*Medical Research*
**Volume 7, Issue 3, 2025, Page 59-65**
**https://doi.org/10.6913/mrhk.070307**

**Medical Research**

# The Predictive Value of Combined Detection of Serum Calcium Ions, Random Blood Glucose, and the Serum CRP/ALB Ratio for the Severity of Early Acute Pancreatitis

Yaoliang ZHOU[1], Weixia YUE[2], Hujie ZHANG[1], Zhifeng MO[1*]

[1]*Emergency and Disaster Medical Center, The Seventh Affiliated Hospital, Sun Yat-sen University, Shenzhen, China.*
[2]*Department of Information Management, The Seventh Affiliated Hospital, Sun Yat-sen University, Shenzhen, China.*
[*]*Corresponding author: Zhifeng MO, Email: mozhifeng@sysush.com*

## Abstract

**Objective:** To investigate the predictive value of serum calcium ion ($Ca^{2+}$), random blood glucose (RBG), and the C-reactive protein to albumin ratio (CRP/ALB) for the severity of early acute pancreatitis (AP). **Methods:** The clinical data of 138 patients with AP who were hospitalized at the Seventh Affiliated Hospital of Sun Yat-sen University from July 2020 to August 2025 were retrospectively analyzed. Among them, 99 cases were classified into the mild acute pancreatitis (MAP) group, and 39 cases into the non-mild acute pancreatitis (NMAP; including moderate and severe cases) group. Univariate analysis was conducted on various demographic and laboratory parameters. Indicators related to the severity of AP were further evaluated using receiver operating characteristic (ROC) curve analysis and binary logistic regression. **Results:** The areas under the ROC curve for $Ca^{2+}$, RBG, and CRP/ALB in predicting the severity of AP were 0.750, 0.697, and 0.864, respectively. Logistic regression analysis showed that $Ca^{2+}$ [OR = 0.014, 95% CI (0.001, 0.313)], RBG [OR = 1.159, 95% CI (1.024, 1.311)], and CRP/ALB [OR = 1.393, 95% CI (1.186, 1.637)] were independent risk factors for the early prediction of AP severity. **Conclusion:** Lower $Ca^{2+}$ levels, higher RBG levels, and a higher CRP/ALB ratio are associated with a greater likelihood of AP progressing to a severe case. RBG and the CRP/ALB ratio are positively correlated with disease severity, while $Ca^{2+}$ is negatively correlated.

**Keywords** Acute pancreatitis; Severity; Serum calcium ion; Random blood glucose; C-reactive protein to albumin ratio

## 1 Introduction

As an acute and critical condition of the digestive system, the global annual incidence of acute pancreatitis (AP) is rising, with reported rates of 13–45 per 100,000 people. Among these patients, 20% will progress to moderately severe acute pancreatitis (MSAP) or severe acute pancreatitis (SAP), with a mortality rate as high as 15–20% [1]. Early and accurate assessment of AP severity is crucial for optimizing treatment

strategies and reducing complications and mortality [2]. Currently, commonly used clinical scoring systems such as Ranson, APACHE II, and BISAP require data from multiple time points and are complex to operate, making them ill-suited for the needs of rapid emergency assessment [3–7]. Furthermore, while single serum indicators like C-reactive protein (CRP) and amylase (AMY) are related to the condition, their predictive efficacy is limited [8]. Recent studies have shown that the combined detection of multiple inflammatory factors (e.g., procalcitonin [PCT], interleukin-6 [IL-6]) or metabolic markers (e.g., blood urea nitrogen [BUN], albumin [ALB]) can improve predictive accuracy, but the optimal combination remains undefined [9]. Therefore, developing efficient and convenient early prediction tools has become a key priority for improving the prognosis of AP. This is particularly important for addressing the clinical challenge of the low recognition rate of severe AP by traditional methods, which have demonstrated sensitivities as low as 68%. This study investigates the early predictive value of serum calcium ion ($Ca^{2+}$), random blood glucose (RBG), and the C-reactive protein to albumin ratio (CRP/ALB) for the severity of AP.

