ORIGINAL RESEARCH

A Rapid Prognostic Score Based on Bedside Arterial Blood Gas Analysis (ABG) Established for Predicting 60-Day Adverse Outcomes in Patients with Acute Pancreatitis in the Emergency Department

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Objective: To establish a rapid and concise prognosis scoring system for pancreatitis in the emergency department based on bedside arterial blood gas analysis (ABG).

Methods: A single-center, retrospective cohort study was used to establish the new scoring system, and a validation group was used to verify it. The primary endpoint was 60-day death, and secondary endpoints were 28-day death, admission to the intensive care unit (AICU), requirement for mechanical ventilation (MV) and persistent organ failure (POF). Receiver operating characteristic (ROC) curves was drawn to validate the predictive value of the new scoring system. The performance of the new scoring system was compared with that of conventional predictive scoring.

Results: 443 patients were in the derivation group and 217 patients in the validation group, of which 27 and 25 died during follow-up. A total of 443 patients in the derivation group, 27 of whom died during the follow-up period. Multivariate regression analysis showed that mental status, hematocrit (HCT), base excess (BE) and Serum ionic calcium (Ca^{2+}) were independent risk factors for 60-day mortality of pancreatitis, and they were used to create a new scoring system (MHBC). In the derivation and validation, the ability of MHBC (AUC= 0.922, 0.773, respectively) to predict 60-day mortality from pancreatitis was no less than that of APACHE II (AUC= 0.838, 0.748, respectively) and BISAP (AUC= 0.791, 0.750, respectively), while, MHBC is more quickly and concisely than APACHE II and BISAP. Compared with MHBC less than or equal to 2, when MHBC is greater than 2, the 28-day mortality, 60-day mortality and the incidence of AICU, MV and POF increased significantly ($P < 0.001$).

Conclusion: The MHBC can quickly and concisely evaluate the 60-day mortality, 28-day mortality, and the incidence of AICU, MV and POF of patients with acute pancreatitis in the emergency department.

Keywords: acute pancreatitis, prognosis, emergency department, arterial blood gas analysis, ABG

Introduction

Acute pancreatitis is an acute inflammatory condition of the pancreas, with broad clinical variation, ranging from mild discomfort to severe systemic complications. It's one of the most common acute abdomens in the emergency department.[1,2] The annual incidence of acute pancreatitis varies from 13 to 45 per 100000 people.[3] The overall incidence of AP is steadily rising, with a median 3.4% yearly growth rate.[4] Under the 2012 revised Atlanta classification for AP, the severity of the disease is categorized into three levels: mild, moderately severe and severe. Mild AP(MAP) lacks both organ failure (OF, which is classified by the modified Marshal scoring system) and complications. Moderately severe AP(MSAP) refers to the OF lasting for <48 h, or local complications. Severe AP(SAP) is defined by the persistence of OF(POF) longer than 48 h.[5,6] MAP patients generally recover within a few days without the need for hospitalization.[7,8] While the overall mortality is

approximately 2%, and it approaches 30% among patients with persistent failure of an organ system.[9] While, early hospitalization or intensive care unit (ICU) treatment can improve outcomes in these patients.[10] Therefore, it is crucial to identify high-risk patients quickly and effectively and initiate evidence-based intensive care.

Several scoring systems, such as the Bedside Index of Severity in Acute Pancreatitis (BISAP) and the Acute Physiology and Chronic Health Evaluation (APACHE) II tools, have sound predictive capabilities for disease severity (mild, moderately severe, and severe per the revised Atlanta classification) and mortality.[2,11–13] BISAP is widely used because of its simplicity and ease of calculation.[2,14,15]

Early and rapid identification of patients with severe AP is essential to provide appropriate care and optimize the use of limited resources, especially in the emergency department. However, BISAP was used to evaluate the condition of AP patients in the first 24 hours.[12] Because it involves blood urea nitrogen and imaging examination, with the help of the current blood biochemical examination, it will take more than 1 hour to get the BISAP score at the fastest, so it's not fast enough for the emergency department, especially the rescue room. Therefore, can we find a more rapid and efficient evaluation system to improve the evaluation efficiency of emergency departments?

