Association of ALBI Grade, APRI Score, and ALBI-APRI Score with Postoperative Outcomes among Patients with Liver Cirrhosis after Non-hepatic Surgery

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ABSTRACT

Background and Objective. Patients with liver cirrhosis have an increased risk for poor postoperative outcomes after non-hepatic surgery, with liver dysfunction being the most important predictor of poor outcomes. This study aims to determine the association of the albumin-bilirubin (ALBI) grade, aspartate aminotransferase-platelet ratio index (APRI) score, and ALBI-APRI score with postoperative outcomes among cirrhotic patients who have undergone non-hepatic surgery.

Methods. This was a retrospective cohort study involving 34 patients. Age, ASA class, urgency of surgery, etiology of liver cirrhosis, preoperative Child-Turcotte-Pugh (CTP) score, Model for End-Stage Liver Disease (MELD) score, ALBI grade, APRI score, and ALBI-APRI score were documented. The outcomes analyzed were postoperative hepatic decompensation (POHD) and in-hospital mortality. Bivariate analysis using the Mann-Whitney U test and Fisher's exact test was performed. Receiver operating characteristic (ROC) curve analysis was performed to compare the ability of the liver scoring systems to predict the occurrence of study outcomes. Binary logistic regression was performed to measure the odds ratio.

Results. The ALBI grade and ALBI-APRI score were significantly associated with both POHD and in-hospital mortality. Both scores were non-inferior to the CTP and MELD scores in predicting study outcomes. Compared to CTP and MELD scores, the ALBI grade was more sensitive but less specific in predicting POHD and as sensitive but more specific in predicting in-hospital mortality. The ALBI-APRI score was less sensitive but more specific than the ALBI grade in predicting both POHD and in-hospital mortality.

Conclusions. The ALBI grade and ALBI-APRI score were both associated with postoperative hepatic decompensation and in-hospital mortality and were non-inferior to the CTP score and MELD score in predicting short-term in-hospital outcomes among cirrhotic patients after non-hepatic surgery.

Keywords: liver cirrhosis, in-hospital mortality, albumin-bilirubin grade, aspartate aminotransferase-to-platelet ratio index, postoperative hepatic decompensation

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INTRODUCTION

Patients with chronic liver disease frequently require surgical procedures, and approximately 10% of patients with advanced liver disease need surgery in the final two years of life.[1,2] Although the most common surgical procedures performed among cirrhotic patients are the resection of hepatic tumors and liver transplantation, these patients may also require non-hepatic surgeries.[3] A significant increase in postoperative complications, including mortality, has been documented among patients with liver cirrhosis who underwent non-hepatic surgeries.[4] The proper preoperative evaluation of cirrhotic patients is needed to mitigate these risks.

Compared with noncirrhotic patients, cirrhotic patients are at a 2-10x increased risk for mortality. Risk factors for poor postoperative outcomes are the severity of liver dysfunction, portal hypertension, comorbidities, age, etiology of liver disease, and type of surgery.[5-8] The degree of liver dysfunction is one of the major determinants of the postoperative outcome of cirrhotic patients. Patients with worse liver function have an increased risk of decompensation from stress of surgery.[3]

The CTP score and MELD score are used for the preoperative evaluation of cirrhotic patients undergoing non-hepatic surgeries and for predicting the risk of postoperative complications and mortality.[9] Both are correlated with postoperative outcomes of cirrhotic patients.[10-13]

Components of the CTP score include ascites, hepatic encephalopathy, serum total bilirubin, serum albumin, and prothrombin time (PT) or international normalized ratio (INR)[14] Limitations of the CTP score include the arbitrary use of cutoff values for the quantitative variables, and vague demarcation for qualitative variables that can be interpreted differently. Additionally, each variable is given the same significance, which can lead to overestimation or underestimation of their true influence on outcome.[15] MELD is derived from INR, serum total bilirubin, and serum creatinine, and heterogeneity between studies regarding the threshold value for high-risk preoperative MELD score is a concern[10,16] A study performed by Hoteit et al., however, did not demonstrate the utility of CTP and MELD scores in predicting outcomes of elective non-hepatic surgeries.[17]

The ALBI grade is a model developed to assess liver function in hepatocellular carcinoma (HCC).[18] Albumin and bilirubin are the two most commonly cited individual independent prognostic indicators according to the study by D' Amico et al.[19] Increased total bilirubin is one of the factors associated with postoperative morbidity, including postoperative hepatic decompensation.[20] In addition to HCC, its role in the prognostication of stable decompensated liver cirrhosis has also been validated, with a higher ALBI grade being a risk factor for mortality.[21]

The APRI score was initially developed to assess the degree of significant fibrosis and cirrhosis among cases of chronic hepatitis C infection.[22] This is one of the preferred noninvasive tests used to assess the presence of liver cirrhosis, as recommended by the Asian Pacific Association for the Study of the Liver (APASL).[23] AST levels increase as the degree of fibrosis worsens because of increased release from the mitochondria and decreased clearance, and platelets decrease due to splenic sequestration and decreased thrombopoietin production.[24]

Significant postoperative risks are associated with liver cirrhosis, and a 45% overall mortality has been reported among cirrhotic patients who underwent non-hepatic surgeries.[13] Appropriate preoperative evaluation is needed to improve the risk stratification of liver cirrhosis patients and improve outcomes. Due to the limitations of CTP and MELD, this study aims to evaluate the association of ALBI grade, APRI score, and the combination of the two with the outcomes of non-hepatic surgery among patients with liver cirrhosis.