## 2 Materials and Methods

### 2.1 Study Participants

A retrospective analysis was conducted on the clinical data of 138 patients diagnosed with AP at the Seventh Affiliated Hospital of Sun Yat-sen University from July 2020 to August 2025. Inclusion criteria were as follows: (1) diagnosis conforming to the "Chinese Guidelines for the Diagnosis and Treatment of Acute Pancreatitis (2021)"; (2) first episode of AP; (3) admission within 48 hours of onset without prior treatment; (4) age $\geq$ 18 years; (5) complete hospital records and examination data; and (6) relevant examinations and tests completed within 24 hours of admission. Exclusion criteria included: (1) chronic pancreatitis; (2) pregnancy or lactation; (3) comorbid malignant tumors or hematological diseases; (4) other severe chronic conditions such as chronic organ dysfunction; and (5) incomplete data or loss to follow-up. This study was approved by the hospital's ethics committee.

### 2.2 Research Methods

Patient clinical data were extracted from electronic medical records and systematically recorded in an electronic spreadsheet. The dataset included: (1) demographic and clinical characteristics, such as age, sex, etiology, length of hospitalization, duration of ICU stay, CT imaging findings, organ dysfunction (including acute respiratory distress syndrome [ARDS], acute kidney injury [AKI], and gastrointestinal dysfunction), systemic inflammatory response syndrome (SIRS), and local complications (e.g., peripancreatic effusion, pancreatic pseudocyst, and acute peripancreatic fluid collection); (2) vital signs upon admission, including body temperature, pulse rate, respiratory rate, and mean arterial pressure; and (3) laboratory parameters measured within 24 hours of admission, including serum levels of $Na^{+}$, $K^{+}$, $Ca^{2+}$, creatinine (Cr), BUN, $CO_2CP$, hematocrit (HCT), white blood cells (WBC), fibrinogen (Fib), D-dimer, AMY, lipase (LPS), PCT, ALB, CRP, triglycerides (TG), total bilirubin (TBIL), indirect bilirubin (IBIL), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), and cholinesterase (CHE), as well as the calculated PCT/ALB and CRP/ALB ratios.

### 2.3 Statistical Methods

Data were analyzed using SPSS version 26.0. Continuous variables with a normal distribution were expressed as mean ± standard deviation, while those with a non-normal distribution were expressed as median (interquartile range). Categorical variables were presented as count (%). For univariate analysis, the independent samples t-test or Mann-Whitney U test was used for continuous variables, and the $\chi^2$ test was

used for categorical variables. The diagnostic value of each indicator for AP severity was evaluated using the area under the receiver operating characteristic (ROC) curve (AUC). Binary logistic regression analysis was performed to identify independent risk factors for the severity of AP. A p-value $< 0.05$ was considered statistically significant.

## 3 Results

### 3.1 Basic Clinical Features

Among the 138 patients with acute pancreatitis (AP), 102 (73.9%) were male and 36 (26.1%) were female; the overall age ranged from 23–83 years (mean $40.25 \pm 9.2$). Etiologies were: biliary, 34 cases (24.6%); hyperlipidemia, 57 cases (41.4%); alcoholism, 14 cases (10.1%); and other causes, 33 cases (23.9%). Based on APACHE II, 99 patients (71.7%) were assigned to the mild acute pancreatitis (MAP) group (age 23–83 years; mean 41.6 years); the ICU admission rate was 3% with a mean ICU stay of 2 days. The remaining 39 patients (28.3%) were assigned to the non-mild acute pancreatitis (NMAP) group (age 27–63 years; mean 41.2 years); the ICU admission rate was 60% with a mean ICU stay of 5 days.

