Accuracy of Conventional and Novel Scoring Systems in Predicting Severity and Outcomes in Acute Pancreatitis: A Retrospective Study

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Abstract

Background: Recently there are several novel scoring systems to evaluate the severity and outcomes of acute pancreatitis. This study is to compare the effectiveness of novel and traditional scoring systems for predicting severity and outcomes in acute pancreatitis.

Methods: Patients between January 2003 and August 2020 were reviewed. Ranson score (RS), Glasgow score (GS), bedside index of severity in acute pancreatitis (BISAP), pancreatic activity scoring system (PASS), and Chinese simple scoring system (CSSS) were determined within 48h after admission. Multivariate logistic regression was used for severity, mortality, and organ failure prediction. Optimum cutoffs were identified using ROC analysis.

Results: A total of 1848 patients were included. AUCs of RS, GS, BISAP, PASS, and CSSS for severity prediction were 0.861, 0.865, 0.829, 0.778, and 0.816, respectively. AUCs for mortality prediction were 0.693, 0.736, 0.789, 0.858, and 0.759. AUCs for ARDS prediction were 0.745, 0.784, 0.834, 0.936, and 0.820. AUCs for ARF prediction were 0.707, 0.734, 0.781, 0.868, and 0.816.

Conclusions: RS, and GS predict severity superior to mortality and organ failure while PASS predicts mortality and organ failure better. BISAP and CSSS shared steady capacity in severity and outcomes prediction.

Background

Acute pancreatitis (AP) is an inflammatory disease of the pancreas with a worldwide incidence varying from 33.2/100,000 to 45/100,000 in the general population[1-3]. Approximately 10%~20% of patients with AP have a severe clinical course, with significant morbidity and mortality due to local and systemic complications[3-6]. Acute respiratory distress syndrome (ARDS) and acute renal failure (ARF) are common complications of SAP, and result in worse outcomes[7-9]. Therefore, the early detection of ARDS and ARF in patients with AP is indispensable.

Many studies have compared biochemical markers and various scoring systems in the early stage to predict disease course and outcomes in AP[10-13]. Conventional scoring systems, including the Ranson score (RS), Glasgow score (GS), and acute physiology, chronic health Evaluation (APACHE) II score, and bedside index of severity in acute pancreatitis (BISAP) have been used to assess the severity of AP. However, these scores are complicated and require multiple difficult clinical parameters for risk stratification. Although biomarkers are easy to obtain, their ability in predicting outcomes varies[14-17]. Recently, some novel scoring systems have been reported. A prospective cohort study[18] showed that Pancreatic activity scoring system (PASS) (Table 1), first reported by Southern California Pancreas Study Group in 2017[19], could forecast important clinical events at different points in AP course. Another new scoring system called Chinese simple scoring system (CSSS) (Table 2) was proposed in 2020 [20]. Both scores haven't been widely used yet.

The present study aimed to specifically determine the accuracy of these traditional and newly scoring systems as well as biomarkers in predicting severity, mortality, and organ failure in patients with AP.

Materials And Methods

Study design and patient selection

A retrospective study was conducted. Records of patients with AP from January 2003 to July 2020 in our hospital were reviewed.

Patients were diagnosed with AP if they met at least two of the following three criteria: (1) abdominal pain consistent with AP, (2) serum lipase activity or amylase activity at least three times greater than the upper limit of normal, and (3) characteristic findings on abdominal imaging. Patients younger than 16 years, or known to have chronic pancreatitis, or without sufficient data were excluded from the study.

Definitions of severity and organ failure

Severity of AP was evaluated based on the revised Atlanta classification[21]. Mild AP was defined as AP in the absence of organ failure and local/systemic complications. Severe AP was characterized by the presence of organ failure and/or local complications. Organ failure was defined according to the modified Marshall scoring system[22].

Biochemical markers, scoring systems, and their cutoffs

Biochemical markers measured within 48 h after admission were analysed. RS[23], GS[24], BISAP[25], PASS[19], and CSSS[20] were calculated for each patient within 48 h after admission. Scores were compared for their accuracy in the prediction of disease severity, mortality, and development of organ failure (ARDS and ARF).

Statistical analysis

SPSS v23.0 (IBM Corp., Armonk, NY) was used for statistical analyses. Continuous variables were displayed as mean $\pm$ standard deviation. The Student t-test was used for continuous variables. The chi-square test was used for categorical variables. Univariate and multivariate logistic regression analyses were carried out to identify risk factors. Potential risk factors with $P < 0.05$ in the univariate analyses were enrolled into the binary logistic backward stepwise regression analysis. The results are presented as odds ratios (OR) with 95% confidence intervals (CIs). ROC curves of the scores were used for the prediction of severe AP, mortality, ARDS, and ARF. Areas under the curve (AUCs) were used to evaluate the predictive accuracy of each scoring system. All optimum cutoffs were identified on the basis of highest sensitivity and specificity values generated from the ROC curves. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. A P value of less than 0.05 was considered as statistical significance.