MATERIALS AND METHODS

Study Design and Population

A retrospective cohort study was performed *via* a review of hospital charts and the results of laboratory tests of patients with liver cirrhosis who underwent non-hepatic surgical procedures at NKTI from January 2009 to December 2019. Patients 18 years old or older who were documented as having liver cirrhosis and who had undergone non-hepatic surgery were included in the study. Documented liver cirrhosis was defined as liver biopsy confirming cirrhosis, an intraoperative finding of a cirrhotic liver, or a combination of imaging and laboratory profiles consistent with cirrhosis. Patients for whom the preoperative CTP score, MELD score, ALBI grade, APRI score, and ALBI-APRI score could not be computed because of insufficient data and those who underwent simultaneous hepatic surgery were excluded. The study was approved by the Clinical Trial and Research Unit (CTRU) and Research Ethics Committee (REC) of NKTI.

The study outcomes were over-all in-hospital mortality and postoperative hepatic decompensation (POHD). POHD was defined as new or worsening ascites, new or worsening encephalopathy, variceal bleeding, increase in bilirubin levels to more than 3 mg/dL, international normalized ratio of more than 1.50 (in the absence of serum bilirubin levels >12 mg/dL) or hepatorenal syndrome.[25,26]

Due to the low number of cases, the study population was collected through total enumeration. Data collected from the medical records included age, sex, etiology of liver cirrhosis, presence of preoperative and postoperative ascites and encephalopathy, preoperative serum albumin, AST, platelet count, serum creatinine, preoperative and postoperative total bilirubin, PT/INR, American Society of Anesthesiologists (ASA) physical status classification, surgical procedure performed, length of hospital stay, and discharge status (discharged or deceased).

Table 1 shows how the liver scoring systems used (CTP score, MELD score, ALBI grade, APRI score, and ALBI-APRI score) were computed and categorized.[14,16,18,22]

Table 1. Liver Scoring Systems

Liver Scoring System	Computation			
CTP score	**Parameter**	**Points**		
		1	**2**	**3**
	Encephalopathy	None	Grade 1-2	Grade 3-4
	Ascites	None	Mild/Moderate (diuretic-responsive)	Severe (diuretic-refractory)
	Bilirubin (mg/dL)	<2	2-3	>3
	Albumin (g/dL)	>3.5	2.8-3.5	<2.8
	PT (sec prolonged) or INR	<4 <1.7	4-6 1.7-2.3	>6 >2.3
	CTP score was obtained by adding the score for each parameter. CTP class: A = 5-6 points B = 7-9 points C = 10-15 points			
MELD score	MELD = 3.78 × ln[serum bilirubin (mg/dL)] + 11.2 × ln[INR] + 9.57 × ln[serum creatinine (mg/dL)] + 6.43			
ALBI grade	($\log_{10}$ bilirubin × 0.66) + (albumin × −0.085). Patients were stratified as described below: Grade 1: ≤ -2.60 Grade 2: > -2.60 to -1.39 Grade 3: > -1.39			
APRI score	APRI score = [(AST value/ULN)/platelet count (10^9/L)] × 100			
ALBI-APRI score	ALBI-APRI score = ALBI score + APRI score			

Statistical Analysis

Categorical variables are presented as percentages and continuous variables are presented as medians and means. Bivariate analyses of ALBI, APRI, APRI-ALBI, CTP, and MELD scores to postoperative outcomes were performed. Bivariate analyses of age, ASA risk score (as a measure of comorbid condition), etiology of liver disease, and type of surgery (whether elective or emergent) to postoperative outcomes were also performed to measure the effect of these possible confounding factors. The Mann-Whitney U test and Fisher's exact test were performed for bivariate analysis where appropriate. Receiver operating characteristic (ROC) curve analysis was performed to measure the discriminatory power of the liver scoring systems as predictors of outcomes, and to identify the cutoff values for the liver scoring system that can be used to predict outcomes. Pairwise comparison of the area under the ROC curve was performed to compare the predictive power of the liver scoring systems. Binary logistic regression was performed to quantify the association of the liver scoring systems with outcomes by measuring the odds ratio when allowed by sample size. Using a 95% confidence interval, the results with a *P*-value of < 0.05 were considered statistically significant. All statistical analyses were performed using Statistical Package for the Social Science.