**Table 1:** Results of a one-way analysis of factors

| Indicators | MAP group | NMAP group | t/Z | P |
|---|---|---|---|---|
| Age | 41.63±11.05 | 41.20±9.21 | 0.215 | 0.830 |
| WBC | 11.50±3.78 | 14.87±6.38 | -3.828 | 0.000 |
| N | 9.00(6.61,12.09) | 13.18(9.20,17.21) | -2.993 | 0.003 |
| L | 1.45(1.17,2.03) | 1.16(0.76,1.40) | -3.414 | 0.001 |
| Hb | 144.57±16.50 | 143.38±27.58 | 0.309 | 0.758 |
| HCT | 42.81±4.17 | 42.41±7.43 | 0.400 | 0.690 |
| PLT | 235.16±64.44 | 219.28±74.47 | 1.246 | 0.215 |
| CRP | 50.00(6.89,143.13) | 211.00(136.47,272.00) | -6.121 | 0.000 |
| PCT | 0.11(0.05,4.11) | 0.64(0.21,4.11) | -3.170 | 0.002 |
| Fib | 4.16(3.08,4.52) | 4.26(3.69,5.86) | -2.521 | 0.012 |
| D-dimer | 1.10(0.45,2.23) | 2.23(0.86,4.00) | -2.918 | 0.004 |
| AMY | 231.00(136.40,571.70) | 364.00(137.00,798.00) | -0.601 | 0.548 |
| LPS | 2218.90(802.00,5355.00) | 3310.00(895.30,7491.00) | -1.036 | 0.300 |
| $Na^+$ | 139.00(136.80,140.60) | 137.70(135.00,139.00) | -2.254 | 0.024 |
| $K^+$ | 4.01(3.74,4.27) | 4.00(3.70,4.23) | -0.553 | 0.580 |
| $Ca^{2+}$ | 2.31(2.23,2.41) | 2.15(1.98,2.26) | -4.569 | 0.000 |
| RBG | 6.69(5.52,8.53) | 8.68(6.82,11.47) | -3.589 | 0.000 |
| $HCO_3^-$ | 23.04±3.63 | 19.89±5.74 | 3.846 | 0.000 |
| Cr | 67.74(54.60,77.26) | 66.46(54.38,75.77) | -0.040 | 0.968 |
| BUN | 4.52(3.20,5.66) | 4.26(3.00,6.30) | -0.024 | 0.981 |
| TBIL | 18.48(12.89,27.35) | 22.65(16.87,32.44) | -1.721 | 0.085 |
| IBIL | 11.63(7.84,16.55) | 13.53(7.74,18.46) | -0.747 | 0.455 |
| AST | 33.00(23.23,55.80) | 32.26(25.80,54.00) | -0.376 | 0.707 |
| ALT | 38.60(23.10,75.71) | 37.36(23.77,65.50) | -0.714 | 0.475 |
| ALP | 85.00(69.00,117.80) | 86.00(65.70,112.36) | -0.300 | 0.764 |
| CHE | 8964.17±2046.23 | 8590.35±2896.46 | 0.854 | 0.395 |
| ALB | 39.66±5.59 | 33.49±6.47 | 5.577 | 0.000 |
| TG | 4.41(1.61,12.88) | 11.19(2.11,32.21) | -2.372 | 0.018 |
| CRP/ALB | 1.24(0.18,3.93) | 6.74(3.75,9.36) | -6.646 | 0.000 |
| PCT/ALB | 0.0031(0.0013,0.0909) | 0.0240(0.0051,0.1178) | -3.431 | 0.001 |

The results of the independent sample t-test and the Mann-Whitney test showed that when $P < 0.05$, there was a statistically significant difference between the groups; when $P > 0.05$, there was no statistically significant difference between the groups.

### 3.2 Univariate Analysis of Early AP Severity

There were statistically significant differences in WBC, N, L, CRP, PCT, Fib, D-dimer, $Na^+$, $Ca^{2+}$, RBG, $CO_2CP$, ALB, CRP/ALB, PCT/ALB, and TG between the MAP group and the NMAP group ($P < 0.05$). However, there were no statistically significant differences in age, Hb, HCT, PLT, AMY, LPS, $K^+$, Cr, BUN, TBIL, IBIL, AST, ALT, ALP, and CHE between the two groups ($P > 0.05$) (Table 1).