Results

Baseline characteristics

Among 1848 patients enrolled, 1164 (62.99%) were mild AP and 684 (37.01%) were severe AP. Mean age of the patients was 48.22 ± 16.21 years. Mean age of severe group was older than that of mild group ($P < 0.001$). A male preponderance (68.19%) was found. ARF was more common in male gender than female gender ($P < 0.001$). A higher BMI was observed in the severe group than that in the mild group ($P < 0.001$). BMI of patients with ARDS/ARF were higher than those without ARDS/ARF ($P < 0.05$) (Table 3). Gallstones (38.47%) were the most common cause of AP, followed by hypertriglyceridemia (16.72%) and alcohol consumption (10.77%). Alcohol-associated pancreatitis was more common in severe AP group, ARDS group, and ARF group (Table 3). Hyperlipidemia (14.88%) and type-2 diabetes mellitus (7.52%) were common comorbidities. Numbers of smoking and alcohol intake history were 541 (29.27%) and 591 (31.98%), respectively. Alcohol consumption was more common in patients with severe AP ($P < 0.001$), ARDS ($P = 0.002$), and ARF ($P < 0.001$) (Table 3). Longer hospital stay was observed in patients with severe AP than in patients with mild AP ($P < 0.001$). Mortality of severe AP group was much higher than that of mild group ($P < 0.001$) (Table 3).

Biomarkers in Predicting Severity, Mortality, and Organ Failure

In the multivariate analysis, white blood cell count, serum albumin, LDH, calcium, glucose, and CRP predicted severity of AP. Their ORs for predicting severe AP were 5.429 (95% CI, 2.5-12), 2.551 (95% CI, 1.1-5.7), and 2.661 (95% CI, 1.3-5.3), respectively. Serum total bilirubin was taken as an independent factor for mortality prediction (OR, 1.013; 95% CI, 1.004-1.023). For predicting organ failure, body mass index, blood leukocyte, and serum calcium were independent variables for ARDS, while blood urea nitrogen and serum triglyceridemic were independent variables for ARF. However, among them only serum calcium showed a better OR value (Table 4).

Scoring Systems in Predicting Severity, Mortality, and Organ Failure

For severe AP prediction, ROC curve indicated an area under the curve (AUC) of 0.861 for RS, 0.865 for GS, 0.829 for BISAP, 0.778 for PASS, and 0.816 for CSSS, respectively. Cutoffs were as following: RS of at least 2, GS of at least 2, BISAP of at least 2, PASS of at least 90, and CSSS of at least 2 (Table 5, Fig.1A). For mortality prediction, AUCs of scoring systems were as following: 0.693 for RS, 0.736 for GS, 0.789 for BISAP, 0.858 for PASS, and 0.759 for CSSS. Cutoffs of scoring systems for mortality prediction were as followings: RS of at least 3, GS of at least 2, BISAP of at least 3, PASS of at least 190, and CSSS of at least 3 (Table 5, Fig.1B). For ARDS prediction, AUCs of scoring systems were as following: 0.745 for RS, 0.784 for GS, 0.834 for BISAP, 0.936 for PASS, and 0.820 for CSSS. Cutoffs of RS, GS, BISAP, and CSSS were all of at least 2, and cutoff of PASS was of at least 195 (Table 5, Fig.1C). For ARF prediction, AUCs of scoring systems were as following: 0.707 for RS, 0.734 for GS, 0.781 for BISAP, 0.868 for PASS, and 0.816 for CSSS. Cutoffs of RS, GS, BISAP, and CSSS were all of at least 3, and cutoff of PASS was of at least 65 (Table 5, Fig.1D).

Discussion

In the present study, BMI was an independent factor of development of ARDS in AP, consistent with a meta-analysis, which demonstrated obesity as an important risk factor for the development of ARDS[26]. This probably due to higher levels of circulating neutrophil[27] and low grade of chronic inflammation triggered by obesity[28].

Our study revealed serum Ca^{2+} showed good ORs for severity and ARDS prediction. Abnormal regulation of Ca^{2+} signals act as a crucial trigger in pathogenesis of AP[29]. Study showed that hypocalcemia was an independent risk factor of severe AP and respiratory failure in AP[30]. According to the present study, WBC predicted development of severe AP and ARDS. Besides, serum albumin, glucose, LDH, and CRP are also predictive factors of severe AP. These biomarkers are common factors to predict severe AP. As for mortality prediction, multivariate analysis identified increase of serum total bilirubin was a risk factor. Although few studies reported certain relationship between total bilirubin and mortality in AP, some studies clarified that albumin-bilirubin (ALBI) score has high predictive capacity for in-hospital mortality or prognosis in patients with critical diseases such as acute upper gastrointestinal bleeding due to liver cirrhosis[31], post-operation of hepatic carcinoma[32, 33] and acute pancreatitis[34]. Moreover, our study showed that elevation of serum triglyceride was a risk factor of ARF in AP, which was consistent with the meta-analysis reported in 2018[35].

RS, GS, and BISAP showed high accuracy in predicting severity rather than outcomes of AP in the present study. RS and GS predicted the severity and three outcomes of AP equally well, which was probably due to similar parameters they shared. Though simple, they are not repeatable. According to our study, BISAP was inferior to both RS and GS in predicting severity, which was consistent with other prospective studies[36, 37]. For items in RS and GS cover more systems than those in BISAP. Nevertheless, BISAP was superior to RS and GS in predicting mortality in the present study. Hall et al also found that RS and GS were not good indicators of mortality in AP[38]. BISAP was also better at predicting ARDS and ARF than RS and GS, possibly because it is based on three important items that are related to the renal and respiratory systems, such as BUN, SIRS, and pleural effusion.