Previous studies have shown that some laboratory indicators such as PH, base excess (BE), calcium, hematocrit (HCT), lactic acid (Lac) are helpful indicators of severity and prognosis in AP and can be used for the early selection of appropriate treatment.[16–22] These laboratory indicators can be quickly known by a bedside arterial blood gas analyzer (ABG). Therefore, we tried to develop a rapid prognosis scoring system based on ABG to predict the adverse outcomes in patients with acute pancreatitis in the emergency department.

Materials and Methods
Study Design
This is a single-center retrospective cohort study, conducted in accordance with the Declaration of Helsinki. Informed consent procedures were approved in writing by the Ethics Committee of West China Hospital, Sichuan University (No.2019–334). Written or oral informed consent was obtained from all participants. Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Study Population
AP patients admitted to the Emergency Department of West China Hospital of Sichuan University from January 1, 2017, to September 30, 2017 (derivation group), from August 1, 2020, to December 31, 2020 (validation group), were retrospectively enrolled. Information from the derivation group was used to establish the new scoring system, and was tested in the validation group.

Inclusion and Exclusion Criteria
Patients were included in the study if they: 1. Had been diagnosed with AP for the first time; 2. Were ≥18 years old; and 3. Met the diagnostic criteria for AP according to the revised Atlanta Classification (2012) guidelines. According to these guidelines, two of the following three features are required to diagnose of AP: persistent abdominal pain, a three-fold increase in the serum levels of amylase and/or lipase, and characteristic findings on abdominal imaging.[5] The exclusion criteria for the study were as follows: 1. Chronic pancreatitis; 2. History of malignancy; 3. AP caused by poisoning, surgical operation, or trauma; 4. Postoperative pancreatic lesions; 5. Pregnancy or perinatal period; 6. When arriving at the hospital, cardiac arrest or mechanical ventilation or vasopressor had occurred to maintain blood pressure; 7. AP is complicated with chronic diseases of liver and kidney insufficiency; 8. Incomplete clinical data; and 9. Missing follow-up information.

Data Collection
The study used data from the retrospective AP database of West China Hospital. After admission, we first collected demographic information, vital signs, mental status, medical history, laboratory test results, and imaging test findings from the database. Among them, altered mental status was defined as any record of disorientation, lethargy somnolence, coma or stupor in the medical record,[23] which is equal to mental status impaired and used in BISAP scoring system.[12] Hematological

indicators including pCO_2, pO2, BE, hematocrit (HCT), serum ionic calcium (Ca^{2+}), lactic acid (Lac) were analyzed using a Cobas-b-123 system (Roche) (An ABG analyzer); white blood cell (WBC) count, PLT, hemoglobin(Hb) and hematocrit (Hct) levels were analyzed using an automated hematology analysis system (Beckman Coulter LH750; Beckman Coulter Inc., Brea, CA, USA); total bilirubin (TBIL), alanine aminotransferase (ALT), aspartate aminotransferase (AST), albumin (ALB), glucose (GLU), Blood urea nitrogen (BUN), creatinine (Cr), triglyceride (TG), cholesterol (CHOL), high-density lipoprotein-cholesterol (HDL-C), amylase (AMY) and lipase (LIP) levels were analyzed using an Architect c16000 analyzer (Abbott Diagnostics); d-dimer and fibrinogen (FIB) levels were measured using a Sysmex CA-7000 analyzer (Siemens Healthcare Diagnostics). Risk stratification of AP patients based on the APACHE II and BISAP scores was conducted by physicians according to the baseline clinical characteristics of patients.

Quality Control

The management team supervised the recording of the data. The data were double-checked, and the medical team verified the data to ensure its authenticity and reliability when data verification was inconsistent. Follow-ups were carried out by dedicated personnel. QL analyzed and interpreted the data. CY carried out quality control on the data.

