Research Paper

External Validation of Six Liver Functional Reserve Models to predict Posthepatectomy Liver Failure after Major Resection for Hepatocellular Carcinoma

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Abstract

Objective: To validate and compare the predictive ability of albumin-bilirubin model (ALBI) with other 5 liver functional reserve models (APRI, FIB4, MELD, PALBI, King's score) for posthepatectomy liver failure (PHLF) in patients with hepatocellular carcinoma (HCC) who underwent major hepatectomy.

Methods: Data of patients undergoing major hepatectomy for HCC from 4 hospitals between January 01, 2008 and December 31, 2019 were retrospectively analyzed. PHLF was evaluated according to the definition of the 50-50 criteria. Performances of six liver functional reserve models were determined by the area under the receiver operating characteristic curve (AUC), calibration plot and decision curve analysis.

Results: A total of 745 patients with 103 (13.8%) experienced PHLF were finally included in this study. Among six liver functional reserve models, ALBI showed the highest AUC (0.64, 95% CI: 0.58-0.69) for PHLF. All models showed good calibration and greater net benefit than treating all patients at a limit range of threshold probabilities, but the ALBI demonstrated net benefit across the largest range of threshold probabilities. Subgroup analysis also showed ALBI had good predictive performance in cirrhotic (AUC=0.63) or non-cirrhotic (AUC=0.62) patients.

Conclusion: Among the six models, the ALBI model shows more accurate predictive ability for PHLF in HCC patients undergoing major hepatectomy, regardless of having cirrhosis or not.

Key words: hepatocellular carcinoma, major hepatectomy, preoperative prediction, posthepatectomy liver failure

Introduction

Hepatocellular carcinoma (HCC) is the fifth most common malignancy in the world. Partial hepatectomy (PH) is still the mainstay of curative-intent treatment for HCC [1]. With improvements in surgical techniques and perioperative management, increasing number of HCC patients are able to undergo PH. However, postoperative morbidity and mortality still exists, and posthepatectomy liver failure (PHLF) remains the most common cause of mortality particularly in patients who underwent major hepatectomy [2]. The reported incidence of PHLF is 0.7%-9.1%, especially in patients underwent major hepatectomy as high as 58.22%, and PHLF is shown as the major cause (between 18% and 75%) of postoperative mortality [3-4]. In consideration of such a high incidence, accurate prediction of PHLF is very important for patient selection and perioperative management in HCC patients following major hepatectomy.

Previously, some liver functional reserve models have been created to assess liver function and predict posthepatectomy outcomes in patients with HCC. MELD model was used to predict survival after hepatectomy of HCC patients [5-7], APRI, FIB4 and King's score models were created to assess liver fibrosis and cirrhosis of HBV and HCV patients [8-12]. These models were gradually adopted to predict PHLF and exhibited a certain predictive ability [13-16]. Recently, ALBI and PALBI model were developed to evaluate liver function and used to predict PHLF after hepatectomy for HCC [17-23]. Although various studies demonstrated the usefulness of these liver functional reserve models in prediction of PHLF, few studies compared their accuracy in HCC patients undergoing major hepatectomy.

The aim of this study is to validate and compare the predictive ability of the ALBI model with other 5 existing liver functional reserve models (PALBI, APRI, MELD, FIB4, and King's score) for PHLF in patients with hepatocellular carcinoma after major hepatectomy.

Patients and methods

Study design

A multicentric retrospective analysis of patients with hepatocellular carcinoma who underwent major hepatectomy (≥ 3 segments) from the Eastern Hepatobiliary Surgery Hospital in Shanghai, Zhongda Hospital, Southeast university in Nanjing, Qin Huai Medical District of Eastern Theater General Hospital in Nanjing and The First Affiliated Hospital of Xi'an Jiao Tong University in Xi'an between January 01, 2008 and December 31, 2019 were recorded. Inclusion criteria are obeyed strictly as follows: (1) pathologically confirmed as hepatocellular carcinoma; (2) underwent major hepatectomy, major hepatectomy is defined as resection of Couinaud's segmentation 3 and above [4]; (3) no anti-tumor treatment before surgery, such as ablation, TACE; (4) no major blood vessel invasion, bile duct cancer thrombus and distant metastasis; (5) age ≥18. Exclusion criteria: (1) intraoperative radiofrequency ablation, particle placement and other treatments; (2) data were missing on the fifth day after surgery, and PHLF could not be defined.

Surgical technique

The technique of hepatectomy has been previously described [24]. Parenchymal transection was usually achieved under intermittent pedicle clamping (15-minute occlusion and 5-minute reperfusion). Under anesthesia, the hemodynamic management aimed to maintain low central venous pressure to minimize blood loss with reduced volume perfusion.