PASS was a system that assesses activity of AP at any time of hospitalization. It contents not only object items (organ failure and SIRS), but also subject items (abdominal pain, morphine usage and ability to tolerate solid diet). The repeatable items make it available at any time of hospitalization. A prospective study[18] demonstrated that an AUC of 0.71 for PASS with cutoff ≥ 140 in predicting severe AP on admission. We shared similar AUC of PASS for severe AP prediction. As our center rarely use morphine to release abdominal pain of patients with AP, so the cutoff for severity prediction was only 90. In the present study, PASS scores predicted best in mortality and organ failure, especially for ARDS prediction. For PASS contents organ failure items. But the subject items (such as abdominal pain, morphine usage and ability to tolerate solid diet) make it inferior to other scores in severity prediction. So far, no more studies report the predictive ability of PASS in outcomes of AP.

Four biomarkers, heart rate, and pancreatic image are enrolled in CSSS. According to the present study, AUCs of CSSS for severity and mortality were 0.834 and 0.838, respectively. And cutoff points were 4 for severity and 6 for mortality. However, our study showed a smaller AUCs and smaller cutoff points comparing to the original study[20]. This probably because sample size of our study was larger than that of the original study. In our study, CSSS showed nearly the same ability in predicting the four outcomes of AP and it shared nearly equal capacity with BISAP in predicting outcomes of AP, which indicates that CSSS is a promising scoring system. However, no more studies referring to CSSS are found. Hence, larger sample size and prospective studies are needed to verify the efficiency of this new score.

Comparison of both conventional and novel scoring systems, as well as biomarkers with a large number of Chinese populations in prediction of severity and outcomes in AP is the characteristics of the present study. Yet it is a study of retrospective and single center. Besides, there was diversity in the period between the onset of AP and admission. This probably resulted in heterogeneity in the timings of score calculations and biochemical marker measurements.

Conclusion

RS, and GS predict severity superior to mortality and organ failure while PASS predicts mortality and organ failure better. BISAP and CSSS shared steady capacity in severity and outcomes prediction. More prospective multicenter studies are needed to confirm the value of novel scoring systems in predicting the severity and outcomes of AP.

Abbreviations

ARF: Acute renal failure; ARDS: Acute respiratory distress syndrome; RS: Ranson score; GS: Glasgow score; APACHE: Acute physiology and chronic health evaluation; BISAP: Bedside index of severity in acute pancreatitis; PASS: Pancreatic activity scoring system; CSSS: Chinese simple scoring system; AUC: Areas under the curve; ROC: Receiver operating characteristic; BMI: body-mass index; T2DM: type-2 diabetes mellitus; WBC: White blood cell count; BUN: Blood urea nitrogen; LDH: Lactate dehydrogenase; CRP: C-reactive protein; AST: Aspartate transaminase

Declarations

Acknowledgements

None.

Authors' contributions

QW and JW contributed in the conception of the work, designing the study, collecting biochemical data and revising the draft. MQ and GDT contributed in the conception of the work and designing the study. HYY contributed in the conception of the work and collecting the biochemical data. ZHL contributed in the conception of the work, conducting the study and revising the draft. All authors approved the final manuscript.

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Availability of data and materials

All data used in this study are available from the corresponding author.

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of First Affiliated Hospital of Guangxi Medical University (No. 2020(KY-E-177)).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no Competing interests.

References

1. Frey CF, Zhou H, Harvey DJ and White RH. The incidence and case-fatality rates of acute biliary, alcoholic, and idiopathic pancreatitis in California, 1994-2001. *Pancreas* 2006; 33: 336-344.
2. Satoh K, Shimosegawa T, Masamune A, Hirota M, Kikuta K, Kihara Y, et al. Nationwide epidemiological survey of acute pancreatitis in Japan. *Pancreas* 2011; 40: 503-507.
3. Shen HN, Lu CL and Li CY. Epidemiology of first-attack acute pancreatitis in Taiwan from 2000 through 2009: a nationwide population-based study. *Pancreas* 2012; 41: 696-702.