Study Follow-Up and Primary Endpoints

All patients with AP underwent a 60-day follow-up. The primary endpoint was 60-day death. Secondary endpoints were adverse outcomes, including 28-day death, the requirement for both invasive and non-invasive ventilator mechanical ventilation (MV), POF, and admission to the intensive care unit (AICU). All emergency pancreatitis patients underwent structured telephone interviews with emergency doctors to determine the all-cause mortality and other adverse consequences after 60 days. If the patient could not be contacted directly, their family members were contacted. Wrong phone numbers or inability to get patients despite three calls at different times were defined as a failure to follow up.

Establishment and Validation of the New System

In the first part of our study, we searched for independent risk factors for 60-day mortality in patients with acute pancreatitis based on ABG indicators by derivation group. We established a new scoring system using these independent risk factors. In the second part, we validate the new scoring system with additional patients.

Statistical Analysis

SPSS v 25.0 and MedCalc® Statistical Software version 18.2.1 analyzed all data. Continuous variables were presented as means + standard deviation (SD) for normally distributed data, and the difference between groups was analyzed by t-test. Other continuous variables that did not conform to the normal distribution were expressed as medians and interquartile range (IQR). The differences between groups were tested with the Mann–Whitney U-test. Categorical variables were presented as frequencies and percentages. The Chi-square test was used for categorical variables. Logistic regression analysis was used to determine the independent risk factors of 60-day death in patients with acute pancreatitis. The ROC curve to find the cut-off value of independent risk factors. Divide each independent risk factor into sub-variables according to the cut-off value. Calculate the weight of each sub variable through logistic regression. Create a new scoring system according to the importance of each sub variable. The correlation was determined using Spearman correlation test. We used the DeLong test to compare the AUCs of APACHE II, BISAP, and the new scoring system, comparing the discriminating ability of the new scoring system and other scores on 28-day mortality, 60-day mortality, AICU, MV, and POF. A two-sided p-value <0.05 was considered statistically significant for all tests.

Results

Clinical Characteristics of the Derivation Group

A total of 449 adult AP patients were included in this study, and 6 were lost to follow-up, with a loss rate of 1.34%. Finally, 443 patients were included, Their median age was 47.0 years, and this group included 278 male patients (62.75%). Of the 443 patients, 27 (6.1%) died within the 60-day follow-up period. The clinical characteristics of these patients are summarized in Table 1.

Establishment of the New System

There were 17 baseline variables with significant differences between the survival group and the death group (Table 1). First, analyze the 17 variables by logistic regression according to whether there was death during the 60-day follow-up period. Then, five independent risk factors were obtained by logistic regression analysis (BE, HCO3-, Ca^{2+}, HCT, mental status. in Table 2). Second, through ROC curve analysis, get the cut-off value of BE, HCO3-, Ca^{2+}, and HCT are −5.2mmol/L, 17.1 mmol/L, 0.98 mmol/L, 0.3, respectively. Third, divide BE, HCO_3^-, Ca^{2+}, HCT and mental status into <-5.2 mmol/L or ≥-5.2 mmol/L, <17.1 mmol/L or ≥17.1 mmol/L, <0.98 mmol/L or ≥0.98 mmol/L, <0.3 or ≥0.3, impaired mental status or not respectively, eight sub-variables in total. Last, calculate the weight of each sub variable through logistic regression analysis; the HCO_3^- was excluded in the end. The weights and scores of the remaining sub-variables are shown in Table 3, and we named the new scores system MHBC according to the weight and the corresponding initials.