Variables of interest

Data were collected by direct extraction from electronic health records, complemented by manual curation. Variables of interest in the dataset included: demographics (age, gender, BMI), laboratory measurements (TBIL, ALB, PLT, PT, INR, ALT, AST and Cr), underlying liver disease (HBsAg, HBeAg, HBV-DNA, anti-HCV and antiviral therapy), radiology reports (ascites and cirrhosis), surgical factors (clamping time, blood loss and intraoperative transfusion) and pathological reports (tumor size, tumor number, microvascular invasion and tumor differentiation).

Liver functional reserve models

A total of 6 liver functional reserve models were investigated: ALBI, PALBI, MELD, APRI, FIB4, King's score which were depicted in detail in Table S1. Comparison of these models was performed through discrimination.

Outcomes and definitions

The main outcome of this study was PHLF. The "50-50 criteria" was used as the definition of PHLF in this study: prothrombin activity < 50% and posthepatectomy serum bilirubin > 50 μmol/L, fifth day after operation [25]. To provide a better overview of the predictive abilities on distinct patient populations, this study performed subgroup analyses based on liver cirrhosis according to imaging findings.

Statistical analysis

Continuous variables were expressed as median with the interquartile range (IQR). Categorical variables were presented as numbers and percentages. The X^2 test or Fisher's exact test was used to analyze categorical variables and the Mann-Whitney ranked sum test for continuous variables. The discrimination ability of models was evaluated by the Receiver Operating Characteristic Curve (ROC) and area under the curve (AUC). Comparisons between the ROC curves were performed using the corresponding DeLong's tests. We assessed calibration by visualizing calibration of predicted vs. observed risk using loess-smoothed plots. Decision curve analyses were done using the rmda package in R [26]. A two-tailed P values <0.05 was considered statistically significant. Statistical analysis was performed using Stata/SE 15.1 (College Station, TX77845, USA) and R (Version 4.0.2, https://www.r-project.org).
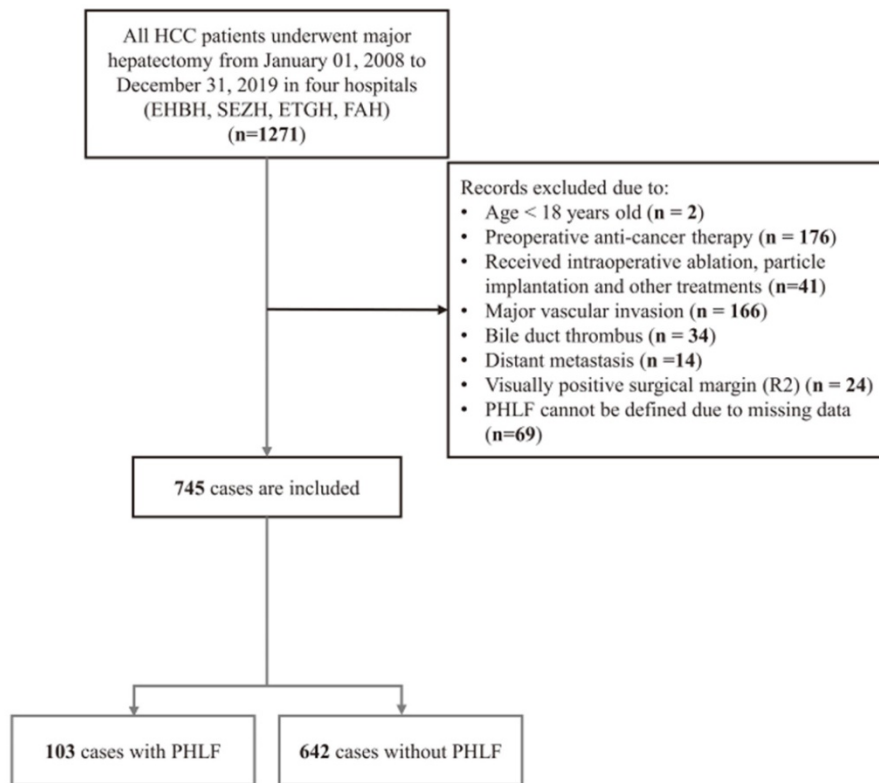
Figure 1. Flow chart of the study.

Results

Baseline characteristics of study population

As was shown in Figure 1, a total of 745 HCC patients were enrolled in the present study, comprising 624 (83.8%) men, with a median age of 53 years (IQR, 45-60 years). Among them, 103 patients experienced PHLF, accounting for 13.8%. The median value of ALBI, PALBI, APRI, MELD, FIB4 and King's score is -2.8 (-3.00 to -2.56), -2.56 (-2.73 to -2.37), 0.52 (0.30-0.88), 7 (6-7), 1.79 (1.06-2.83), and 11.0 (6.06-18.5), respectively. According to the ALBI grade, the majority of patients had grade 1 (532/745, 71.4%), 28.5% (212/745) as grade 2 and 0.1% (1/745) as grade 3. The patient's basic characteristics, preoperative clinical indicators and six model information are shown in Table 1. There was statistical significance difference in terms of BMI, HBV-DNA, Cirrhosis, TBIL, ALB, PLT, PT/INR, ALT, blood loss, intraoperative transfusion, and the six liver functional reserve models.