4. Hamada S, Masamune A, Kikuta K, Hirota M, Tsuji I, Shimosegawa T, et al. Nationwide epidemiological survey of acute pancreatitis in Japan. *Pancreas* 2014; 43: 1244-1248.
5. Frossard JL, Steer ML and Pastor CM. Acute pancreatitis. *Lancet* 2008; 371: 143-152.
6. Zhu Y, Pan X, Zeng H, He W, Xia L, Liu P, et al. A Study on the Etiology, Severity, and Mortality of 3260 Patients With Acute Pancreatitis According to the Revised Atlanta Classification in Jiangxi, China Over an 8-Year Period. *Pancreas* 2017; 46: 504-509.
7. Naqvi R. Acute Kidney Injury in association with Acute Pancreatitis. *Pak J Med Sci* 2018; 34: 606-609.
8. Lin HY, Lai JI, Lai YC, Lin PC, Chang SC and Tang GJ. Acute renal failure in severe pancreatitis: A population-based study. *Ups J Med Sci* 2011; 116: 155-159.
9. Manohar M, Verma AK, Venkateshaiah SU, Sanders NL and Mishra A. Chronic Pancreatitis Associated Acute Respiratory Failure. *MOJ Immunol* 2017; 5.
10. Tan YHA, Rafi S, Tyebally Fang M, Hwang S, Lim EW, Ngu J, et al. Validation of the modified Ranson versus Glasgow score for pancreatitis in a Singaporean population. *ANZ J Surg* 2017; 87: 700-703.
11. Jones MJ, Neal CP, Ngu WS, Dennison AR and Garcea G. Early warning score independently predicts adverse outcome and mortality in patients with acute pancreatitis. *Langenbecks Arch Surg* 2017; 402: 811-819.
12. Vasudevan S, Goswami P, Sonika U, Thakur B, Sreenivas V and Saraya A. Comparison of Various Scoring Systems and Biochemical Markers in Predicting the Outcome in Acute Pancreatitis. *Pancreas* 2018; 47: 65-71.
13. Zheng J, Fan J, Huang C, Lu Y, Huang Z, Wang X, et al. Dynamic Detection of Monocyte Subsets in Peripheral Blood of Patients with Acute Hypertriglyceridemic Pancreatitis. *Gastroenterol Res Pract* 2019; 2019: 5705782.
14. Cho JH, Kim TN, Chung HH and Kim KH. Comparison of scoring systems in predicting the severity of acute pancreatitis. *World J Gastroenterol* 2015; 21: 2387-2394.
15. Kiat TTJ, Gunasekaran SK, Junnarkar SP, Low JK, Woon W and Shelat VG. Are traditional scoring systems for severity stratification of acute pancreatitis sufficient? *Ann Hepatobiliary Pancreat Surg* 2018; 22: 105-115.
16. Hagjer S and Kumar N. Evaluation of the BISAP scoring system in prognostication of acute pancreatitis - A prospective observational study. *Int J Surg* 2018; 54: 76-81.
17. de Grooth HJ, Geenen IL, Girbes AR, Vincent JL, Parienti JJ and Oudemans-van Straaten HM. SOFA and mortality endpoints in randomized controlled trials: a systematic review and meta-regression analysis. *Crit Care* 2017; 21: 38.
18. Buxbaum J, Quezada M, Chong B, Gupta N, Yu CY, Lane C, et al. The Pancreatitis Activity Scoring System predicts clinical outcomes in acute pancreatitis: findings from a prospective cohort study. *Am J Gastroenterol* 2018; 113: 755-764.
19. Wu BU, Batech M, Quezada M, Lew D, Fujikawa K, Kung J, et al. Dynamic Measurement of Disease Activity in Acute Pancreatitis: The Pancreatitis Activity Scoring System. *Am J Gastroenterol* 2017; 112: 1144-1152.
20. Wang L, Zeng YB, Chen JY, Luo Q, Wang R, Zhang R, et al. A simple new scoring system for predicting the mortality of severe acute pancreatitis: A retrospective clinical study. *Medicine (Baltimore)* 2020; 99: e20646.
21. Banks PA, Bollen TL, Dervenis C, Gooszen HG, Johnson CD, Sarr MG, et al. Classification of acute pancreatitis–2012: revision of the Atlanta classification and definitions by international consensus. *Gut* 2013; 62: 102-111.
22. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL and Sibbald WJ. Multiple organ dysfunction score: a reliable descriptor of a complex clinical outcome. *Crit Care Med* 1995; 23: 1638-1652.
23. Ranson JH, Rifkind KM, Roses DF, Fink SD, Eng K and Spencer FC. Prognostic signs and the role of operative management in acute pancreatitis. *Surg Gynecol Obstet* 1974; 139: 69-81.
24. Blamey SL, Imrie CW, O'Neill J, Gilmour WH and Carter DC. Prognostic factors in acute pancreatitis. *Gut* 1984; 25: 1340-1346.
25. Wu BU, Johannes RS, Sun X, Tabak Y, Conwell DL and Banks PA. The early prediction of mortality in acute pancreatitis: a large population-based study. *Gut* 2008; 57: 1698-1703.
26. Zhi G, Xin W, Ying W, Guohong X and Shuying L. "Obesity Paradox" in Acute Respiratory Distress Syndrome: Asystematic Review and Meta-Analysis. *PLoS One* 2016; 11: e0163677.
27. Kim JA and Park HS. White blood cell count and abdominal fat distribution in female obese adolescents. *Metabolism* 2008; 57: 1375-1379.
28. Saltiel AR and Olefsky JM. Inflammatory mechanisms linking obesity and metabolic disease. *J Clin Invest* 2017; 127: 1-4.
29. Frick TW. The role of calcium in acute pancreatitis. *Surgery* 2012; 152: S157-163.
30. Peng T, Peng X, Huang M, Cui J, Zhang Y, Wu H, et al. Serum calcium as an indicator of persistent organ failure in acute pancreatitis. *Am J Emerg Med* 2017; 35: 978-982.
31. Zou D, Qi X, Zhu C, Ning Z, Hou F, Zhao J, et al. Albumin-bilirubin score for predicting the in-hospital mortality of acute upper gastrointestinal bleeding in liver cirrhosis: A retrospective study. *Turk J Gastroenterol* 2016; 27: 180-186.
32. Mohammed MAA, Khalaf MH, Liang T, Wang DS, Lungren MP, Rosenberg J, et al. Albumin-Bilirubin Score: An Accurate Predictor of Hepatic Decompensation in High-Risk Patients Undergoing Transarterial Chemoembolization for Hepatocellular Carcinoma. *J Vasc Interv Radiol* 2018; 29: 1527-1534 e1521.
33. Ye L, Liang R, Zhang J, Chen C, Chen X, Zhang Y, et al. Postoperative albumin-bilirubin grade and albumin-bilirubin change predict the outcomes of hepatocellular carcinoma after hepatectomy. *Ann Transl Med* 2019; 7: 367.