Ethical Considerations

There was no patient contact, and there was no foreseeable risk or benefit for the actual patient subjects. Data collected in this study were maintained and treated with utmost confidentiality and were stored in a password-protected device to ensure privacy of data. Only the researcher and members of the NKTI REC had access to records and data collected.

RESULTS

A total of 61 patients with liver cirrhosis underwent non-hepatic surgeries in NKTI from January 2009 to December 2019. Seven patients underwent simultaneous hepatic surgery and were excluded. Another twenty patients were excluded due to one or more missing parameters needed for the liver scoring system calculation. A total of 34 patients were included in the study (Figure 1).

Baseline Characteristics

Table 2 shows the baseline demographic, preoperative clinical, and biochemical characteristics of the study population. Median age was 60 years. The majority were female, with an approximately 4:5 male (44.1%) to female (55.9%) ratio. The most common etiologies of liver cirrhosis were hepatitis B infection (41.2%) and nonalcoholic steatohepatitis (NASH) (35.3%). The majority had ASA risk

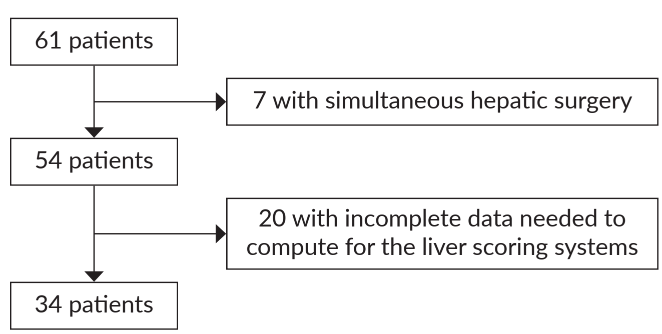


Figure 1. Inclusion and exclusion of study population.

scores of 2 (47.1%) or 3 (44.1%), and the majority underwent elective surgeries (82.4%). The median length of hospital stay was 8 days (range).

Table 3 shows the preoperative liver scoring systems of the study population. The majority had lower preoperative CTP scores of A (35.3%) or B (35.3%) and higher ALBI grades of 2 (41.2%) or 3 (35.3%). The median score for MELD was 12, APRI was 1.66, and ALBI-APRI was -0.32.

The outcomes of the patients in the study are shown in Table 4. Seven patients (20.6%) had postoperative hepatic decompensation and seven (20.6%) had in-hospital mortality.

Risk Factors and Postoperative Outcomes

The bivariate analyses presented in Table 5 show that CTP score (p < 0.001), MELD score (p 0.001), ALBI grade (p 0.001) and ALBI-APRI score (p 0.006) were significantly associated with POHD. However, the APRI score did not show a significant association with POHD (p 0.07).

All patients who developed POHD had a CTP score of B or C, and all had an ALBI grade of 3. Those who developed POHD had higher MELD and ALBI-APRI scores.

Table 6 shows the bivariate analysis of other risk factors for POHD. Out of the four other risk factors that were analyzed, the etiology of liver disease was the only one that was associated with POHD (p=0.029).

The bivariate analyses presented in Table 7 show that CTP score (p=0.003), MELD score (p=0.006), ALBI grade (p=0.001), and ALBI-APRI score (p=0.016) were significantly associated with in-hospital mortality. However, there was no significant association between the APRI score and in-hospital mortality (p=0.206). All seven patients with in-hospital mortality had ALBI grades of 3, three of which were CTP class B and four were class C. In-hospital mortality was associated with higher MELD and ALBI-APRI scores. None of the other risk factors analyzed showed a significant association with in-hospital mortality, as shown in Table 8.

Table 2. Demographic, Clinical, and Biochemical Characteristics of the Study Population

Variables	No. of patients (n = 34)
Age (years)	60 (22)
Sex	
Male	15 (44.1%)
Female	19 (55.9%)
Etiology of liver cirrhosis	
Hepatitis B	14 (41.2%)
NASH	12 (35.3%)
ALD	2 (5.9%)
Hepatitis C	1 (2.9%)
Others	5 (5.9%)
ASA risk score	
1	0 (0%)
2	16 (47.1%)
3	15 (44.1%)
4	2 (5.9%)
5	1 (2.9%)
Preoperative ascites	
Yes	15 (44.1%)
No	19 (55.9%)
Preoperative encephalopathy	
Yes	10 (29.4%)
No	24 (70.6%)
Serum albumin (g/dL)	3.1 (0.8)
Serum total bilirubin (mg/dL)	1.35 (5.5)
AST (IU/L)	55 (69)
Serum creatinine (mg/dL)	0.9 (0.4)
Platelet count ($x10^9$)	124 (55)
PT (second)	14.3 (4.8)
INR	1.22 (0.35)
Type of Surgery	
Emergency	6 (17.6%)
Elective	28 (82.4%)
Length of hospital stay (days)	10 (12)

Table 3. Preoperative Liver Scoring Systems

Liver Scoring System	No. of patients (n = 34)
CTP Score	
A	12 (35.3%)
B	12 (35.3%)
C	5 (14.7%)
No Data	5 (14.7%)
MELD	12 (10)
ALBI grade	
1	3 (8.8%)
2	14 (41.2%)
3	12 (35.3%)
No Data	5 (14.7%)
APRI score	1.66 (1.72)
ALBI-APRI score	-0.32 (2.55)

Categorical variables are presented as frequencies (percentages) and continuous variables are presented as medians (interquartile ranges).