Significant univariable predictors for PHLF

Univariate logistic regression was performed on the aforementioned possible clinical risk factors (Table 2). The possible discriminating univariable factors for PHLF were BMI, HBV-DNA, TBIL, ALB, PLT, prothrombin time, INR, blood loss, while the most accurate one was prothrombin time (AUC: 0.64, 95% CI: 0.58-0.69).

Table 1. Baseline characteristics of patients

Variable	Total (n = 745)	Without PHLF (n = 642)	PHLF (n = 103)	*P* value
Demographics				
Age, years	53.0 (45.0-60.0)	53.0 (44.0-60.0)	54.0 (47.5-60.5)	0.154
Sex				0.724
Female	121 (16.2%)	106 (16.5%)	15 (14.6%)	
Male	624 (83.8%)	536 (83.5%)	88 (85.4%)	
BMI, Kg/m²	23.3 (21.5-24.8)	23.3 (21.5-24.9)	22.5 (21.2-24.2)	0.038
Diabetes				0.060
No	694 (93.2%)	601 (93.6%)	93 (90.3%)	
Yes	51 (6.8%)	41 (6.4%)	10 (9.7%)	
Underlying liver disease				
HBsAg				0.492
Negative	165 (22.1%)	139 (21.7%)	26 (25.2%)	
Positive	580 (77.9%)	503 (78.3%)	77 (74.8%)	
HBeAg				0.511
Negative	600 (80.5%)	520 (81.0%)	80 (77.7%)	
Positive	145 (19.5%)	122 (19.0%)	23 (22.3%)	
HBV-DNA, Log10 IU/mL	0.00 (0.00-4.53)	0.00 (0.00-4.47)	3.00 (0.00-5.00)	0.022
Anti-HCV				1.000
No	736 (98.8%)	634 (98.8%)	102 (99.0%)	
Yes	9 (1.2%)	8 (1.2%)	1 (1.0%)	
Antiviral therapy				0.280
No	604 (81.1%)	523 (81.4%)	81 (78.6%)	
Yes	129 (17.3%)	107 (16.7%)	22 (21.4%)	
Data Missing	12 (1.6%)	12 (1.9%)	0 (0.0%)	
Radiological findings				
Ascites				0.372
No	669 (89.8%)	579 (90.2%)	90 (87.4%)	
Mild	76 (10.2%)	63 (9.8%)	13 (12.6%)	
Cirrhosis				0.033
No	437 (58.7%)	387 (60.3%)	50 (48.5%)	