### 3.3 Binary Logistic Regression Analysis of Early AP Severity

Variables that were statistically significant in the univariate analysis were included in the multivariate

Variables that were statistically significant in the univariate analysis, as well as those considered clinically relevant, were included in the multivariate logistic regression model. Considering the collinearity among the independent variables, the backward stepwise LR method was adopted. The results showed that $Ca^{2+}$ [OR = 0.014, 95% CI (0.001, 0.313)], RBG [OR = 1.159, 95% CI (1.024, 1.311)], and CRP/ALB [OR = 1.393, 95% CI (1.186, 1.637)] were independent risk factors for the early prediction of the severity of AP ($P < 0.05$) (Table 2).

**Table 2:** The results of the multivariate binary logistic regression analysis

| Indicators | B | S.E. | Wald | P | OR | 95% CI for OR | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Limit | Upper Limit |
| L | -0.598 | 0.378 | 2.506 | 0.113 | 0.550 | 0.262 | 1.153 |
| $Na^{+}$ | 0.145 | 0.083 | 3.041 | 0.081 | 1.156 | 0.982 | 1.360 |
| $Ca^{2+}$ | -4.250 | 1.576 | 7.273 | **0.007** | 0.014 | 0.001 | 0.313 |
| RBG | 0.147 | 0.063 | 5.470 | **0.019** | 1.159 | 1.024 | 1.311 |
| CRP/ALB | 0.332 | 0.082 | 16.223 | **<0.001** | 1.393 | 1.186 | 1.637 |

OR: odds ratio; CI: confidence interval. Bold *P*-values indicate statistical significance ($P < 0.05$).

### 3.4 Analysis of ROC Curves for $Ca^{2+}$, RBG, and CRP/ALB

The results of the ROC curve analysis for predicting the severity of acute pancreatitis (AP) using $Ca^{2+}$, RBG, and CRP/ALB are shown in Figure 1 and Table ??. The AUC value of $Ca^{2+}$ was 0.750 (95% CI: 0.652–0.849), the AUC value of RBG was 0.697 (95% CI: 0.603–0.790), and the AUC value of CRP/ALB was 0.864 (95% CI: 0.804–0.924). These three indicators demonstrated good predictive value for the severity of early AP. The optimal cut-off values were 2.210, 6.810, and 2.150, respectively. The sensitivities were 0.692, 0.769, and 0.974, and the specificities were 0.778, 0.556, and 0.657, respectively. Among the three indicators, CRP/ALB had the highest sensitivity, whereas $Ca^{2+}$ had the highest specificity.(Talbe 3)

**Table 3:** Diagnostic Analysis Results

| Indicator | AUC | 95% CI | Cut-off | Sensitivity | Specificity | Youden Index | p-value |
|---|---|---|---|---|---|---|---|
| $Ca^{2+}$ | 0.750 | 0.652–0.849 | 2.210 | 0.692 | 0.778 | 0.470 | **<0.001** |
| RBG | 0.697 | 0.603–0.790 | 6.810 | 0.769 | 0.556 | 0.325 | **<0.001** |
| CRP/ALB | 0.864 | 0.804–0.924 | 2.150 | 0.974 | 0.657 | 0.631 | **<0.001** |