34. Shi L, Zhang D and Zhang J. Albumin-bilirubin score is associated with in-hospital mortality in critically ill patients with acute pancreatitis. *Eur J Gastroenterol Hepatol* 2020.
35. Kiss L, Fur G, Matrai P, Hegyi P, Ivany E, Cazacu IM, et al. The effect of serum triglyceride concentration on the outcome of acute pancreatitis: systematic review and meta-analysis. *Sci Rep* 2018; 8: 14096.
36. Mounzer R, Langmead CJ, Wu BU, Evans AC, Bishehsari F, Muddana V, et al. Comparison of existing clinical scoring systems to predict persistent organ failure in patients with acute pancreatitis. *Gastroenterology* 2012; 142: 1476-1482; quiz e1415-1476.
37. Papachristou GI, Muddana V, Yadav D, O'Connell M, Sanders MK, Slivka A, et al. Comparison of BISAP, Ranson's, APACHE-II, and CTSI scores in predicting organ failure, complications, and mortality in acute pancreatitis. *Am J Gastroenterol* 2010; 105: 435-441; quiz 442.
38. Hall TC, Stephenson JS, Jones MJ, Ngu WS, Horsfield MA, Rajesh A, et al. Is Abdominal Fat Distribution Measured by Axial CT Imaging an Indicator of Complications and Mortality in Acute Pancreatitis? *J Gastrointest Surg* 2015; 19: 2126-2131.

Tables

Table 1. Pancreatic activity scoring system (PASS).

Parameter	weights
Organ failure	× 100 for each system
SIRS	× 25 for each criteria
Abdominal pain (0-10)	× 5
Morphine equivalent dose (mg)	× 5
Tolerating solid diet (yes=0, no=1)	× 40

SIRS: systemic inflammatory response syndrome; Organ failure definition: modified Marshall or SOFA score ≥ 2 pts any category

Table 2. Chinese simple scoring system (CSSS).

variables	0	1	2	3	4
Serum creatinine (μmol/L)	<100	≥100			
Blood glucose (mmol/L)	<12	≥12			
LDH (U/L)	<380	≥380			
CRP (mmol/L)	<65	≥65			
Heart rate (beats/min)	<100	≥100			
Extent of pancreatic necrosis	0	<30%	30%-50%	50%-70%	≥70%

LDH: lactate dehydrogenase; CRP: C-reactive protein

Table 3. Univariate analysis of factors associated with severity, mortality, ARDS, and ARF in AP.