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease

Table 4. Study Outcomes

Variables	No. of patients (n = 34)
POHD	
Yes	7 (20.6%)
No	27 (79.4%)
In-hospital mortality	
Yes	7 (20.6%)
No	27 (79.4%)

Categorical variables are presented as frequencies (percentages).

POHD – postoperative hepatic decompensation

Predictive Power of Liver Scoring Models for Postoperative Hepatic Decompensation

Table 9 and Figure 2 show that the CTP score (AUC 0.935, p<0.0001), MELD score (AUC 0.919, p <0.0001), ALBI grade (AUC 0.886, p <0.0001), and ALBI-APRI score (AUC 0.886, p <0.0001) were able to predict the occurrence of POHD based on ROC curve analysis. However, in the pairwise comparison, there was no significant difference in the AUROC curves of the CTP score, MELD score, ALBI grade or ALBI-APRI score (Table 10). The APRI score was not able to predict the occurrence of POHD (p 0.0904).

The optimal cutoff value to predict postoperative hepatic decompensation for ALBI grade is 3, which is more sensitive but less specific than the CTP, MELD, and ALBI-APRI scores. For the ALBI-APRI score, the cutoff value is 1.13, which is less sensitive but more specific than the MELD score and ALBI grade.

For every 1-unit increase in the ALBI score, there was a 44-fold increased chance for postoperative decompensation to occur (p=0.011) and a 3-fold increased chance for every 1-unit increase in the ALBI-APRI score (p= 0.019) (Table 11).

Predictive Power of Liver Scoring Models for In-hospital Mortality

Table 12 and Figure 3 show that the CTP score (AUC 0.880, p<0.0001), MELD score (AUC 0.847, p <0.0001), ALBI grade (AUC 0.886, p <0.0001), and ALBI-APRI score (AUC 0.833, p <0.0001) were able to predict the occurrence of in-hospital mortality based on ROC curve

Table 5. Liver Scoring Systems and Postoperative Hepatic Decompensation (POHD)

Liver Scoring System		With POHD (N=7)	Without POHD (N=27)	*P*-value
CTP score	A	0 (0%)	12 (44.4%)	0.000085
	B	2 (28.6%)	10 (37.0%)	
	C	5 (71.4%)	0 (0%)	
	No Data	0 (0%)	5 (18.5%)	
MELD score	Median (IQR)	20.0 (13.0)	9.5 (9.0)	0.001
ALBI grade	1	0 (0%)	3 (11.1%)	0.001
	2	0 (0%)	14 (51.9%)	
	3	7 (100%)	5 (18.5%)	
	No Data	0 (0%)	5 (18.5%)	
APRI score	Median (IQR)	2.97 (2.82)	1.37 (1.20)	0.070
ALBI-APRI score	Median (IQR)	2.12 (3.28)	- 0.66 (1.78)	0.006

Categorical variables are presented as frequencies (percentages) and continuous variables are presented as medians (interquartile ranges).

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease

Table 6. Other Risk Factors and Postoperative Hepatic Decompensation (POHD)

Risk Factor		With POHD (N=7)	Without POHD (N=27)	*P*-value
Age	Median (IQR)	51.0 (16)	64.0 (23)	0.186
ASA Risk	2	2 (28.6%)	14 (51.9%)	0.386
	3	4 (57.1%)	11 (40.7%)	
	4	1 (14.3%)	1 (3.7%)	
	5	0 (0%)	1 (3.7%)	
Type of surgery	Elective	5 (71.4%)	23 (85.2%)	0.580
	Emergency	2 (28.6%)	4 (14.8%)	
Etiology of liver cirrhosis	Hepatitis B	3 (42.9%)	11 (40.7%)	0.029
	Hepatitis C	1 (14.3%)	0 (0%)	
	NASH	0 (0%)	12 (44.4%)	
	ALD	1 (14.3%)	1 (3.7%)	
	Others	2 (28.6%)	3 (11.1%)	

Categorical variables are presented as frequencies (percentages) and continuous variables are presented as medians (interquartile ranges).

