

The Association of Albumin-Bilirubin (ALBI) Grade with Mortality Risk in Trauma Patients with Liver Injuries

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Introduction: The albumin-bilirubin (ALBI) grade objectively assesses liver function with better performance than the Child-Pugh and end-stage liver disease scores. However, the evidence is lacking on the ALBI grade in trauma cases. This study aimed to identify the association between the ALBI grade and mortality outcomes in trauma patients with liver injury.

Methods: Data from 259 patients with traumatic liver injury at a level I trauma center between January 1, 2009, and December 31, 2021 were retrospectively analyzed. Independent risk factors for predicting mortality were identified using multiple logistic regression analysis. Participants were characterized by ALBI score into grade 1 (≤ -2.60 , $n = 50$), grade 2 ($-2.60 < \text{and} \leq -1.39$, $n = 180$), and grade 3 (> -1.39 , $n = 29$).

Results: Compared to survival ($n = 239$), death ($n = 20$) was associated with a significantly lower ALBI score (2.8 ± 0.4 vs 3.4 ± 0.7 , $p < 0.001$). The ALBI score was a significant independent risk factor for mortality (OR, 2.79; 95% CI, 1.27–8.05; $p = 0.038$). Compared with grade 1 patients, grade 3 patients had a significantly higher mortality rate (24.1% vs 0.0%, $p < 0.001$) and a longer hospital stay (37.5 days vs 13.5 days, $p < 0.001$).

Discussion: This study showed that ALBI grade is a significant independent risk factor and an useful clinical tool to discover liver injury patients who are more susceptible to death.

Keywords: trauma, liver injury, mortality, albumin-bilirubin grade, ALBI grade, liver function

Introduction

Accurate measurement of the liver functional reserve is difficult. To evaluate liver function, Pugh et al introduced the Child-Pugh score in 1973 as a prognostic indicator for liver cirrhosis.¹ The Child-Pugh score comprises five factors (albumin, bilirubin, prothrombin/international normalized ratio (INR), magnitude of ascites, and stage of hepatic encephalopathy) and is one of the most commonly used systems for grading liver function in patients with hepatocellular carcinoma.^{2,3} However, critics of the Child-Pugh score reference the non-standardization of clinical parameters used for ascites and encephalopathy, as well as the simultaneous use of the interrelated variables, ascites and serum albumin level.^{4,5}

The model for end-stage liver disease (MELD) score is a validated severity scoring system for predicting the survival of patients with chronic liver disease based on serum levels of bilirubin, creatinine, and the INR.³ However, the INR level variability between different laboratories significantly impacts the accuracy and consistency of the MELD score.^{6–8} The interlaboratory variability in the INR has the largest impact on the MELD score, with a mean difference of around 5 MELD points in most studies.⁶ This interlaboratory variability is also seen for serum creatinine levels and has disadvantages for certain patient populations, especially women.⁷

Indocyanine green clearance has been reported to assess liver functional reserve; however, it is time-consuming and expensive.^{9,10} Furthermore, although some serological tests for liver enzymes are commonly used in the clinical setting, they may reflect the degree of liver damage or dysfunction, but not the liver function reserve.²

In 2015, Johnson proposed the albumin-bilirubin (ALBI) grade to objectively assess liver function.¹¹ This evidence-based model is calculated using serum levels of albumin and bilirubin with the following formula: $ALBI\ score = 0.66 \times \log_{10}[\text{total bilirubin}(\mu\text{mol/L})] - 0.085 \times [\text{albumin}(\text{g/L})]$. Based on the ALBI score, patients could be stratified into classes with clearly different prognoses: grade 1 (≤ -2.60), grade 2 ($-2.60 < \text{and} \leq -1.39$), and grade 3 (> -1.39) [10]. Compared with the Child-Pugh score, the ALBI grade has better predictive performance in evaluating liver function in patients with hepatocellular carcinoma.^{12–14} The ALBI grade also functions as a useful and valuable predictor for outcomes in early stage and intermediate-stage hepatocellular, as well as in many systemic interventions or treatments for hepatocellular carcinoma.^{15–20} It also functions as a crucial biomarker for the development of liver disease, reflecting the potential for hepatic failure and mortality from liver-related causes.^{21–27} Patients with cholangiocarcinoma,²⁸ intrahepatic cholangiocarcinoma,²⁹ pancreatic cancer with liver metastases,³⁰ colorectal cancer with liver metastases,³¹ and primary biliary cholangitis³² can all benefit from knowing their ALBI grade as a prognostic indicator. Additionally, other non-hepatological disorders, including aortic dissection,³³ heart failure,^{34,35} acute pancreatitis,³⁶ lung cancer,^{24,37,38} esophageal cancer,³⁹ gastric cancer,⁴⁰ lung cancer,⁴¹ and medulloblastoma,⁴² have shown a high correlation between ALBI and death.