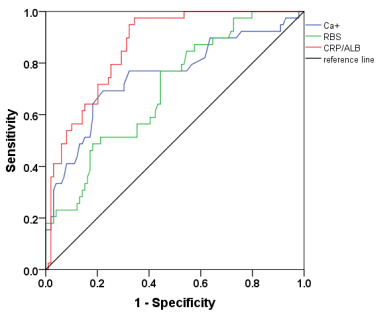


**Figure 1:** ROC curves for $Ca^{2+}$, RBG, and CRP/ALB in predicting the severity of acute pancreatitis.

## 4 Discussion

The pathogenesis of AP is currently unclear[10]. There are many hypotheses, and the widely accepted one is that the massive destruction of pancreatic acinar cells and the abnormal activation of the self-secreted trypsin lead to acinar damage, resulting in the release of inflammatory cytokines, chemokines, and oxygen free radicals aggregation, and a large amount of trypsin entering the peripheral blood can stimulate macrophages to release a large amount of pro-inflammatory factors, causing SIRS, leading to mitochondrial dysfunction and microcirculation damage, and ultimately resulting in organ failure and even death[11]. The course of AP can be divided into three stages: local inflammation, SIRS, and multiple organ dysfunction[12].

The level of $Ca^{2+}$ is closely related to the inflammatory response of SAP, and hypocalcemia also indicates a severe injury state of the pancreas. The main mechanism of the decrease in $Ca^{2+}$ is the activation of trypsinogen in the acinus, and the pancreatic released lipase will break down the fat cells inside it into free fatty acids, which will combine with calcium in the blood to form fatty acid calcium, depositing on the surface of the pancreas, thereby causing a decrease in $Ca^{2+}$[13]. Studies have shown that $Ca^{2+}$ is an independent risk factor for SAP and plays a crucial role in early prediction of the severity of AP[14].

The pancreas is an important endocrine organ in the human body. When AP occurs, the $\beta$ cells of the pancreas are damaged, insulin secretion and release decrease, resulting in or aggravating the hyperglycemic state. Animal experiments have shown that high blood sugar can promote inflammatory reactions and cell apoptosis, leading to the deterioration of AP[15].

The level of CRP is related to the development of pancreatic necrosis and the course of SAP[16], but its serum level peak appears late, has low specificity, and its increase is not related to the early infection of AP[17]. ALB has physiological effects such as protecting the microcirculation system, reducing vascular permeability, anticoagulation, anti-inflammatory, and anti-apoptosis[18]. And ALB has more significant effects in antioxidation and inflammation, can regulate the body's pH value and vascular internal osmotic pressure, and can reflect the severity and prognosis of severe diseases[19]. Studies have shown that hypoproteinemia within 24 hours of admission is an independent risk factor for persistent organ failure and death in AP patients[20]. The study by Kaplan et al. proved that CRP/ALB can better predict the severity of acute pancreatitis[21-22]. The results of this study are consistent with this. In this study, the AUC of CRP/ALB was 0.864, the sensitivity was 97.4%, the specificity was 65.7%, and the $P$ value was < 0.001, which is an independent risk factor for predicting SAP.

This study investigated the early predictive value of $Ca^{2+}$, RBG, and CRP/ALB for the severity of AP. The ROC curve was used to determine the critical values. Univariate analysis revealed that $Ca^{2+}$, RBG, and CRP/ALB were all correlated with the early severity of AP. The AUC value of $Ca^{2+}$ was 0.750, with a specificity of 77.8%, and the AUC value of CRP/ALB was 0.864, with a sensitivity of 97.4%. When using these two indicators for the early prediction of AP severity, they can effectively compensate for the low specificity of CRP/ALB and provide a more accurate assessment of the severity of the disease. In the multivariate regression analysis, $Ca^{2+}$, RBG, and CRP/ALB were all independent risk factors for the severity of AP.

However, this study still has limitations. Firstly, as this study is a single-center, small-sample clinical retrospective study, its design may introduce selection bias, and the reliability and generalizability of the conclusions are limited. It needs to be verified through multi-center prospective studies. Secondly, this study has not deeply explored the predictive potential of the dynamic changes of $Ca^{2+}$, RBG, CRP/ALB on the severity of AP, and has not included imaging parameters (such as CT severity index). In the future, a multimodal data fusion model can be explored, and multi-center, large-sample prospective randomized controlled clinical trials can be conducted.