ASA – American Society of Anesthesiologists

Table 7. Liver Scoring Systems and In-hospital Mortality

Liver Scoring System		In-hospital Mortality		*P*-value
		Yes (N=7)	No (N=27)	
CTP score	A	0 (0%)	12 (44.44%)	0.003
	B	3 (42.86%)	9 (33.33%)	
	C	4 (57.14%)	1 (3.7%)	
	No Data	0 (0%)	6 (18.52%)	
MELD score	Median (IQR)	22.5 (17)	10.0 (10)	0.006
ALBI grade	1	0 (0%)	3 (11.11%)	0.001
	2	0 (0%)	14 (51.85%)	
	3	7 (100%)	5 (18.52%)	
	No Data	0 (0%)	5 (18.52%)	
APRI score	Median (IQR)	2.54 (3.68)	1.54 (3.68)	0.206
ALBI-APRI score	Median (IQR)	2.03 (4.39)	-0.63 (1.91)	0.016

Categorical variables are presented as frequencies (percentages) and continuous variables are presented as medians (interquartile ranges).

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease

Table 8. Other Risk Factors and In-hospital Mortality

Risk Factor		In-hospital Mortality		*P*-value
		Yes (N=7)	Yes (N=7)	
Age	Median (IQR)	53.0 (11)	64.0 (23)	0.550
ASA Risk	2	1 (14.29%)	15 (55.56%)	0.133
	3	5 (71.42%)	10 (37.04%)	
	4	1 (14.29%)	1 (3.70%)	
	5	0 (0%)	1 (3.70%)	
Type of surgery	Elective	5 (71.43%)	23 (85.19%)	0.360
	Emergency	2 (28.57%)	4 (14.81%)	
Etiology of liver disease	Hepatitis B	3 (42.86%)	11 (40.74%)	0.183
	Hepatitis C	1 (14.29%)	0 (%)	
	NASH	1 (14.29%)	11 (40.74%)	
	ALD	0 (0%)	2 (7.41%)	
	Others	2 (28.6%)	3 (11.1%)	

Categorical variables are presented as frequencies (percentages) and continuous variables are presented as medians (interquartile ranges).

ASA – American Society of Anesthesiologists

analysis. However, in the pairwise comparison, there was no significant difference in the AUROC curves of the CTP score, MELD score, ALBI grade or ALBI-APRI score (Table 13). The APRI score was not able to predict the occurrence of in-hospital mortality (p 0.2558).

The optimal cutoff to predict in-hospital mortality for ALBI grade is 3, which is as sensitive as and more specific than the CTP and MELD scores. For the ALBI-APRI score, the cutoff value is 1.24, which is less sensitive but more specific than the ALBI grade.

For every 1 unit increase in ALBI score, there was a 70-fold increased chance for a patient to die postoperatively (p 0.013). For every 1 unit increase in ALBI-APRI score, there was a 2-fold increased chance for a patient to die postoperatively (p 0.035) (Table 14).

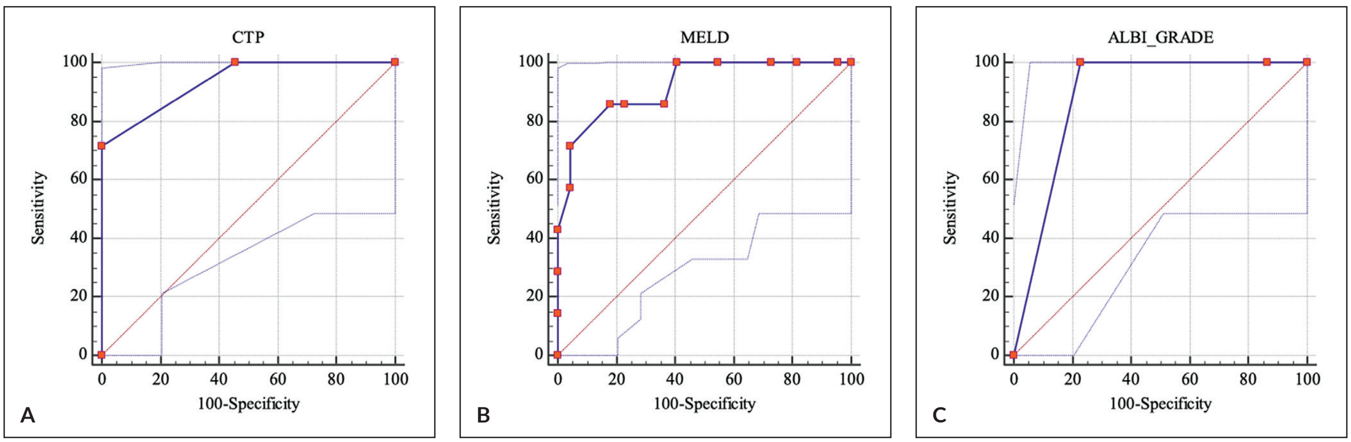
DISCUSSION

This study demonstrated the association of the degree of liver dysfunction, which was assessed using CTP score, MELD score, ALBI grade, and ALBI-APRI score, with POHD and in-hospital mortality. These liver scoring systems were also able to predict the occurrence of POHD and in-hospital mortality, and the ALBI grade and ALBI-APRI score were non-inferior to the CTP score and MELD score in terms of predicting these outcomes. Compared to the CTP and MELD scores, the ALBI grade is more sensitive but less specific in predicting POHD, and as sensitive but more specific in predicting in-hospital mortality. The ALBI-APRI score is less sensitive but more specific than the ALBI grade in predicting both POHD and in-hospital mortality.