Table 1 Comparison of Characteristics of Survival and Death in Derivation Cohort

Variable	Survival (416)	Death (27)	$t/Z/\chi^2$	p
Baseline variables				
Age (years)	48.58±15.12	35.67±14.16	−0.974	0.331
Male, n (%)	263 (63.2%)	15 (55.6%)	0.637	0.425
Temperature (°C)	36.83±0.63	36.83±0.45	−0.022	0.983
Heart rate (beats/min)	22.72±4.92	28.37±7.16	5.600	0.000**
Breathing rate (beats/min)	103.13±23.27	125.52±23.80	4.838	0.000**
MAP (mmHg)	83.03±13.62	81.93±16.47	−0.404	0.686
Impaired mental status, n (%)	24 (5.8%)	17 (63%)		0.000**
PCO_2 (mmHg)	32.16±14.07	34.27±10.51	0.766	0.444
PO_2 (mmHg)	98.02±33.91	92.81±29.41	−0.779	0.437
BE (mmol/L)	−2.77±3.82	−6.39±6.30	−4.559	0.000**
HCO_3^-(mmol/L)	20.59±3.83	18.82±6.85	−2.184	0.029*
Lac (mmol/L)	1.50 (1.20, 2.20)	2.60 (1.70, 3.30)	−3.751	0.000**
Ca^{2+}(mmol/L)	0.96±0.15	0.83±0.17	−4.444	0.000**
HCT	0.40±0.06	0.36±0.11	−2.520	0.012*
WBC (10^9/L)	14.16±5.64	17.21±7.56	2.661	0.008**
PLT (10^9/L)	161.50 (121.25, 200.75)	152.00 (96.00, 186.00)	−0.876	0.381
TBIL (μmol/L)	31.03±1.74	49.54±13.40	2.433	0.015*
ALT (IU/L)	32.65 (18.00, 67.00)	33.00 (15.00, 45.00)	−0.562	0.574
AST (IU/L)	32.00 (21.00, 65.75)	70.00 (40.00, 93.00)	−3.676	0.000**
ALB (g/L)	36.70 (31.70, 41.70)	31.00 (28.30, 37.10)	−3.749	0.000**
GLU (mmol/L)	8.26 (6.37, 11.72)	12.39 (7.41, 16.74)	−2.731	0.006**
BUN (mmol/L)	4.86 (3.40, 6.85)	11.26 (6.01, 15.28)	−5.154	0.000**
Cr (mg/dL)	67.50 (55.00, 88.75)	129.00 (78.00, 324.00)	−5.116	0.000**
Triglyceride (mmol/L)	2.08 (1.10, 5.48)	2.91 (1.36, 6.41)	−0.822	0.411
Cholesterol (mmol/L)	4.17 (3.23, 5.81)	3.42 (2.12, 5.19)	−2.023	0.043*
HDL-C (mmol/L)	0.86 (0.55, 1.18)	0.46 (0.25, 0.85)	−3.362	0.001**
AMY (IU/L)	220.50 (93.25, 636.50)	843.00 (83.00, 1395.00)	−2.179	0.029*
LIP (IU/L)	266.00 (99.50, 828.25)	555.00 (165.00, 1445.00)	−2.148	0.032*
Fib (g/L)	4.45 (3.20, 6.96)	4.28 (2.65, 7.30)	−0.324	0.746
D-dimer (mg/L)	3.41 (1.26, 6.70)	5.94 (3.52, 12.54)	−3.782	0.000**
Scores				
APACHE II	6 (4, 10)	13 (10, 16)	−5.871	0.000**
BISAP	2 (1, 2)	3 (2, 3)	−5.346	0.000**

Note: *p<0.05, **p<0.01.
Abbreviations: MAP, mean arterial pressure; PCO_2, arterial carbon dioxide partial pressure; PO_2, arterial oxygen partial pressure; BE, whole blood base excess; HCO_3^-, bicarbonate ion; Lac, lactic acid; Ca^{2+}, serum ionic calcium; HCT, hematocrit; WBC, white blood cell; PLT, platelet; TBIL, total bilirubin; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ALB, albumin; GLU, glucose; BUN, blood urea nitrogen; Cr, serum creatinine; HDL-C, high-density lipoprotein-cholesterol; AMY, amylase; LIP, lipase; Fib, Fibrinogen; APACHE II, acute physiology and chronic health evaluation II; BISAP, bedside index for severity in acute pancreatitis.