**Conflict of Interest:** The authors declare that they have no conflict of interest.
**Data Availability Statements:** The data underlying this article will be shared on reasonable request to the corresponding author.

**To Cite This Article** Yaoliang ZHOU, et al. (2025). The Predictive Value of Combined Detection of Serum Calcium Ions, Random Blood Glucose, and the Serum CRP/ALB Ratio for the Severity of Early Acute Pancreatitis. *Medical Research*, 7(3), 59-65. https://doi.org/10.6913/mrhk.070307

**References**

[1] Bradford, A. (2020). *The Brussels effect: How the European Union rules the world*. Oxford University Press.

[2] European Commission. (2021). *Proposal for a regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts*. COM(2021) 206 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0206

[3] Food and Drug Administration. (2021). *Artificial intelligence/machine learning (AI/ML)-based software as a medical device (SaMD) action plan*. U.S. Department of Health and Human Services. https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-and-machine-learning-software-medical-device

[4] Gerke, S., Minssen, T., & Cohen, G. (2020). Ethical and legal challenges of artificial intelligence-driven healthcare. In *Artificial intelligence in healthcare* (pp. 295-336). Academic Press. https://doi.org/10.1016/B978-0-12-818438-7.00012-5

[5] Gless, S., Silverman, E., & Weigend, T. (2023). A transatlantic perspective on the EU's proposed AI Act. *European Journal of Criminology*, *20*(4), 1318 1338. https://doi.org/10.1177/14773708211035540

[6] Hao, Y., & Cui, W. (2024). Regulating generative AI in China: A focus on algorithm registration and security assessment. *Computer Law & Security Review*, *52*, 105921. https://doi.org/10.1016/j.clsr.2024.105921

[7] Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with artificial intelligence. *BMC Medicine*, *17*(1), 195. https://doi.org/10.1186/s12916-019-1426-2

[8] Liu, Y., Chen, P. C., Krause, J., & Peng, L. (2019). How to read articles that use machine learning: Users' guides to the medical literature. *JAMA*, *322*(18), 1806 1816. https://doi.org/10.1001/jama.2019.16489

[9] Obstfeld, M., Shambaugh, J. C., & Taylor, A. M. (2005). The trilemma in history: Tradeoffs among exchange rates, monetary policies, and capital mobility. *The Review of Economics and Statistics*, *87*(3), 423-438. https://doi.org/10.1162/0034653054638300

[10] Roberts, H., Cowls, J., Morley, J., Taddeo, M., Wang, V., & Floridi, L. (2021). The Chinese approach to artificial intelligence: An analysis of policy, ethics, and regulation. *AI & Society*, *36*(1), 59-77. https://doi.org/10.1007/s00146-020-00992-2

[11] Su, J. (2023). Techno-nationalism, the US-China tech cold war, and the future of globalization. In *The Palgrave handbook of globalization with Chinese characteristics* (pp. 427-448). Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-19-8622-6_22

[12] Topol, E. J. (2019). High-performance medicine: the convergence of human and artificial intelligence. *Nature Medicine*, *25*(1), 44-56. https://doi.org/10.1038/s41591-018-0300-7

[13] Vayena, E., Blasimme, A., & Cohen, I. G. (2018). Machine learning in medicine: Addressing ethical challenges. *PLOS Medicine*, *15*(11), e1002689. https://doi.org/10.1371/journal.pmed.1002689

[14] World Health Organization. (2021). *Ethics and governance of artificial intelligence for health: WHO*

*guidance*. World Health Organization. https://www.who.int/publications/i/item/9789240029200

[15] Wu, E., Wu, K., Daneshjou, R., Ouyang, D., Ho, D. E., & Zou, J. (2021). How medical AI devices are evaluated: limitations and recommendations from an analysis of FDA approvals. *Nature Medicine*, *27*(4), 582-584. https://doi.org/10.1038/s41591-021-01312-x