Characteristic	Severity			Mortality			ARDS			ARF	
	Mild (n = 1164)	Severe (n = 684)	<i>P</i>	Survivor (n = 1782)	Non-survivor (n = 66)	<i>P</i>	No (n = 1735)	Yes (n = 113)	<i>P</i>	No (n = 1706)	Yes (n = 14)
Age, y	46.22 (15.40)	51.62 (16.99)	<0.001	48.07 (16.10)	52.09 (18.69)	0.048	48.12 (16.18)	49.79 (16.66)	0.288	48.12 (16.22)	49.79 (16.66)
Male gender, n (%)	783 (67.27)	477 (69.74)	0.271	1210 (67.90)	50 (75.76)	0.178	1175 (67.72)	85 (75.22)	0.097	1142 (66.94)	113 (79.86)
BMI, kg/m ²	23.43 (4.26)	24.73 (4.52)	<0.001	23.99 (4.45)	23.07 (2.92)	0.293	23.85 (4.39)	25.44 (4.44)	0.009	23.85 (4.33)	25.44 (4.44)
Comorbidities, n (%)											
Hyperlipidemia	169 (14.52)	106 (15.50)	0.568	267 (14.98)	8 (12.12)	0.521	257 (14.81)	18 (15.93)	0.747	245 (14.36)	30 (21.43)
T2DM	85 (7.30)	54 (7.89)	0.641	134 (7.52)	5 (7.58)	0.986	130 (7.49)	9 (7.96)	0.854	135 (7.91)	4 (28.57)
Etiology, n (%)											
Gallstones	467 (40.12)	244 (35.67)	0.058	697 (39.11)	14 (21.21)	0.003	681 (39.25)	30 (26.55)	0.007	679 (39.80)	32 (214.29)
Alcoholic	101 (8.68)	98 (14.33)	<0.001	191 (10.72)	8 (12.12)	0.718	178 (10.26)	21 (18.58)	0.006	169 (9.91)	30 (214.29)
Hypertriglyceridemia	186 (15.98)	123 (17.98)	0.265	301 (16.89)	11 (16.67)	0.308	288 (16.60)	21 (18.58)	0.584	278 (16.30)	31 (214.29)
Smoker, n (%)	337 (28.95)	204 (29.82)	0.691	525 (29.46)	16 (24.24)	0.36	505 (29.11)	36 (31.86)	0.533	490 (28.72)	51 (364.29)
Alcohol intake history, n (%)	334 (28.69)	257 (37.57)	<0.001	568 (31.87)	23 (34.85)	0.611	540 (31.12)	51 (45.13)	0.002	520 (30.48)	71 (507.14)
Hospital stay, d	12.35 (8.18)	16.56 (11.95)	<0.001	14.01 (9.68)	10.08 (14.82)	0.042	13.53 (8.85)	19.38 (19.8)	0.003	13.58 (9.02)	17.14 (12.64)
Death, n (%)	6 (0.52)	60 (8.77)	<0.001	-	-	-	29 (1.67)	37 (32.74)	<0.001	26 (1.52)	40 (285.71)
WBC (*10 ⁹ /L)	10.46 (4.96)	14.71 (6.37)	<0.001	11.94 (5.77)	14.58 (8.26)	0.012	11.84 (5.81)	14.89 (6.36)	<0.001	11.79 (5.58)	14.58 (8.26)
Hemoglobin (g/L)	127.61 (21.99)	128.11 (30.90)	0.713	128.26 (24.63)	115.28 (43.57)	0.019	127.78 (24.37)	127.99 (40.63)	0.957	127.78 (23.77)	128.11 (30.90)
Hematocrit	0.46 (1.52)	0.41 (0.52)	0.408	0.45 (1.26)	0.33 (0.10)	0.452	0.45 (1.28)	0.39 (0.15)	0.632	0.45 (1.29)	0.33 (0.10)
BUN (mmol/L)	4.70 (4.51)	7.06 (6.74)	<0.001	5.35 (5.16)	12.37 (10.53)	<0.001	5.27 (5.01)	10.40 (9.88)	<0.001	4.93 (4.32)	13.33 (11.33)
Creatinine (μmol/L)	77.41 (35.51)	109.02 (99.68)	<0.001	85.73 (60.61)	191.88 (159.04)	<0.001	84.88 (58.86)	156.95 (140.72)	<0.001	76.51 (28.59)	244.29 (199.68)
Total bilirubin (μmol/L)	38.25 (67.41)	41.66 (52.51)	0.277	38.41 (59.80)	72.16 (107.79)	0.023	39.54 (62.76)	39.40 (53.76)	0.983	39.07 (60.74)	41.66 (52.51)
Albumin (g/L)	37.78 (7.16)	34.19 (7.33)	<0.001	36.69 (7.31)	28.97 (7.02)	<0.001	36.66 (7.36)	32.31 (7.32)	<0.001	36.76 (7.24)	32.31 (7.32)
AST (IU/L)	68.94 (113.56)	104.17 (293.67)	0.004	76.66 (121.03)	244.29 (894.16)	0.145	82.42 (206.45)	76.95 (82.21)	0.794	76.34 (120.21)	156.95 (140.72)
Calcium (mmol/L)	2.20 (0.24)	2.00 (0.33)	<0.001	2.14 (0.27)	1.85 (0.63)	0.001	2.14 (0.27)	1.89 (0.48)	<0.001	2.14 (0.27)	1.85 (0.63)
Blood glucose (mmol/L)	7.41 (3.84)	10.21 (5.37)	<0.001	8.25 (4.47)	13.33 (7.78)	0.003	8.20 (4.40)	11.54 (7.09)	0.001	8.12 (4.26)	12.37 (7.78)
LDH (IU/L)	234.9 (104.21)	420.76 (235.22)	<0.001	305.78 (186.17)	476.00 (326.16)	0.003	298.31 (177.79)	493.86 (291.49)	<0.001	298.65 (176.75)	476.00 (326.16)
Triglycerides (mmol/L)	2.89 (4.37)	4.5 (6.08)	<0.001	3.51 (5.12)	3.99 (6.52)	0.558	3.38 (5.00)	5.60 (6.88)	<0.006	3.27 (4.79)	6.08 (6.08)
CRP (mg/L)	78.53 (58.34)	138.28 (60.29)	<0.001	109.77 (66.56)	128.77 (62.19)	0.036	106.83 (65.32)	143.21 (66.71)	<0.001	107.57 (66.88)	138.28 (60.29)
Ranson score	0.67(0.77)	2.57 (1.37)	<0.001	1.34 (1.36)	2.41 (1.58)	<0.001	1.29 (1.33)	2.64 (1.46)	<0.001	1.29 (1.32)	2.41 (1.58)