Variable	Total (n = 745)	Without PHLF (n = 642)	PHLF (n = 103)	P value
Yes	308 (41.3%)	255 (39.7%)	53 (51.5%)	
Laboratory measurements				
TBIL, µmol/L	13.4 (10.0-18.0)	13.2 (10.0-17.6)	15.0 (10.5-19.8)	0.029
ALB, g/L	41.5 (39.0-44.0)	42.0 (39.0-44.3)	40.0 (38.0-42.5)	<0.001
PLT, ×10⁹/L	182 (138-237)	184 (141-240)	164 (120-223)	0.011
PT, seconds	12.0 (11.3-12.9)	12.0 (11.2-12.7)	12.4 (11.9-13.4)	<0.001
INR	1.00 (0.98-1.03)	1.00 (0.98-1.03)	1.00 (1.00-1.09)	0.001
ALT, U/L	36.0 (24.0-52.4)	35.0 (23.0-52.0)	41.9 (26.3-65.0)	0.012
AST, U/L	36.0 (23.0-58.0)	35.0 (23.0-56.0)	40.0 (25.0-63.0)	0.069
Cr, µmol/L	68.0 (59.0-77.0)	68.0 (59.0-76.8)	67.0 (58.0-77.5)	0.848
Surgical factor				
Clamping time, min	16.0 (9.00-22.0)	16.0 (9.00-22.0)	16.0 (10.0-20.0)	0.411
Blood loss, mL	400 (200-800)	350 (200-700)	500 (200-1000)	0.003
Intraoperative transfusion				0.005
No	519 (69.7%)	460 (71.7%)	59 (57.3%)	
Yes	226 (30.3%)	182 (28.3%)	44 (42.7%)	
Tumor factor				
Tumor size, cm	9.00 (5.85-12.7)	9.00 (5.20-12.4)	10.0 (7.00-13.0)	0.064
Tumor number				0.487
1	626 (84.0%)	543 (84.6%)	83 (80.6%)	
2	118 (15.9%)	98 (15.3%)	20 (19.4%)	
3	1 (0.1%)	1 (0.1%)	0 (0.0%)	
Microvascular invasion				0.280
No	289 (38.8%)	254 (39.6%)	35 (44.0%)	
Yes	456 (61.2%)	388 (60.4%)	68 (66.0%)	
Differentiation				0.173
well	7 (0.9%)	7 (1.1%)	0 (0.0%)	
moderate	718 (96.4%)	621 (96.7%)	97 (94.2%)	
poor	20 (2.7%)	14 (2.2%)	6 (5.8%)	
Liver functional reserve models				
ALBI	-2.80 (-3.00 – -2.56)	-2.81 (-3.01 – -2.58)	-2.66 (-2.88 – -2.44)	<0.001
ALBI grade				0.004
1	532 (71.4%)	472 (73.5%)	60 (58.3%)	
2	212 (28.5%)	169 (26.3%)	43 (41.7%)	
3	1 (0.1%)	1 (0.2%)	0 (0.0%)	
MELD	7.00 (6.00-7.00)	7.00 (6.00-7.00)	7.00 (6.00-8.00)	0.007
MELD grade				0.007
1	588 (78.9%)	517 (80.5%)	71 (68.9%)	
2	153 (20.5%)	123 (19.2%)	30 (29.1%)	
3	4 (0.6%)	2 (0.3%)	2 (2.0%)	
PALBI	-2.56 (-2.73 – -2.37)	-2.56 (-2.74 – -2.38)	-2.50 (-2.65 – -2.33)	0.026
PALBI grade				0.153
1	398 (53.4%)	352 (54.8%)	46 (44.7%)	
2	290 (38.9%)	243 (37.9%)	47 (45.6%)	
3	57 (7.7%)	47 (7.3%)	10 (9.7%)	
APRI	0.52 (0.30-0.88)	0.50 (0.29-0.85)	0.62 (0.38-1.05)	0.006
APRI grade				0.063
1	360 (48.3%)	321 (50.0%)	39 (37.9%)	
2	321 (43.1%)	269 (41.9%)	52 (50.5%)	
3	64 (8.6%)	52 (8.1%)	12 (11.6%)	
FIB4	1.79 (1.06-2.83)	1.74 (1.04-2.77)	2.04 (1.38-3.37)	0.015
FIB4 grade				0.051
1	280 (37.6%)	250 (38.9%)	30 (29.1%)	
2	320 (43.0%)	275 (42.8%)	45 (43.7%)	
3	145 (19.4%)	117 (18.3%)	28 (27.2%)	
King's score	11.0 (6.06-18.5)	10.4 (5.88-17.8)	14.0 (8.60-23.0)	<0.001
King's grade				0.001
1	258 (34.6%)	235 (36.6%)	23 (22.3%)	
2	267 (35.8%)	232 (36.1%)	35 (34.0%)	
3	220 (29.5%)	175 (27.3%)	45 (43.7%)	

Abbreviations: PHLF, post-hepatectomy liver failure; HCC, hepatocellular carcinoma; BMI, body mass index; HBsAg, Hepatitis B surface antigen; HBeAg, Hepatitis B e-antigen; HBV-DNA, hepatitis B virus deoxyribonucleic acid; Anti-HCV, hepatitis C virus antibody; TBIL, total bilirubin; ALB, albumin; PLT, platelet; PT, prothrombin time; INR, international normalized ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Cr, creatinine; OR, odds ratio; CI, confidence interval; ALBI, albumin-bilirubin; PALBI, platelet-albumin-bilirubin; APRI, AST to platelet ratio index; MELD, model for end-stage liver disease; FIB4, fibrosis index based on 4 factors.

Table 2. AUCs of univariable predictors for PHLF in HCC patients undergoing major hepatectomy

Predictor	AUC	95%CI	P value
Demographics			
Age, years	0.54	0.48-0.61	0.154
Sex (Male/Female)	0.51	0.45-0.57	0.751
BMI, Kg/m²	0.44	0.38-0.50	0.039
Antiviral therapy (Yes/No)	0.52	0.46-0.58	0.476
Underlying liver disease			
HBsAg (Positive/Negative)	0.48	0.42-0.54	0.558
HBeAg (Positive/Negative)	0.52	0.46-0.58	0.587
Anti-HCV (Positive/Negative)	0.50	0.44-0.56	0.964
HBV-DNA, U/mL	0.58	0.52-0.64	0.016
Radiological findings			
Cirrhosis (Yes/No)	0.56	0.50-0.62	0.056
Ascites (Yes/No)	0.51	0.45-0.56	0.875
Laboratory measurements			
TBIL, µmol/L	0.57	0.51-0.62	0.029
ALB, g/L	0.39	0.33-0.45	<0.001
PLT, ×10⁹/L	0.42	0.36-0.48	0.011
PT, seconds	0.64	0.58-0.69	<0.001
INR	0.60	0.55-0.66	<0.001
ALT, U/L	0.58	0.52-0.64	0.012
AST, U/L	0.56	0.50-0.62	0.069
Cr, µmol/L	0.51	0.45-0.56	0.848
Surgical factor			
Blood loss, ml	0.59	0.53-0.65	0.004
Intraoperative transfusion (Yes/No)	0.57	0.51-0.63	0.019
Clamping time, min	0.47	0.41-0.54	0.413
Tumor factor			
Tumor size, cm	0.56	0.49-0.62	0.064
Tumor number	0.52	0.46-0.58	0.520
Microvascular invasion	0.53	0.48-0.58	0.281
Differentiation	0.53	0.49-0.57	0.173

