.34; 95% CI, 14.18-109.12; p < 0.001). APRI and FIB-4 were not significant independent discriminators (Table 5).

Table 5. Multivariable logistic regression for discriminating Child-Pugh B/C versus A.

Index	Odds ratio	95% CI	p-value
APRI	1.03	0.89-1.18	0.693
FIB-4	0.96	0.89-1.03	0.249
ALBI	39.34	14.18-109.12	<0.001

CI, confidence interval; ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

3.6. Diagnostic Performance

ROC analysis showed high discrimination of ALBI for Child-Pugh B/C versus A in this dataset, with an AUC of 0.919 (95% CI, 0.884-0.950; p < 0.001). By contrast, APRI (AUC, 0.517) and FIB-4 (AUC, 0.559) showed poor discrimination and were not significantly different from chance (Table 6).

Table 6. Receiver operating characteristic analysis for discriminating Child-Pugh B/C.

Index	AUC	95% CI	p-value
APRI	0.517	0.421-0.609	0.717
FIB-4	0.559	0.464-0.650	0.181
ALBI	0.919	0.884-0.950	<0.001

AUC, area under the curve; CI, confidence interval; ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

3.7. Optimal Thresholds and Classification Accuracy

The estimated optimal ALBI threshold in this cohort was -1.753, yielding a sensitivity of 82.2% and a specificity of 89.4%. Its positive predictive value was high (97.7%), whereas the negative

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predictive value was modest (48.3%), consistent with the high prevalence of Child-Pugh B/C in the study sample. APRI and FIB-4 yielded substantially less balanced classification profiles (Table 7).

Table 7. Optimal cut-offs and classification performance for Child-Pugh B/C versus A.

Index	Cut-off	Sensitivity, %	Specificity, %	PPV, %	NPV, %
APRI	0.863	86.2	25.5	86.2	25.5
FIB-4	10.217	39.9	74.5	89.4	18.7
ALBI	-1.753	82.2	89.4	97.7	48.3

PPV, positive predictive value; NPV, negative predictive value; ALBI, albumin-bilirubin score; APRI, aspartate aminotransferase-to-platelet ratio index; FIB-4, fibrosis-4 index.

3.8. Incremental Value of ALBI

Adding ALBI to models based on APRI, FIB-4, or APRI plus FIB-4 was associated with improved discrimination and reclassification indices. Continuous NRI ranged from 1.397 to 1.455 and IDI was approximately 0.39-0.40, suggesting additional discriminative information from ALBI beyond APRI and FIB-4 in this dataset (Table 8).

Table 8. Incremental value of ALBI for discriminating Child-Pugh B/C versus A.

Compared model	NRI	IDI
ALBI added to APRI model	1.397	0.390
ALBI added to FIB-4 model	1.447	0.397
ALBI added to APRI + FIB-4 model	1.455	0.396

NRI, continuous net reclassification improvement; IDI, integrated discrimination improvement; ALBI, albumin-bilirubin score.

4. Discussion

This study found that, among the three evaluated non-invasive indices, ALBI showed the most consistent association with Child-Pugh classification in this hospital-based cohort. ALBI differed progressively across Child-Pugh classes, showed a strong correlation with Child-Pugh score, and retained statistical significance in multivariable models including APRI and FIB-4. In ROC analysis, ALBI demonstrated higher discrimination for Child-Pugh B/C versus A than APRI and FIB-4, which showed more limited discriminative performance in this cohort.

The comparatively better performance of ALBI is biologically plausible. Because ALBI is derived from albumin and bilirubin, two markers of hepatic synthetic and excretory function, it may capture functional impairment more directly than APRI or FIB-4, which were primarily developed as fibrosis-oriented indices, which were primarily developed as fibrosis-oriented indices [4–7]. These findings are consistent with previous reports suggesting that ALBI may have broader utility beyond hepatocellular carcinoma, including the assessment of severity gradients in chronic liver disease and cirrhosis [7,8].