Glasgow score	0.48 (0.69)	2.24 (1.25)	<0.001	1.09 (1.23)	2.39 (1.53)	<0.001	1.05 (1.22)	2.45 (1.20)	<0.001	1.04 (1.20)	2.39 (1.20)
BISAP	0.6 (0.72)	1.95 (1.1)	<0.001	1.05 (1.06)	2.42 (1.25)	<0.001	1.01 (1.04)	2.49 (1.00)	<0.001	1.00 (1.02)	2.39 (1.20)
PASS	105.51 (52.27)	172.05 (81.08)	<0.001	125.56 (66.82)	253.64 (94.44)	<0.001	120.82 (61.05)	273.19 (76.21)	<0.001	120.73 (61.42)	249.05 (94.44)
CSSS	0.55 (0.78)	2.12 (1.50)	<0.001	1.08 (1.29)	2.62 (1.69)	<0.001	1.01 (1.22)	2.98 (1.65)	<0.001	0.99 (1.19)	2.39 (1.20)

ARDS: acute respiratory distress syndrome; ARF: acute renal failure; AP: acute pancreatitis; BMI: body-mass index; T2DM: type-2 diabetes mellitus; WBC: white blood cell count; BUN: blood urea nitrogen; CRP: C-reactive protein; AST: aspartate transaminase; LDH: lactate dehydrogenase; BISAP: bedside index of severity in acute pancreatitis; PASS: pancreatic activity scoring system; CSSS: Chinese simple scoring system. $P<0.05$ accepted as statistically significant

Table 4. Multivariate analysis of factors predicting severity, mortality, ARDS, and ARF in AP.

Characteristic	Severity		Mortality		ARDS		ARF	
	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>	OR (95% CI)	<i>P</i>
Age	0.994 (0.975-1.014)	0.575	1.023 (0.979-1.069)	0.308	-	-	-	-
Male gender	-	-	-	-	-	-	0.731 (0.101-5.295)	0.731
BMI, kg/m ²	0.985 (0.919-1.055)	0.66	-	-	1.139 (1.022-1.271)	0.019	1.125 (0.996-1.269)	0.057
Etiology								
Gallstones	1.256 (0.635-2.487)	0.512	0.255 (0.036-1.826)	0.174	1.794 (0.620-5.193)	0.281	0.974 (0.197-4.821)	0.974
Alcoholic	1.416 (0.526-3.808)	0.491	-	-	0.378 (0.074-1.923)	0.241	0.844 (0.153-4.649)	0.846
Hypertriglyceridemia							0.365 (0.065-2.036)	0.25
Smoker							0.996 (0.285-3.488)	0.995
Alcohol intake history	0.862 (0.467-1.590)	0.634	-	-	1.956 (0.657-5.827)	0.228	3.613 (0.810-16.122)	0.092
Comorbidities								
Hyperlipidemia	-	-	-	-	-	-	1.501 (0.529-4.26)	0.446
T2DM	-	-	-	-	-	-	0.999 (0.363-2.749)	0.998
WBC (*10 ⁹ /L)	1.110 (1.040-1.184)	0.002	0.946 (0.819-1.094)	0.456	1.135 (1.048-1.23)	0.002	0.946 (0.839-1.067)	0.368
Hemoglobin (g/L)	-	-	1.023 (0.994-1.052)	0.118	-	-	-	-
BUN (mmol/L)	1.124 (0.974-1.297)	0.109	1.013 (0.914-1.122)	0.808	0.99 (0.917-1.069)	0.802	1.243 (1.097-1.408)	0.001
Creatinine (μmol/L)	1.005 (0.996-1.015)	0.268	1.006 (0.999-1.013)	0.105	1.002 (0.996-1.009)	0.484	-	-
Total bilirubin (μmol/L)	-	-	1.013 (1.004-1.023)	0.007	-	-	-	-
Albumin (g/L)	0.940 (0.894-0.989)	0.016	0.948 (0.833-1.079)	0.418	1.035 (0.978-1.095)	0.234	0.939 (0.854-1.032)	0.191
AST (IU/L)	1.002 (0.999-1.006)	0.18	-	-	-	-	-	-
Calcium (mmol/L)	0.196 (0.065-0.592)	0.004	0.882 (0.089-8.692)	0.914	0.042 (0.006-0.303)	0.002	1.205 (0.313-4.639)	0.786
Blood glucose (mmol/L)	1.081 (1.016-1.150)	0.014	1.023 (0.916-1.143)	0.686	1.021 (0.938-1.112)	0.624	1.054 (0.956-1.162)	0.294
LDH (IU/L)	1.004 (1.002-1.006)	<0.001	1.003 (1.000-1.005)	0.061	1.000 (0.998-1.002)	0.785	1.000 (0.998-1.003)	0.781
Triglycerides (mmol/L)	1.022 (0.961-1.086)	0.486	-	-	0.943 (0.845-1.051)	0.287	1.119 (1.012-1.239)	0.029
CRP (mg/L)	1.007 (1.003-1.012)	0.002	0.999 (0.988-1.011)	0.844	1.002 (0.995-1.008)	0.409	1.000 (0.993-1.008)	0.926

ARDS: acute respiratory distress syndrome; ARF: acute renal failure; AP: acute pancreatitis; BMI: body-mass index; T2DM: type-2 diabetes mellitus; CRP: C-reactive protein; AST: aspartate transaminase; BUN: blood urea nitrogen; LDH: lactate dehydrogenase; BISAP: bedside index of severity in acute pancreatitis; PASS: pancreatic activity scoring system; CSSS: Chinese simple scoring system. *P*<0.05 accepted as statistically significant.