Abbreviations: AUC, area under the curve; PHLF, post-hepatectomy liver failure; HCC, hepatocellular carcinoma; CI, confidence interval; BMI, body mass index; HBsAg, Hepatitis B surface antigen; HBeAg, Hepatitis B e-antigen; HBV-DNA, hepatitis B virus deoxyribonucleic acid; Anti-HCV, hepatitis C virus antibody; TBIL, total bilirubin; ALB, albumin; PLT, platelet; PT, prothrombin time; INR, international normalized ratio; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Cr, creatinine.

Evaluation of liver functional reserve models for PHLF

AUCs for the six models were as follows: ALBI AUC 0.64 (95% CI: 0.58-0.69), MELD AUC 0.58 (95% CI: 0.52-0.64), APRI AUC 0.59 (95% CI: 0.53-0.64), FIB4 AUC 0.57 (95% CI: 0.51-0.63), PALBI AUC 0.57 (95% CI: 0.51-0.63), and King's score AUC 0.61 (95% CI: 0.55-0.67) (Table 3 and Figure 2A). ALBI model had the greatest AUC for predicting PHLF. Furthermore, when the six models were categorized into 3 classifications, most of their prediction performance will declined with exception of King's score (Table 3 and Figure 2B). For all models, calibration appeared visually good (Figure 3).