The comparatively modest performance of APRI and FIB-4 in this study may be explained by their original design and biological components. Both indices depend heavily on aminotransferase activity and platelet count, which can be influenced by inflammatory activity, hypersplenism, alcohol use, and extrahepatic factors. Accordingly, they may be more informative for fibrosis estimation than for direct grading of functional impairment. Prior studies have reported better performance of FIB-4-based models in selected populations, particularly etiologically homogeneous cohorts or models targeting decompensation rather than cross-sectional Child-Pugh class [8,9]. These findings support the view that the intended clinical purpose of each index should be considered when applying non-

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invasive markers: fibrosis-oriented indices may not necessarily provide optimal discrimination of functional severity.

The ALBI cut-off of -1.753 showed an apparently favorable balance of sensitivity and specificity in this dataset. However, this threshold should not be generalized uncritically because optimal cut-offs may vary with disease spectrum, etiology distribution, and the prevalence of advanced disease. Importantly, ALBI and Child-Pugh share bilirubin and albumin as components, so the strong observed association is partly structural. This overlap should be considered when interpreting the comparatively higher performance of ALBI than APRI and FIB-4.

Several limitations merit consideration. First, the study was retrospective and based on a single-center dataset, which may limit external validity. Second, the source records did not consistently record INR, and the Child-Pugh classification was reconstructed using PT% as the coagulation component. Third, the APRI calculation used a uniform AST upper limit because time-specific laboratory reference limits were not fully available. Fourth, the cohort contained no MASLD/NAFLD cases and included a predominance of alcohol-related cirrhosis, which may influence generalizability across etiologies. Finally, because the study was cross-sectional, it supports association and discrimination rather than prospective prediction of clinical outcomes.

Despite these limitations, the findings may have practical implications for routine assessment of cirrhosis severity. Because ALBI uses only albumin and bilirubin, both widely available in routine chemistry panels, it may be a feasible laboratory-based adjunct for supporting severity stratification, particularly in settings where complete clinical documentation is not consistently available. In settings where clinical documentation of ascites or encephalopathy is incomplete or variable, ALBI may provide a reproducible adjunct to support initial severity stratification and clinical review, while not replacing comprehensive assessment using established clinical scoring systems.

5. Conclusions

In this hospital-based retrospective cohort of 302 patients with liver cirrhosis, ALBI showed a more consistent association with Child-Pugh severity and higher discrimination for Child-Pugh B/C versus A than APRI and FIB-4. APRI and FIB-4 showed more limited discriminative performance for functional severity stratification in this dataset. These findings suggest that ALBI may be considered as a simple laboratory-based adjunct to support Child-Pugh stratification in routine cirrhosis assessment, particularly where reproducible biochemical markers are desirable. Further prospective multicenter studies are needed to validate these findings across broader etiological groups and clinically relevant outcome-based endpoints.

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Informed Consent Statement: Patient consent was waived by the approving body because this retrospective study used de-identified medical records and did not involve direct patient contact.

Data Availability Statement: The data underlying this study are not publicly available because they contain potentially identifiable clinical information. De-identified data may be made available from the corresponding author on reasonable request, subject to institutional approval and applicable data-protection regulations.

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Abbreviations

The following abbreviations are used in this manuscript:

ALBI	Albumin-bilirubin score
APRI	Aspartate aminotransferase-to-platelet ratio index
AUC	Area under the receiver operating characteristic curve
CI	Confidence interval
FIB-4	Fibrosis-4 index
HBV	Hepatitis B virus
HCV	Hepatitis C virus
IDI	Integrated discrimination improvement
IQR	Interquartile range
MASLD	Metabolic dysfunction-associated steatotic liver disease
NAFLD	Non-alcoholic fatty liver disease
NRI	Net reclassification improvement
PT%	Prothrombin time percentage
ROC	Receiver operating characteristic

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