Table 2 Results of Uni/Multi-Variate Ordinal Logistic Regression Analysis in Derivation Cohort

Variable	β	S. E	Wals	p	OR	95% CI	
						5%	95%
Heart rate (beats/min)	0.016	0.017	0.961	0.327	1.016	0.984	1.050
Breathing rate (beats/min)	0.092	0.058	2.476	0.116	1.096	0.978	1.228
Mental status (Impaired or not)	−2.538	0.634	16.050	0.000**	0.079	0.023	0.273
Lac (mmol/L)	0.260	0.203	1.640	0.200	1.296	0.871	1.928
BE (mmol/L)	−0.576	0.202	8.141	0.004**	0.562	0.379	0.835
HCO_3^- (mmol/L)	0.610	0.202	9.123	0.003**	1.841	1.239	2.736
Ca^{2+} (mmol/L)	−4.588	1.682	7.445	0.006**	0.010	0.000	0.275
HCT	−13.447	4.984	7.280	0.007**	0.000	0.000	0.025
WBC (10^9/L)	0.092	0.048	3.661	0.056	1.096	0.998	1.204
TBIL (μmol/L)	0.013	0.006	3.825	0.050	1.013	1.000	1.026
ALB (g/L)	−0.002	0.017	0.009	0.923	0.998	0.965	1.033
GLU (mmol/L)	0.040	0.042	0.913	0.339	1.041	0.958	1.131
BUN (mmol/L)	0.064	0.080	0.637	0.425	1.066	0.911	1.246
Cr (μmol/L)	−0.001	0.004	0.020	0.889	0.999	0.991	1.008
HDL-C(mmol/L)	1.249	0.849	2.165	0.141	3.487	0.965	18.405
AMY (IU/L)	0.001	0.000	1.755	0.185	1.001	0.661	1.002
D-dimer (mg/L)	0.006	0.043	0.020	0.888	1.006	1.000	1.094

Note: **$p < 0.01$.
Abbreviations: BE, whole blood base excess; HCO_3^-, bicarbonate ion; Ca^{2+}, serum ionic calcium; HCT, hematocrit; WBC, white blood cell; PLT, platelet; TBIL, total bilirubin; ALB, albumin; GLU, glucose; BUN, blood urea nitrogen; Cr, serum creatinine; HDL-C, high-density lipoprotein-cholesterol; AMY, amylase.

Correlation Between the MHBC and Other Prognostic Scores in the Derivation Group

In addition, we analyzed MHBC association with APACHE II and BISAP—the most widely used scoring systems for pancreatitis severity. A significant positive correlation was observed between The MHBC and APACHE II (r=0.491, P < 0.001) and BISAP (r=0.489, P < 0.001). These findings confirmed the usefulness of MHBC in assessing AP severity.

MHBC and Adverse Outcomes in the Derivation Group

The 28-day mortality, 60-day mortality, AICU, MV, and POF rates gradually increased as the MHBC increased. Especially when MHBC is greater than 2, the incidence of adverse outcomes are significantly higher than when MHBC is equal to or less than 2.

Table 3 Weight and Score of Scoring Items in the New Scoring System (MHBC)

		β	OR	p	score
BE (mmol/L)	≥-5.2				0
	<-5.2	1.962	7.110	0.000**	2
Ca^{2+} (mmol/L)	≥0.98				0
	<0.98	1.917	6.798	0.003**	2
HCT	≥0.3				0
	<0.3	2.439	11.456	0.000**	2
Mental status	Unimpaired				0
	Impaired	2.701	14.889	0.000**	3

Note: **$p < 0.01$.
Abbreviations: BE, whole blood base excess; Ca^{2+}, serum ionic calcium; HCT, hematocrit.

There were significant differences in the incidence of 28-day mortality, 60-day mortality, AICU, MV, and POF between the two groups, and these detailed data are shown in the Table 4.

Comparison Between the MHBC and Other Prognostic Scores in in Derivation Cohort

We also assessed the performances of MHBC, APACHE II, and BISAP in the prediction of 60-day mortality, 28-day mortality, AICU, MV and POF. As shown in Table 5, the ability of MHBC to predict 60-day mortality, 28-day mortality and AICU is better than APACHE II respectively ($p=0.021<0.05$, $p=0.026<0.05$ and $p=0.009<0.05$, respectively), and is comparable to APACHE II in MV ($p=0.056$) and POF ($p=0.088$). Compared with BISAP, MHBC has more advantages in predicting 60-day mortality ($p=0.003<0.05$) and AICU ($p=0.045<0.05$), and is equivalent in predicting 28-day mortality ($p=0.092$), MV ($p=0.396$) and POF ($p=0.887$).