Decision curve analyses to assess clinical utility

This study compared net benefit for each model to the strategies of treating all patients, treating no patients for PHLF. Although all models showed greater net benefit than treating all patients at a limit range of threshold probabilities, the ALBI demonstrated net benefit across the largest range of threshold probabilities (Figure 4).
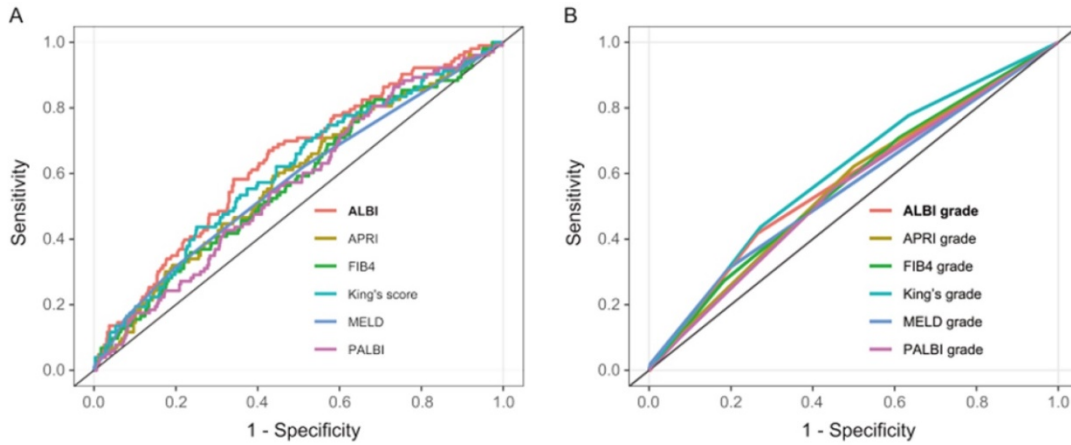
Figure 2. Receiver operating characteristic (ROC) curves of six liver functional reserve models (A) and hierarchical models (B) predicting posthepatectomy liver failure (PHLF) for hepatocellular carcinoma (HCC) patients who underwent major hepatectomy.
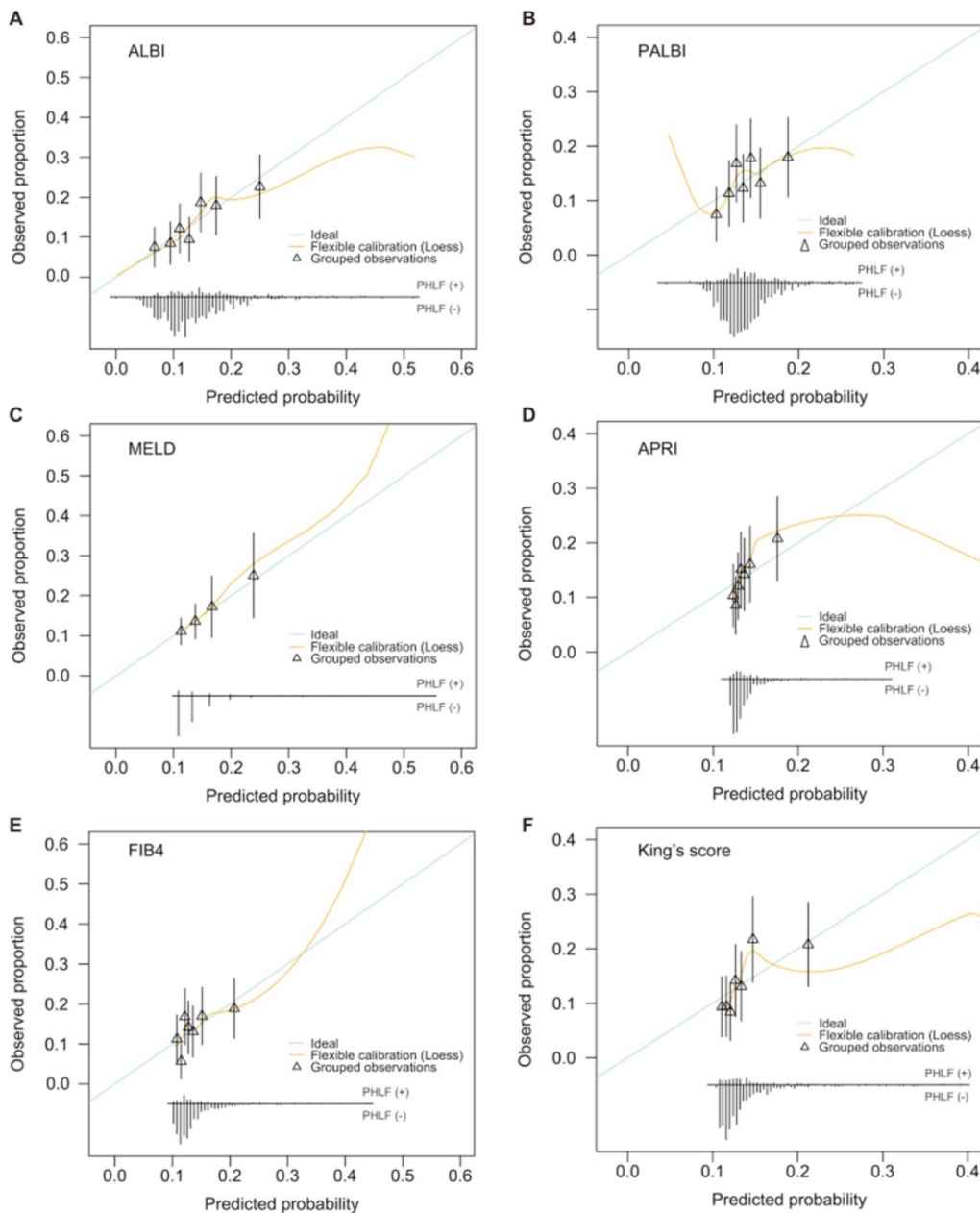