Table 9. ROC Curve Analysis for Postoperative Hepatic Decompensation

Liver Scoring System	AUC	*P*-value	Cutoff	Sensitivity	Specificity
CTP score	0.935	<0.0001	> B	71.43	100.00
MELD score	0.919	<0.0001	>14	85.71	81.82
ALBI grade	0.886	<0.0001	>2	100.00	77.27
APRI score	0.731	0.0904	>1.93	71.43	81.82
ALBI-APRI score	0.866	<0.0001	>1.13	71.43	94.12

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease, ROC – receiver operating characteristics



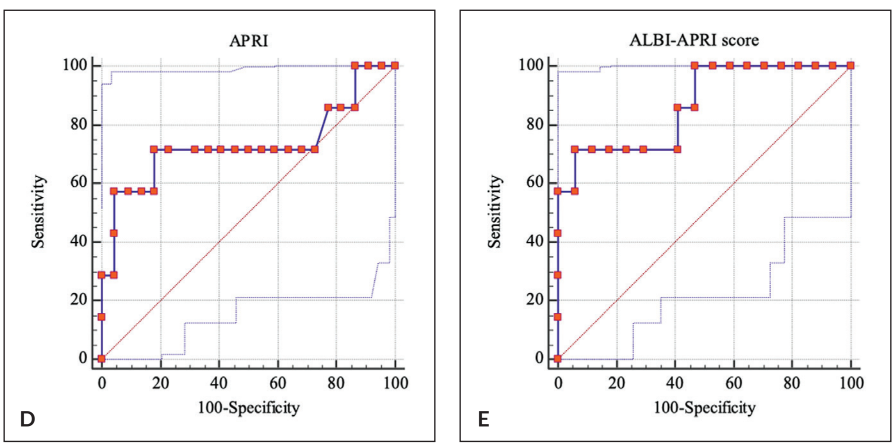


Figure 2. Receiver operating characteristic (ROC) curves for postoperative hepatic decompensation. Predictors used are **(A)** CTP score, **(B)** MELD score, **(C)** ALBI grade, **(D)** APRI score, and **(E)** ALBI-APRI score.

Among the risk factors for poor postoperative outcome in cirrhotic patients, the degree of liver dysfunction is the most important predictor of mortality.[5,7] Overall postoperative mortality ranged from 10% to 85% depending on liver function.[2] In the study of Reverter et al., the preoperative degree of liver dysfunction, as represented by the CTP score, was one of the predictors of hepatic decompensation, and preserved liver function was noted to be protective against decompensation.[6] These previous findings were supported by a positive association between the liver function models used in this study (CTP score, MELD score, and ALBI grade) and poor postoperative outcomes established in this study.

Portal hypertension is also a predictor of postoperative outcomes. The CTP score, MELD score, ALBI grade and APRI score are all associated with portal hypertension, and among these scoring models, the ALBI grade has the strongest correlation with portal hypertension.[27] The MELD score was noted to be less correlated with severe portal hypertension among patients with good hepatic reserve.[7] The ALBI grade is also significantly correlated with mortality among cirrhotic patients. In this study, three patients with a CTP score of B who died postoperatively during their hospital stay had an ALBI grade of 3, and two patients with a CTP score of B who developed POHD also had an ALBI grade of 3, which may suggest that the ALBI grade can be more discriminatory than the CTP score when stratifying the risk of poor postoperative outcome. The ALBI score was also previously found to identify which HCC patients with compensated

Table 10. Pairwise Comparison of AUROC Curves for Postoperative Hepatic Decompensation

Liver Scoring System	Difference Between AUC	*P*-value
ALBI grade and MELD score	0.00893	0.9109
ALBI grade and CTP score	0.0402	0.5670
ALBI grade and ALBI-APRI score	0.0491	0.6075
ALBI-APRI score and MELD score	0.0580	0.5478
ALBI-APRI score and CTP score	0.0893	0.2804
MELD score and CTP score	0.0313	0.5857

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease, AUROC – area under the receiver operating characteristics

Table 11. Binary Logistic Regression Analysis for Postoperative Hepatic Decompensation