Validation of the Ability of MHBC to Predict the Prognosis of AP

To validate the predictive performance of MHBC, we collected an additional 217 AP patients. Their median age was 48.6 years, and this group included 140 male patients (64.5%). Of the 217 patients, 25 patients (11.5%) died within the 60-day follow-up period. We compared the performances of MHBC, APACHE II and BISAP in the prediction of 60-day mortality, 28-day mortality, AICU, MV, and POF. We found that the ability of MHBC to predict these adverse outcomes was comparable to APACHE II ($p= 0.668, 0.797, 0.751, 0.348, 0.401$, respectively), and BISAP ($p= 0.736, 0.896, 0.981, 0.594, 0.635$, respectively) (Table 6).

Discussion

There are various scoring systems in AP. Some are designed to predict severity and some are designed to predict mortality. However, whether it is to predict mortality or severity, its ultimate goal is to try to improve treatment or adjust treatment through early evaluation to improve prognosis, such as APACHE II,[24] BISAP,[12] Ranson criteria,[25] Balthazar grade systems,[26] etc. Among them, Ranson criteria needs to measure the test indicators at the time of admission and 48 hours after admission, so its application is greatly limited, Balthazar grade systems is limited in repeated measurement due to the need for CT. Although APACHE II and BISAP have their own limitations, they are currently widely used.[13,27–29] The emergency department should not only pay attention to the severity of the patient's condition, but also pay attention to what kind of medical resources the patient needs, and pay more attention to the allocation and utilization of resources, so that patients can receive effective treatment and avoid resource waste. Therefore, it is particularly important for the emergency department to quickly evaluate the adverse outcomes of patients. BISAP is the most concise,[12,14] but it's not fast enough for the emergency department. Therefore, we derived and validated a rapid prognostic scoring system

Table 4 Comparison of Adverse Prognosis in Patients with Acute Pancreatitis with Different MHBC Scores in Derivation Cohort

Outcomes, n (%)	MHBC		χ^2	p
	≤2	>2		
60-day death	3 (0.9%)	24 (23.8%)	71.35	<0.001
28-day death	2 (0.6%)	15 (14.9%)	43.00	<0.001
AICU	22 (6.4%)	52 (51.5)	113.74	<0.001
MV	67 (19.6%)	61 (60.4%)	63.19	<0.001
POF	68 (19.9%)	72 (71.3%)	95.31	<0.001

Abbreviations: AICU, admission to the intensive care unit; MV, requirement for mechanical ventilation; POF, persistent organ failure.

Table 5 AUC Comparison of Adverse Outcome Prediction Based on MHBC, APACHE II and BISAP in Derivation Cohort

	Scores	AUC (95% CI)	SE	*P*- value	*P* for Comparison
60-day death	MHBC	0.922(0.893,0.945)	0.025	<0.001	Ref
	APACH II	0.838(0.798,0.869)	0.035	<0.001	0.021*
	BISAP	0.791(0.750,0.828)	0.048	<0.001	0.003**
28-day death	MHBC	0.897(0.865,0.924)	0.032	<0.001	Ref
	APACH II	0.869(0.833,0.899)	0.043	<0.001	0.026*
	BISAP	0.814(0.775,0.849)	0.058	<0.001	0.092
AICU	MHBC	0.846(0.808, 0.878)	0.028	<0.001	Ref
	APACH II	0.777(0.735, 0.815)	0.028	<0.001	0.009**
	BISAP	0.781(0.740, 0.819)	0.031	<0.001	0.045
MV	MHBC	0.722 (0.677, 0.763)	0.028	<0.001	Ref
	APACH II	0.775(0.734, 0.813)	0.024	<0.001	0.056
	BISAP	0.746 (0.703, 0.786)	0.026	<0.001	0.396
POF	MHBC	0.753 (0.710, 0.793)	0.025	<0.001	Ref
	APACH II	0.799(0.758, 0.835)	0.023	<0.001	0.088
	BISAP	0.757(0.714, 0.796)	0.023	<0.001	0.887

Note: *$p < 0.05$, **$p < 0.01$.
Abbreviations: APACHE II, acute physiology and chronic health evaluation II; BISAP, bedside index for severity in acute pancreatitis; MHBC, A new rapid prognostic scoring system for acute pancreatitis was established in this study.