Figure 3. Calibration plots for six models estimating PHLF probabilities. A: ALBI; B: PALBI; C: MELD; D: APRI; E: FIB4; F: King's score.
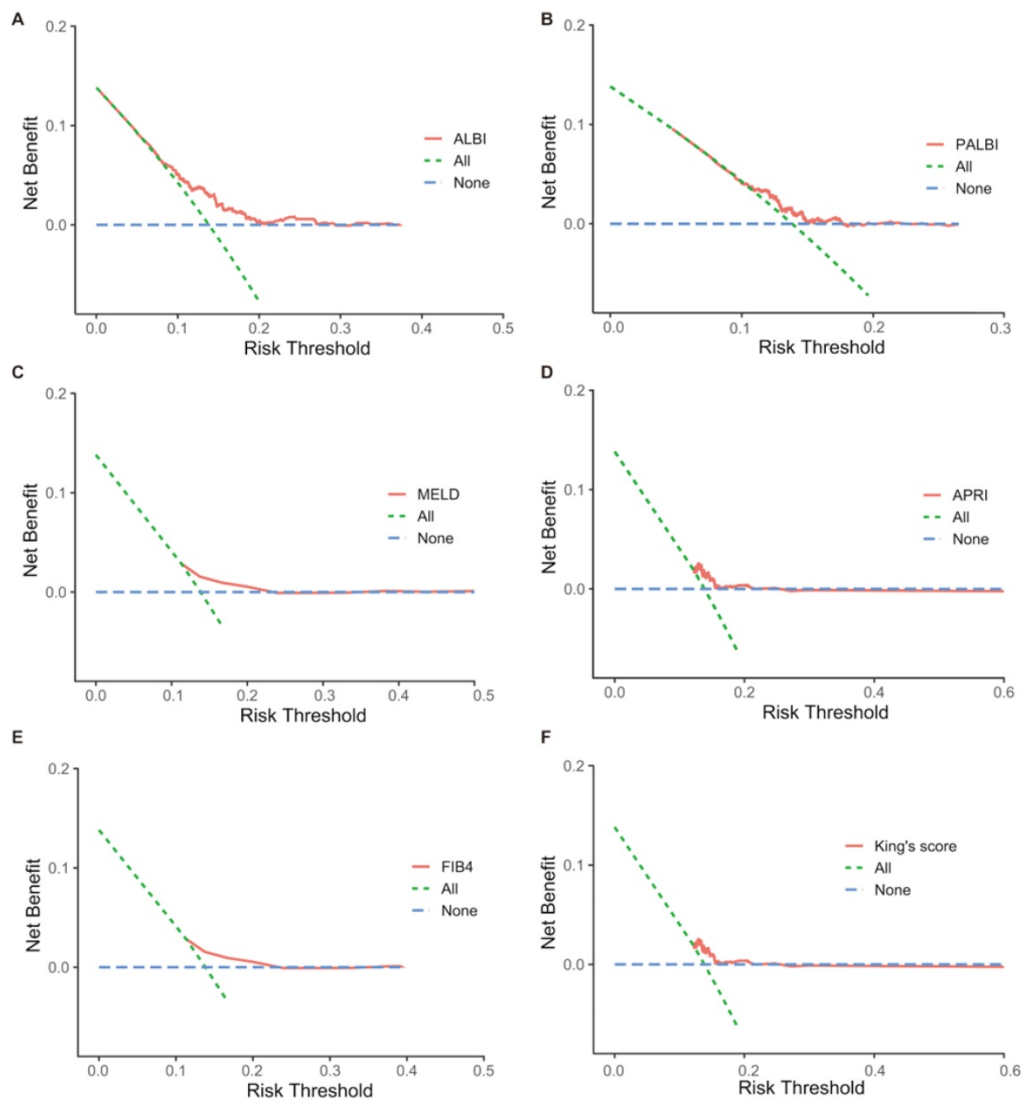
Figure 4. Decision curve analysis comparing net benefit of each liver functional reserve model for PHLF. A: ALBI; B: PALBI; C: MELD; D: APRI; E: FIB4; F: King's score.

Table 3. Discriminative ability of each liver functional reserve model in cohort

Model	AUC	95% CI	*P* value	DeLong's test for two correlated ROC curves
ALBI	0.64	0.58-0.69	<0.001	Ref.
ALBI Grade 1/2/3 (<-2.6/-2.6 ≤ -1.39 /> -1.39)	0.58	0.52-0.63	0.013	<0.001
PALBI	0.57	0.51-0.63	0.026	0.005
PALBI Grade 1/2/3 (≤ -2.53, -2.53-2.09, > -2.09)	0.55	0.50-0.61	0.09	0.001
APRI	0.59	0.53-0.64	0.006	0.153
APRI Grade, 1/2/3 (<0.5/0.5-1.5/>1.5)	0.56	0.51-0.62	0.035	0.039
MELD	0.58	0.52-0.64	0.012	0.007
MELD Grade, 1/2/3 (<8/8-12/>12)	0.56	0.51-0.61	0.053	0.012
FIB4	0.57	0.51-0.63	0.015	0.094
FIB4 Grade 1/2/3 (<1.45/1.45-3.25/>3.25)	0.57	0.51-0.62	0.028	0.062
King's score	0.61	0.55-0.67	<0.001	0.395
King's grade 1/2/3 (<7.6/7.6-16.7/16.7)	0.60	0.55-0.66	<0.001	0.351

Abbreviations: AUC, area under the curve; CI, confidence interval; ROC, receiver operating characteristic curve; ALBI, albumin-bilirubin; PALBI, platelet-albumin-bilirubin; APRI, AST to platelet ratio index; MELD, model for end-stage liver disease; FIB4, fibrosis index based on 4 factors.

Subgroup analysis

Finally, subpopulation analyses were done in the patients with or without cirrhosis to assess the overall performance of ALBI compared with the other 5 models. Subgroup analysis was presented in a forest plot (Figure S1). In cirrhotic patients, ALBI and PALBI had the better predictive accuracy (AUC = 0.63 and 0.60, respectively) compared with other 4 models. In subgroup patients without cirrhosis, ALBI, MELD, FIB4 and King's score had significant predictive accuracy (P = 0.012, 0.030, 0.011, 0.007 and AUC = 0.62, 0.59, 0.61 and 0.63, respectively).

Discussion

Liver failure is one of the leading causes of perioperative death in patients with hepatocellular carcinoma after major hepatectomy. This study applied the "50-50 criteria" proposed by Silvio Balzan et al. in 2005 as a diagnostic criterion for liver failure.