Currently, there are no studies on the usefulness of ALBI grade in trauma patients. Therefore, this study aimed to identify the association between the ALBI grade and mortality outcomes in trauma patients with liver injury. This retrospective study was performed using data collected from a registered trauma database from a level I trauma center.

Materials and Methods

Institutional Review Board Statement

The Chang Gung Memorial Hospital's Institutional Review Board granted ethics approval (202201380B0), which complies with the Helsinki Declaration. Patients were not required to provide informed consent for this study as anonymous retrospective data was gathered after the acceptance of treatment with written consent from each patient.

Patient Inclusion and Clinical Variables

Of the 46,808 registered trauma patients enrolled between January 1, 2009, and December 31, 2021 (Figure 1), 720 trauma patients had sustained liver injury (ICD-9-CM diagnosis code 864). After excluding patients aged less than 20 years ($n = 157$) and those with incomplete data for albumin or bilirubin ($n = 304$), 259 adult trauma patients with liver injuries were included in the study population. The ALBI score was calculated using the following formula: $ALBI\ score = 0.66 \times \log_{10}[\text{total bilirubin}(\mu\text{mol/L})] - 0.085 \times [\text{albumin}(\text{g/L})]$; the study population was categorized into grade 1 (score ≤ -2.60 , $n = 50$), grade 2 ($-2.60 < \text{score} \leq -1.39$, $n = 180$), and grade 3 (score > -1.39 , $n = 29$), respectively, according to the ALBI score.¹¹ Medical information of the study population was retrieved from the registered trauma database of the hospital.^{43–45} We collected the following data: age; sex; body mass index (BMI), vital signs upon arrival at emergency room, trauma mechanism (blunt or penetration injury), level of albumin, bilirubin, glutamic oxaloacetic transaminase (GOT), and glutamate-pyruvate transaminase (GPT) at admission; preexisting comorbidities, including coronary artery disease (CAD), diabetes mellitus (DM), hypertension (HTN), end-stage renal disease (ESRD), Glasgow Coma Scale (GCS), injury severity score (ISS), length of hospital stay (LOS), and in-hospital mortality.

Statistical Analyses

We used SPSS version 23.0 for Windows (IBM Inc., Chicago, IL) for all statistical analyses. The two-sided Fisher's exact test or Pearson's χ^2 test was used to compare categorical data. The Kolmogorov–Smirnov test was used to test the normalization of the distributed continuous variables. Unpaired Student's *t*-test was performed to analyze normally distributed continuous data, whereas non-normally distributed continuous data were analyzed using the Mann–Whitney *U*-test. Normally and non-normally distributed continuous data were expressed as mean \pm standard deviation and median with interquartile range (IQR, Q1–Q3), respectively. Multivariate logistic regression analysis was performed to identify the independent effects of univariate predictive variables on mortality in the study population, with the presentation of