Table 6 AUC Comparison of Adverse Outcome Prediction Based on MHBC, APACHE II and BISAP in Validation Cohort

	Scores	AUC (95% CI)	SE	*P*- value	*P* for Comparison
60-day death	MHBC	0.773(0.712,0.827)	0.0511	<0.001	Ref
	APACH II	0.748(0.685,0.804)	0.0482	<0.001	0.668
	BISAP	0.750(0.687,0.806)	0.0488	<0.001	0.736
28-day death	MHBC	0.770(0.709,0.825)	0.0532	<0.001	Ref
	APACH II	0.754(0.691,0.810)	0.0470	<0.001	0.797
	BISAP	0.761(0.698,0.816)	0.0469	<0.001	0.896
AICU	MHBC	0.746(0.683,0.803)	0.0424	<0.001	Ref
	APACH II	0.733(0.669,0.791)	0.0417	<0.001	0.751
	BISAP	0.745(0.682,0.802)	0.0332	<0.001	0.981
MV	MHBC	0.785(0.725,0.838)	0.0305	<0.001	Ref
	APACH II	0.750(0.686,0.806)	0.0336	<0.001	0.348
	BISAP	0.806(0.747,0.856)	0.0253	<0.001	0.594
POF	MHBC	0.810(0.752,0.860)	0.0283	<0.001	Ref
	APACH II	0.780(0.718,0.833)	0.0315	<0.001	0.401
	BISAP	0.792(0.732,0.844)	0.0263	<0.001	0.635

Abbreviations: APACHE II, acute physiology and chronic health evaluation II; BISAP, bedside index for severity in acute pancreatitis; MHBC, A new rapid prognostic scoring system for acute pancreatitis was established in this study.

based on AP patients for rapid prediction of adverse outcomes (ie mortality, AICU, MV, POF) in the emergency department, and named it MHBC. Using the scoring system constructed by impaired mental status, ionic calcium, BE, and HCT, we may be able to quickly assess the risk of adverse outcomes of AP patients after they arrive at the emergency department.

In the present study, we found that MHBC has a significant positive correlation with APACHE II and BISAP. In subgroup analysis, we found that the risk of poor prognosis was significantly higher in patients with AP when MHBC was greater than 2. That is, when a patient's mental state is impaired or any two of the four indicators are met at the same time, it is considered to have a higher risk of adverse consequences. In the derivation cohort, MHBC was superior to APACHE II and BISAP in predicting the risk of 60-day mortality in patients with pancreatitis. However, in the validation set, the ability of MHBC to predict the risk of 60-day mortality was comparable to APACHE II and BISAP. This discrepancy may be due to the fact that MHBC is derived from the derivation group. Therefore, we compared it with further prognostic evaluation in the validation group, and the ability of MHBC to predict 28-day mortality, and the incidence of MV, AICU, POF was comparable to APACHE II and BISAP.

The main advantage of MHBC is its rapidity. Compared with BISAP, the new score (MHBC) in this study does not have particularly outstanding predictive ability. But the new score (MHBC) can be obtained more quickly than BISAP. For the emergency department, its significance lies in the rapid and efficient assessment of the condition, which is conducive to identify, classify and triage patients, thus optimizing the use of medical resources.