In our study, the incidence of liver failure after major liver resection is 13.8%, the 90-day mortality of patients with PHLF was significantly higher than the patients who did not experience liver failure (38.6% vs. 26.2%, P = 0.011) in our multi-institutional cohort. Selection criteria for major hepatectomy and prediction of the individual PHLF risk are debatable. Accurate assessment of preoperative liver reserve function is one of the keys to reducing the occurrence and death of liver failure after major liver resection [27]. Clinicians have been preferring to use new classification of objective indicators to assess liver function more accurately. Therefore, MELD, APRI, FIB4, King's score, ALBI and PALBI models have been proposed successively. This study aimed at evaluating these six common models of PHLF in HCC patients undergoing major hepatectomy.

In this article, 745 patients with hepatocellular carcinoma who underwent major hepatectomy were retrospectively analyzed. As for univariable risk factor, BMI, HBV-DNA, TBIL, ALB, PLT, prothrombin time, INR, and blood loss were predictors for PHLF. Thus, the factors which were related to patients' demographic, HBV-related, liver related and surgical factors have been shown the associations with PHLF. The result was partially consistent with Kauffmann et al. and Shoup et al. who validate TBIL and coagulation as risk factors of PHLF [28-29].

As an integrated variable, ALBI indicated the best predictive accuracy, regardless of having cirrhosis or not. Although these models are calculated using objective indicators, the numerical results and the accuracy of predictions vary a lot. The ALBI model proposed in 2015 was simply calculated from two indicators, ALB and TBIL, and many literatures have confirmed its accuracy in assessing liver function in patients with hepatocellular carcinoma [30-31]. At the same time, ALBI and King's score models were equally statistically significant in predicting PHLF after major liver resection (P = 0.395). As verified by this article, for HCC patients undergoing major hepatectomy, the ALBI model has a better ability to predict PHLF then PALBI (P = 0.005) and MELD (P = 0.007). This result was in accordance with the study reported by Alexander M. that ALBI can predict PHLF better than MELD after hepatectomy [21]. Subgroup analysis was then performed based on patients with or without cirrhosis. For cirrhotic patients, except ALBI, PALBI may be also a good choice for predicting PHLF. Moreover, for patients without cirrhosis, ALBI, MELD, FIB4 and King's score may be more suitable.

The strengths of this study lie in the large patient population. However, the present study has some limitations. First, it is a retrospective study with inherent shortcoming. Second, although our data are from four well-known hospitals, they are all from Chinese people, whether our conclusion is suitable in patients from the West remains uncertain. Third, there is no data on remnant liver volume and ICG-15, which may be useful in predicting PHLF. Further external validation of our results is needed.

Conclusion

In conclusion, among the six liver functional reserve models (ALBI, APRI, FIB4, MELD, PALBI, King's score), the ALBI exhibits more accurate predictive ability for PHLF in HCC patients undergoing major hepatectomy, regardless of having cirrhosis or not.

Abbreviations

PHLF: post-hepatectomy liver failure; HCC: hepatocellular carcinoma; CTP: Child-Turcotte-Pugh classification; ALBI: albumin-bilirubin; PALBI: platelet-albumin-bilirubin; APRI: AST to platelet ratio index; MELD: model for end-stage liver disease; FIB4: fibrosis index based on 4 factors; HCV: hepatitis C virus; HBV: hepatitis B virus; BMI: body mass index; HBsAg: Hepatitis B surface antigen; HBeAg: Hepatitis B e-antigen; HBV-DNA: hepatitis B virus deoxyribonucleic acid; Anti-HCV: hepatitis C virus antibody; TBIL: total bilirubin; ALB: albumin; PLT: platelet; PT: prothrombin time; INR: international normalized ratio; ALT: alanine aminotransferase; AST: aspartate aminotransferase; Cr: creatinine; OR: odds ratio; CI: confidence interval; ROC: Receiver Operating Characteristic Curve; AUC: area under the curve; IQR: interquartile range.

Supplementary Material

Supplementary figure and table.
http://www.jcancer.org/v12p5260s1.pdf

Acknowledgements

Ethics approval statement

The study was approved by the Institutional Ethics Committees of the Eastern Hepatobiliary Surgery Hospital, Zhongda Hospital Southeast university, Qin Huai Medical District of Eastern Theater General Hospital and the First Affiliated Hospital of Xi'an Jiao Tong University. The informed consent was obtained from each patient for using their

data in the research.

Data availability statement

All data generated or analyzed during this study are included in this article.

Author Contributions

- Conception and design: Zhangjun Cheng, Zhengqing Lei, Guangmeng Guo.
- Financial support: Zhangjun Cheng.
- Collection and assembly of data: all authors.
- Data analysis and interpretation: all authors.
- Manuscript writing: all authors.

Competing Interests

The authors have declared that no competing interest exists.

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