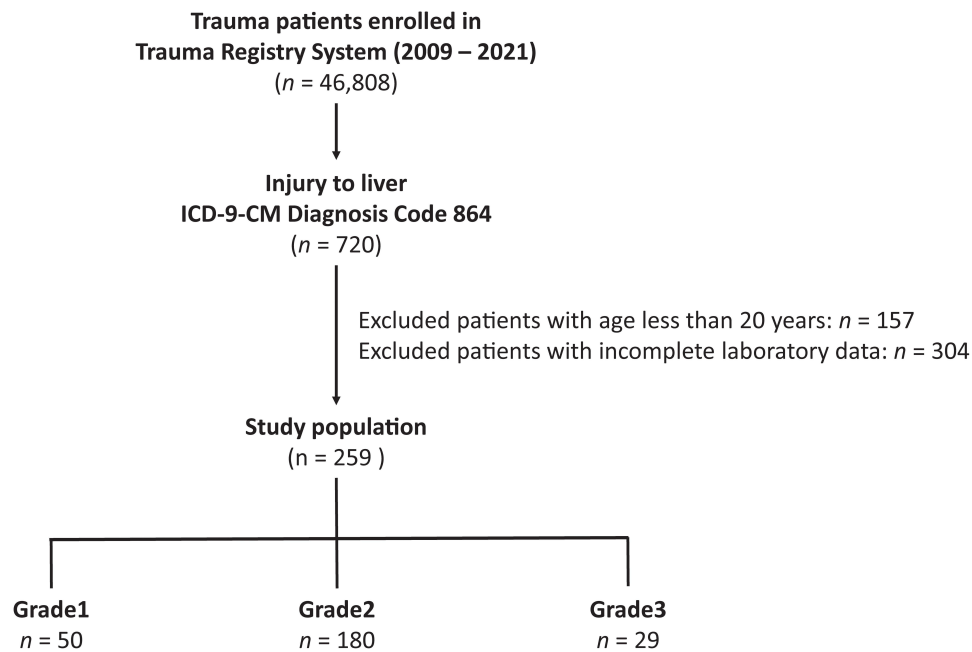


Figure 1 Flow chart illustrating the participant selection process and characterization into albumin-bilirubin (ALBI) grade 1 to 3.

odds ratios (ORs) and 95% confidence intervals (CIs) of the risk factors associated with mortality. Statistical significance was set at $p < 0.05$.

Results

Comparison of Patient and Injury Characteristics in Death and Survival

As shown in [Table 1](#), there were 20 deaths and 239 survivors in the study population. No significant difference in age, sex, and trauma mechanisms in blunt or penetration injuries was found between the patients who died and those who survived. The death patients had a significantly higher BMI (28.0 ± 4.0 vs 24.5 ± 4.4 , $p < 0.001$) and heart rate (109.3 ± 28.9 vs 95.1 ± 19.6 beats/min, $p = 0.003$) upon arrival at emergency room than the survival patients. There was a significantly higher rate of patients with preexisting CAD, ESRD, and HTN in the death group than in the survival group. There were significantly lower levels of albumin and GPT in the death group than in the survivors; however, there were no significant differences in the levels of total bilirubin and GOT between the groups. Patients who died had a significantly lower ALBI score than those who survived (2.8 ± 0.4 vs 3.4 ± 0.7 , $p < 0.001$). Patients who died had a significantly lower GCS score (median [Q₁-Q₃]; 8 [3–13] vs 15 [14–15], $p < 0.001$) but higher ISS (median [Q₁-Q₃]; 33 [24–40] vs 20 [13–29], $p < 0.001$) than the surviving patients.

Risk Factors for Mortality

As shown in [Table 2](#), univariate logistic regression analysis revealed that pre-existing CAD, ESRD, HTN, BMI, heart rate upon arrival at emergency room, GCS, ISS, GPT level, and ALBI score were significant risk factors for mortality in adult trauma patients with liver injuries. Multivariate logistic regression analysis revealed that heart rate, GCS, ISS, GPT level, and ALBI score were significant independent risk factors for mortality. The increase of each ALBI score was associated with around 2.8- fold of mortality risk in the patients (OR, 2.79; 95% CI, 1.27–8.05; $p = 0.038$).

Comparison of Patient and Injury Characteristics Based on ABLI Grade

There was no significant difference in age or sex predominance among the three groups of patients ([Table 3](#)). There were no significant intergroup differences in the prevalence of preexisting comorbidities, except for a significantly higher rate of CAD in grade 3 patients than in grade 1 patients. The albumin levels of grade 2 and grade 3 patients were significantly

Table 1 Patient and Injury Characteristics Based on Mortality Outcomes in Patients with Traumatic Liver Injury

Variables	Death n = 20	Survival n = 239	OR (95% CI)	P
Age, years	43.5±16.9	42.2±17.0	–	0.745
Male, n (%)	17(85.0)	136(56.9)	4.29(1.23–15.04)	0.014
Comorbidities				
CAD, n (%)	2(10.0)	3(1.3)	8.74(1.37–55.72)	0.006
DM, n (%)	1(5.0)	19(7.9)	0.61(0.08–4.80)	0.635
ESRD, n (%)	1(5.0)	1(0.4)	12.53(0.75–208.25)	0.025
HTN, n (%)	6(30.0)	23(9.6)	4.03(1.41–11.49)	0.006
BMI	28.0±4.0	24.5±4.4	–	0.001
Mechanisms				0.560
Blunt, n (%)	20(100)	235(98.3)	–	–
Penetration, n (%)	0(0.0)	4(1.7)	–	–
Vital signs at ER				
SBP, mmHg	108.7±38.4	122.1±32.2	–	0.081
Heart rate, beats/min	109.3±28.9	95.1±19.6	–	0.003
Respiration rate, times/min	21.0±4.7	19.6±3.6	–	0.117
Laboratory data				
Albumin, g/dL	2.8±0.4	3.4±0.7	–	<0.001
Total bilirubin, mg/dL	1.1±0.6	1.0±0.7	–	0.628
GOT, U/L	689.0±1193.7	456.9±442.0	–	0.064
GPT, U/L	202.4±202.1	308.8±220.0	–	0.038
ALBI	2.8±0.4	3.4±0.7	–	<0.001
GCS, median (IQR)	8(3–13)	15(14–15)	–	<0.001
ISS, median (IQR)	33(24–40)	20(13–29)	–	<0.001
1–15, n (%)	2(10.0)	70(29.3)	0.27(0.06–1.19)	0.064
16–24, n (%)	3(15.0)	89(37.2)	0.30(0.09–1.04)	0.046
≥ 25, n (%)	15(75.0)	80(33.5)	5.96(2.09–16.99)	<0.001