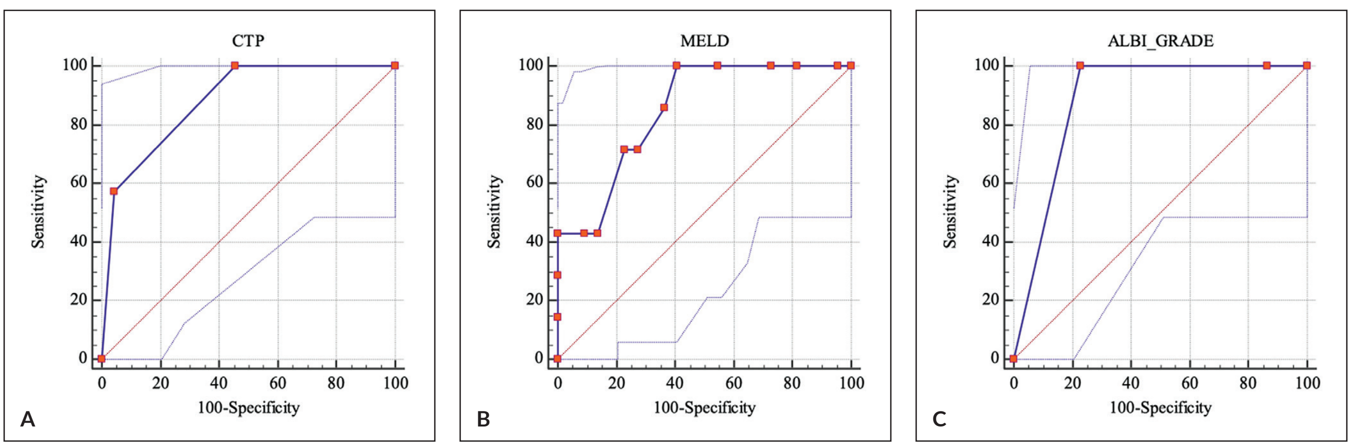
Liver Scoring System	Odds Ratio	*P*-value
ALBI score	44.151	0.011
ALBI-APRI score	3.024	0.019
MELD score	1.447	0.020

ALBI grade – albumin-bilirubin grade, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, MELD – model for end-stage liver disease

Table 12. Receiver Operating Characteristic (ROC) Curve Analysis for In-hospital Mortality

Liver Scoring System	AUC	*P*-value	Cutoff	Sensitivity	Specificity
CTP score	0.880	<0.0001	>B	100.00	54.55
MELD score	0.847	<0.0001	>10	100.00	59.09
ALBI grade	0.886	<0.0001	>2	100.00	77.27
APRI score	0.670	0.2558	>1.95	66.67	82.61
ALBI-APRI score	0.833	0.0009	>1.24	66.67	94.44

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease, ROC – receiver operating characteristics



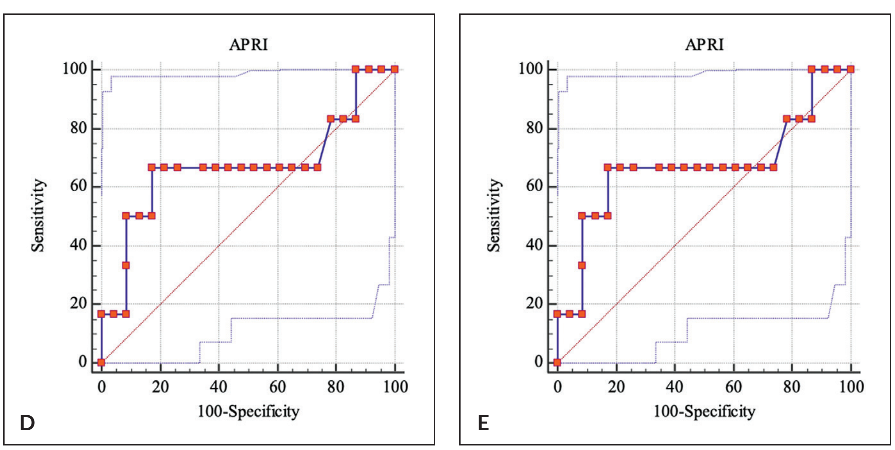


Figure 3. Receiver operating characteristic (ROC) curves for in-hospital mortality. Predictors used are **(A)** CTP score, **(B)** MELD score, **(C)** ALBI grade, **(D)** APRI score, and **(E)** ALBI-APRI score.