Table 5. Effectiveness of scoring systems for predicting severity, mortality, ARDS, and ARF in AP.

	Cutoff	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Severity						
Ranson score	≥2	0.861 (0.844-0.876)	0.741 (0.707-0.774)	0.864 (0.843-0.883)	0.762 (0.728-0.794)	0.850 (0.828-0.870)
Glasgow score	≥ 2	0.865 (0.849-0.881)	0.708 (0.672-0.742)	0.900 (0.882-0.917)	0.807 (0.773-0.838)	0.840 (0.818-0.860)
BISAP	≥ 2	0.829 (0.811-0.846)	0.649 (0.612-0.685)	0.869 (0.848-0.887)	0.744 (0.707-0.778)	0.808 (0.785-0.830)
PASS	≥ 90	0.778 (0.759-0.797)	0.889 (0.863-0.912)	0.545 (0.516-0.574)	0.534 (0.505-0.564)	0.893 (0.868-0.915)
CSSS	≥ 2	0.816 (0.797-0.833)	0.605 (0.568-0.642)	0.894 (0.876-0.910)	0.750 (0.712-0.786)	0.812 (0.791-0.832)
Mortality						
Ranson score	≥3	0.693 (0.671-0.714)	0.515 (0.389-0.640)	0.976 (0.967-0.983)	0.500 (0.376-0.624)	0.978 (0.968-0.985)
Glasgow score	≥ 2	0.736 (0.715-0.756)	0.727 (0.604-0.830)	0.690 (0.668-0.712)	0.080 (0.060-0.105)	0.986 (0.977-0.991)
BISAP	≥ 3	0.789 (0.770-0.807)	0.606 (0.478-0.724)	0.882 (0.866-0.897)	0.160 (0.117-0.211)	0.984 (0.976-0.989)
PASS	≥ 190	0.858 (0.841-0.874)	0.788 (0.670-0.879)	0.809 (0.790-0.827)	0.133 (0.101-0.170)	0.990 (0.984-0.995)
CSSS	≥ 3	0.759 (0.738-0.778)	0.515 (0.389-0.640)	0.872 (0.856-0.887)	0.130 (0.092-0.177)	0.980 (0.972-0.986)
ARDS						
Ranson score	≥2	0.745 (0.725-0.765)	0.761 (0.672-0.836)	0.666 (0.644-0.689)	0.129 (0.105-0.157)	0.977 (0.967-0.985)
Glasgow score	≥2	0.784 (0.764-0.802)	0.779 (0.691-0.851)	0.705 (0.683-0.726)	0.147 (0.119-0.178)	0.980 (0.971-0.987)
BISAP	≥2	0.834 (0.816-0.851)	0.823 (0.740-0.888)	0.710 (0.688-0.731)	0.156 (0.127-0.187)	0.984 (0.975-0.990)
PASS	≥ 195	0.936 (0.924-0.946)	0.903 (0.833-0.950)	0.860 (0.843-0.876)	0.296 (0.248-0.347)	0.993 (0.987-0.996)
CSSS	≥ 2	0.820 (0.802-0.838)	0.752 (0.662-0.829)	0.731 (0.709-0.752)	0.154 (0.125-0.187)	0.978 (0.969-0.986)
ARF						
Ranson score	≥ 3	0.707 (0.686-0.728)	0.507 (0.422-0.592)	0.792 (0.772-0.811)	0.169 (0.134-0.208)	0.951 (0.938-0.961)
Glasgow score	≥ 3	0.734 (0.711-0.752)	0.542 (0.457-0.626)	0.857 (0.841-0.872)	0.213 (0.172-0.259)	0.963 (0.954-0.972)
BISAP	≥ 3	0.781 (0.761-0.800)	0.346 (0.283-0.413)	0.897 (0.882-0.911)	0.300 (0.244-0.361)	0.915 (0.901-0.928)
PASS	≥ 165	0.868 (0.852-0.883)	0.831 (0.759-0.889)	0.754 (0.733-0.774)	0.219 (0.185-0.257)	0.982 (0.973-0.988)
CSSS	≥ 3	0.816 (0.798-0.834)	0.578 (0.492-0.660)	0.895 (0.879-0.909)	0.313 (0.257-0.373)	0.962 (0.952-0.971)

ARDS: acute respiratory distress syndrome; ARF: acute renal failure; AP: acute pancreatitis; AUC: area under the curve; PPV: positive predictive value; NPV: negative predictive value; BUN: blood urea nitrogen; BISAP: bedside index of severity in acute pancreatitis; PASS: pancreatic activity scoring system; CSSS: Chinese simple scoring system.

Figures

Figure 1

A: Receiver operating characteristic curves of scoring systems in to predict severe AP. B: Receiver operating characteristic curves of scoring systems in to predict mortality in patients of AP. C: Receiver operating characteristic curves of scoring systems in to predict ARDS in patients of AP. D: Receiver operating characteristic curves of scoring systems in to predict ARF in patients of AP.