Abbreviations: ALBI, albumin-bilirubin; BMI, body mass index; CAD, coronary artery disease; CI, confidence interval; DM, diabetes mellitus; ER, emergency room; ESRD, end-stage renal disease; GCS, Glasgow Coma Scale; GOT, glutamic oxaloacetic transaminase (aspartate aminotransferase); GPT, glutamic pyruvic transaminase (alanine aminotransferase); HTN, hypertension; IQR, interquartile range; ISS, injury severity score; OR, odds ratio; SBP, systolic blood pressure.

Table 2 Univariate and Multivariate Analysis to Identify the Risk Factors for Mortality in the Trauma Patients with Liver Injury

	Univariate Analysis			Multivariate Analysis		
	OR	95% CI	P	OR	95% CI	P
Male	4.29	(1.23–15.04)	0.014	5.19	(0.91–29.68)	0.064
CAD	8.74	(1.37–55.72)	0.006	0.86	(0.04–18.96)	0.925
ESRD	12.53	(0.75–208.25)	0.025	5.51	(0.71–30.17)	0.299
HTN	4.03	(1.41–11.49)	0.006	6.66	(1.00–44.23)	0.052
BMI	1.17	(1.06–1.29)	0.002	1.11	(0.97–1.27)	0.136
Heart rate	1.03	(1.01–1.05)	0.004	1.02	(1.01–1.06)	0.042
GCS	0.75	(0.68–0.84)	<0.001	0.82	(0.70–0.96)	0.016
ISS	1.08	(1.04–1.12)	<0.001	1.07	(1.03–1.12)	0.002
GPT	0.97	(0.94–1.00)	0.038	0.97	(0.97–0.99)	0.032
ALBI	3.29	(1.64–6.60)	<0.001	2.79	(1.27–8.05)	0.038

Abbreviations: ALBI, albumin-bilirubin; BMI, body mass index; CAD, coronary artery disease; CI, confidence interval; ESRD, end-stage renal disease; GCS, Glasgow Coma Scale; GPT, glutamic pyruvic transaminase (alanine aminotransferase); HTN, hypertension; ISS, injury severity score; OR, odds ratio.

Table 3 Outcomes and Characteristics of the Trauma Patients with Liver Injury According to ALBI Grade

Variables	Grade 1 n = 50	Grade 2 n = 180	Grade 3 n = 29	P
Age, years	39.9±16.2	42.3±17.1	46.6±17.4	0.240
Male, n (%)	33(66.0)	99(55.0)	21(72.4)	0.113
Comorbidities				
CAD, n (%)	0(0.0)	2(1.1)	3(10.3)*	0.002
DM, n (%)	3(6.0)	13(7.2)	4(13.8)	0.412
ESRD, n (%)	0(0.0)	1(0.6)	1(3.4)	0.201
HTN, n (%)	4(8.0)	19(10.6)	6(20.7)	0.200
Laboratory data				
Albumin, g/dL	4.1±0.3	3.4±0.5*	2.2±0.5*	<0.001
Total bilirubin, mg/dL	0.7±0.5	1.1±0.6*	1.5±0.9*	<0.001
GOT, U/L	393.3±316.6	516.4±604.9	357.1±333.8	0.164
GPT, U/L	307.3±213.5	304.7±218.2	263.3±246.8	0.627
ISS, median (IQR)	18(9–29)	20(14–29)	25(18–38)*	0.016
1–15, n (%)	18(36.0)	50(27.8)	4(13.8)	0.105
16–24, n (%)	17(34.0)	65(36.1)	10(34.5)	0.995
≥ 25, n (%)	15(30.0)	65(36.1)	15(51.7)	0.149
LOS in hospital, days	13.5±11.3	19.0±13.1	37.5±29.6*	<0.001
Mortality, n (%)	0(0.0)	13(7.2)	7(24.1)*	<0.001

Note: *Indicates significance when compared to patients in the grade 1 group.