In the new score MHBC, Be, Ca^{2+}, and HCT contributed 2 points respectively, impaired mental status contributed 3 points to a total 9 points score. Without any additional calculation, we can obtain the results of BE, Ca^{2+}, and HCT directly from ABG, and it does not take more than 15 min from blood sampling to get the ABG result. The only subjective parameter in the new scoring system is the assessment of mental status. We utilized impaired mental status in BISAP, defined as any documentation of disorientation, lethargy, coma, or stupor in the medical record.[12] After a physical examination, the doctor can quickly obtain the mental status of the patient. Therefore, the fraction of MHBC can be completed in a concise time. In MHBC, all indicators are binomial. Although in order to achieve higher accuracy, people are more and more inclined to not use the "binomial" scoring system, on the premise of ensuring accuracy, the concise characteristics of the "binomial" scoring system are more suitable for scenarios requiring rapid assessment, such as emergency departments.

In addition, BE, Ca^{2+}, and HCT used in this study were predictors of poor outcomes in AP in previous studies. But there are some differences.

BE has been shown to accurately reflect the changes in oxygen delivery and oxygen consumption during compensated shock and is one of the most commonly used endpoints of therapy or resuscitation,[30] and it has been repeatedly reported to be an independent risk factor for the prognosis of AP. When base excess < - 3.0 mmol/L, the risk of adverse outcomes increase.[21,31–33] In our study, we found that BE lower than −5.2 may be an independent factor for the early prediction of adverse outcomes in AP patients.

Hypocalcemia is not uncommon during acute pancreatitis and is associated with a poor outcome.[34] Many studies showed that Serum calcium is a valuable predictor of the severity of acute pancreatitis.[17,21,22,31,35] However, the serum calcium used in these studies is serum total calcium. The calcium used in this study is serum ionic calcium obtained from ABG measurement (a Cobas-b-123 system (Roche)), which is an integral part of serum total calcium. In this study, it was found that when serum ionized calcium was lower than 0.98 mmol/l, the incidence of adverse outcomes of pancreatitis were significantly increased.

Early fluid resuscitation is recommended to reduce morbidity and mortality among patients with acute pancreatitis.[36] However, rapid hemodilution is associated with increased sepsis and mortality in patients with severe acute pancreatitis.[18] Many studies have shown that HCT is closely related to the prognosis of pancreatitis, and it is used as a reference index for the endpoint of fluid resuscitation.[37] It is recommended to keep the HCT between 0.3 and 0.4 during fluid resuscitation in the past research.[18] In this study, we found that 0.3 was the cut-off value of HCT in predicting poor prognosis. When HCT was less than 0.3, the incidence of poor prognosis increased significantly. This may be because most AP patients in our hospital are referred from other hospitals. They had been treated to some degree in other hospitals before they came. Most of them had been treated with excessive fluid resuscitation. Therefore, determining the relationship between early rehydration rate, rehydration volume, and prognosis in patients with pancreatitis may be the focus of our future research.

Limitations

There are several limitations to the present study. For one, the study design was retrospective and is thus susceptible to potential selection bias, and specific clinical or laboratory details corresponding to individual patients may have been poorly documented. Second, the West China Hospital of Sichuan University is the largest tertiary A hospital in Western China, and the patients admitted to this center are in relatively severe condition. Therefore, the proportion of severe patients with persistent organ dysfunction in our study population was relatively high. Third, it may be the cause of COVID-19, the prevention and control measures of COVID-19 reduced the willingness of patients to be referred, which resulted in fewer patient referrals between hospitals, leading to more critically ill patients in the validation group than in the derivation group. Fourth, mental status is a subjective indicator, which has a certain impact on the rigor of scoring. Fifth, Severe comorbidities themselves have poor prognosis, so we excluded some comorbidities, which may reduce the universality of the study. Studies with larger data are needed to further analyze the possible impact of these comorbidities on the prognosis of AP patients. Hence, multicenter prospective studies with a large sample size are necessary to validate our findings in the future.

Conclusions

The rapid scoring system MHBC based on ABG analysis created in this study is not different from the previous classical scoring systems APACHE II and BISAP in predicting the incidence of adverse outcomes in AP patients. Still, its concise and rapid characteristics may be particularly suitable for the emergency department to evaluate the adverse outcomes of pancreatitis.

Disclosure

The authors declare that they have no conflicts of interest.

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