Table 13. Pairwise Comparison of AUROC Curves for In-hospital Mortality

Liver Scoring System	Difference Between AUC	*P*-value
ALBI grade and MELD score	0.0245	0.7983
ALBI grade and CTP score	0.0196	0.8125
ALBI grade and ALBI-APRI score	0.0588	0.5883
ALBI-APRI score and MELD score	0.0343	0.7592
ALBI-APRI score and CTP score	0.0784	0.4217
MELD score and CTP score	0.0441	0.5664

ALBI grade – albumin-bilirubin grade, APRI – aspartate aminotransferase-to-platelet ratio index, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, CTP – Child-Turcotte-Pugh score, MELD – model for end-stage liver disease, AUROC – area under the receiver operating characteristics

Table 14. Binary Logistic Regression Analysis for In-hospital Mortality

Liver Scoring System	Odds Ratio	*P*-value
ALBI score	69.934	0.013
ALBI-APRI score	2.384	0.035
MELD score	1.272	0.019

ALBI grade – albumin-bilirubin grade, ALBI-APRI – albumin-bilirubin score-aspartate aminotransferase-to-platelet ratio index score, MELD – model for end-stage liver disease

liver disease (CTP A) are at a higher risk of dying.[18] Similar findings were seen among cirrhotic patients with low MELD scores and their risk for poorer outcomes.[27] Thus, the ALBI score can provide a more discerning way of risk stratifying cirrhotic patients prior to non-hepatic surgical procedures. The utility of the ALBI grade for cirrhotic patients can be generalized irrespective of etiology.[21]

The median APRI score of the study population was 1.37, which is correlated with cirrhosis.[28] The degree of liver fibrosis has a good correlation with liver function.[29] Similar to the ALBI grade, the APRI score also correlated fairly with the degree of portal hypertension.[30] However, this study failed to show a significant association of the APRI score with POHD and in-hospital mortality. Previous studies have shown that the APRI score is significantly correlated with the degree of fibrosis and cirrhosis among patients with chronic hepatitis C infection, but the correlation was not as strong across all other etiologies of liver cirrhosis.[31] Failure to demonstrate an association of the APRI score with study outcomes could be secondary to the etiology of liver disease in our study population, where only 2.9% had hepatitis C infection and only 14.29% of the subjects who developed POHD or died during admission had hepatitis C.

The sum of the ALBI and APRI scores was also demonstrated in this study to be associated with poor postoperative outcomes among cirrhotic patients. This may be secondary to the contribution of the ALBI score. In the study done by Mai et al., the cutoff value for the ALBI-APRI score, which they measured in order to predict post-hepatectomy liver failure, was -13.1.[32] In the study done by Pereyra et al., the cutoff value for the ALBI-APRI score for predicting postoperative liver dysfunction among patients who underwent liver resection for metastasis from colorectal cancer was -2.46.[33] The higher cutoff values measured in our study can be secondary to the less negative values of the ALBI scores and higher APRI scores.

Although liver function is the most important predictor of poor surgical outcomes among cirrhotic patients, there are other factors, such as age, comorbidities, etiology of liver cirrhosis, and type of surgery, that can affect postoperative outcomes. However, in the present study, only the etiology of liver disease was demonstrated to be significantly associated with POHD; however, its association with in-hospital mortality was not significant. These findings may signify that the associations of the ALBI grade, APRI score, and ALBI-APRI score with postoperative hepatic decompensation are significant across different etiologies of liver cirrhosis.

The Mayo risk score is the only model used for estimating surgical risk among cirrhotic patients and is able to incorporate multiple predictors of postoperative outcomes (age, MELD score and ASA risk). Because of the limitations of this model, such as lack of prospective study validation, inability to account for procedure-specific risks and risk for overestimation of mortality risk, there is a demand for a better surgical risk model to prevent inaccurate predictions and overestimations, which can lead to deferral of elective procedures until an emergent indication arises or a risk-aversion phenomenon.[5,6,34,35]

The ALBI grade and ALBI-APRI scores are relatively recent liver scoring tools compared to the CTP score and MELD score. The ability of these two scoring tools to predict postoperative outcomes of cirrhotic patients after hepatic surgeries has been studied extensively[32,36-38], but up to the writing of this paper, none of these three has been used in a study to evaluate their association with outcomes of cirrhotic patients who underwent non-hepatic surgery. With the limitations intrinsic to both the CTP score and MELD score, these scoring systems can possibly be evaluated and utilized as part of a more comprehensive preoperative risk stratification scoring system, such as the Mayo risk score, as representative of the degree of liver dysfunction or to complement the CTP and MELD scores.

CONCLUSION

The ALBI grade and ALBI-APRI score are associated with postoperative hepatic decompensation and in-hospital mortality among patients with liver cirrhosis who underwent non-hepatic surgery. These two models are non-inferior to the CTP and MELD scores in terms of predicting these outcomes. Therefore, these can be used to predict short-term in-hospital outcomes in this study population. These liver scoring systems can possibly be incorporated in a comprehensive preoperative hepatic risk stratification or can be used to complement other liver scoring systems or prediction models.

The major limitations of this study are the small sample size and retrospective nature of the analysis. Retrospective nature of the study limited our ability to establish causality. Validating the findings of this study with a larger sample size with prospective analysis is recommended. Since only short-term in-hospital outcomes were included in this study, we also recommend exploring the association of these scoring systems with long-term outcomes of the study population.

Statement of Authorship

Both authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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