Abbreviations: CAD, coronary artery disease; CI, confidence interval; DM, diabetes mellitus; ESRD, end-stage renal disease; GCS, Glasgow Coma Scale; GOT, glutamic oxaloacetic transaminase (aspartate aminotransferase); GPT, glutamic pyruvic transaminase (alanine aminotransferase); HTN, hypertension; IQR, interquartile range; ISS, injury severity score; LOS, length of stay; OR, odds ratio.

lower, while the total bilirubin levels were significantly higher than those in Grade 1 patients. There were no significant intergroup differences in the GOT and GPT levels. A significantly higher ISS was observed in grade 3 patients than in grade 1 patients. Grade 3 patients had a significantly longer LOS in hospital (37.5 days vs 13.5 days, $p < 0.001$) and higher mortality rate (24.1% vs 0.0%, $p < 0.001$) than grade 1 patients.

Discussion

This study revealed that the ALBI score was a significant independent risk factor for mortality in traumatic liver injury. In our study, death was significantly associated with a lower ALBI score compared to survival. In addition, grade 3 patients had a significantly higher mortality rate and a longer length of hospital stay than grade 1 patients. ALBI grade could be a valuable tool for stratifying the mortality risk of adult trauma patients with liver injury.

In this study, the percentage of patients with grade 1, grade 2 and grade 3 ALBI scores was 7.7% (20/259), 69.5% (180/259), and 11.2% (29/259), respectively. These characteristics are similar to that of a study that initially established the ALBI grade based on the training set of the Japanese patient population,¹⁴ where 25%, 65%, and 10% of patients were classified as grade 1, grade 2, and grade 3, respectively.¹⁵ In addition, in the cancer patients undergoing liver resection, higher ALBI grades were associated with 2.06 odds of poor overall survival.⁴⁶ In this study, in addition to commonly recognized risk factors for mortality in trauma patients such as increased heart rate, lower conscious level, and injury severity, the multivariate logistic regression analysis revealed that the ALBI score had a 2.79 odds of mortality risk in trauma patients with liver injury. The ALBI grade as a proxy for liver function explains mortality risk not only in patients with mild or early stage liver diseases receiving liver resection,¹⁰ but also in trauma patients with liver injury.

An increase in the serum level of GOT indicates parenchymal liver illness with liver-specific dysfunction because GPT is found predominantly in the cytosol of hepatocytes.^{47,48} Notably, this study investigated subjects with liver injury and revealed that there were significantly lower levels of GPT in patients who died than in those who survived, and

multivariate logistic regression analysis also revealed that GPT level was a significant independent risk factor for mortality (OR, 0.97; 95% CI, 0.97–0.99). In addition, in the comparison among patients with different ABLI grades, although there was a significantly different risk for mortality among these groups, there were no significant intergroup differences in the levels of GPT. This result implies that the ABLI grade may have a better prognostic value than the serum level of GPT.

This study has some limitations that should be recognized. First, because patients declared dead on arrival at the emergency room were not registered in the trauma database, only in-hospital mortality was evaluated in this study, thus leading to some selection bias in the outcome measurement. Second, the number of patients included in the study population was relatively small. Third, there were unknown and uncontrolled conditions such as resuscitation, massive blood transfusion, and liver surgery in the retrospective design of this study, leading to bias in outcome measurement. We can only assume that the outcomes of the intervention or treatment were uniform across the studied groups. Fourth, this study excluded many patients who had no data on albumin or bilirubin levels, which may have led to a selection bias. Furthermore, because the study is limited to a single level I trauma center, additional verification is required before generalizing the study's findings to other medical facilities. Furthermore, the ALBI was developed based on a study of the adult population; there were no comparable references in the children's literature. As a result, additional research was required to determine whether the ALBI score is beneficial for pediatric trauma patients with liver injury. Finally, we examined the utility of ALBI grades in a single urban trauma center in southern Taiwan, and inter-country validation has not yet been confirmed.

Conclusions

This study demonstrated that ALBI grade is a significant independent risk factor and a valuable screening tool to identify patients with liver injury with a higher risk for mortality.

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Disclosure

The authors declare no conflicts of interest in this work.

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