SCINDEKS Serbian Citation Index
J Med Biochem 2026; 45 DOI: 10.5937/jomb0-62521

UDK 577.1 : 61 **ISSN 1452-8258**

J Med Biochem 45: 1–8, 2026

Original paper
Originalni naučni rad

CORRELATION RISK ANALYSIS OF SERUM AMYLOID A, PROCALCITONIN AND IFN-β2 IN ADVERSE OUTCOMES OF ACUTE PANCREATITIS

ANALIZA KORELACIJE RIZIKA SERUMSKOG AMILOIDA A, PROKALCITONINA I IFN-β2 U NEPOVOLJNIM ISHODIMA KOD AKUTNOG PANKREATITISA

Naibo Yu[1], Ruxia Han[2], Chen Menghui[3], Li Xuke[3], Kangjian Wang[4]*

[1]Department of Emergency, Shanghai Fengxian District Central Hospital, No. 6600, Nanfeng Road, Fengxian District, Shanghai City 201499, China
[2]Intensive Care Unit, Department of Hepatobiliary and Pancreatic Surgery, the First Medical Centre of PLA General Hospital, No. 28, Fuxing Road, Haidian District, Beijing City 100853, China
[3]Gastroenterology Department, the First Affiliated Hospital of Zhengzhou University, No. 1, Jianshe East Road, Erqi District, Zhengzhou City 451191, China
[4]Department of Critical Care Medicine, Shulan (Hang Zhou) Hospital, No. 848, Dongxin Road, Gongshu District, Hangzhou City 310000, China

Summary

Background: To investigate the relationships between the severity and prognosis of individuals with acute pancreatitis (AP) and the levels of serum amyloid A, procalcitonin, and interferon-β2 (IFN-β2).
Methods: 224 AP patients admitted to our hospital between February 2022 and February 2024 were selected as research participants. According to the Acute Physiology and Chronic Health Evaluation II (APACHE II) score, the patients were divided into a mild AP group (140 patients) and a severe AP group (84 patients). The levels of serum amyloid A, CRP, procalcitonin, and IFN-β2 in the two groups were compared, and the relationships between these levels and the severity of the disease were analysed using Spearman correlation. The factors affecting the prognosis of AP patients were examined using binary logistic regression. Receiver operating characteristic (ROC) curves were used to evaluate the prognostic significance of serum amyloid A, CRP, procalcitonin, and IFN-β2.
Results: The levels of serum amyloid A, CRP, procalcitonin and IFN-β2 in the mild AP group were significantly lower than those in the severe AP group ($P<0.05$). The severity of AP was favourably connected with serum amyloid A, CRP, procalcitonin, and IFN-β2 levels ($r=0.774$, 0.678, 0.830, 0.584, $P<0.05$). After 28 days of follow-up,

Kratak sadržaj

Uvod: Cilj je bio da se ispita povezanost između težine bolesti i prognoze kod pacijenata sa akutnim pankreatitisom (AP) i nivoa serumskog amiloida A, prokalcitonina i interferona-β2 (IFN-β2).
Metode: U istraživanje je uključeno 224 pacijenta sa AP primljenih u našu bolnicu između februara 2022. i februara 2024. godine. Na osnovu APACHE II skora, pacijenti su podeljeni u grupu sa blagim AP (n=140) i grupu sa teškim AP (n=84). Mereni su nivoi serumskog amiloida A, C-reaktivnog proteina (CRP), prokalcitonina i IFN-β2, koji su zatim upoređeni između grupa. Korelacija ovih biomarkera sa težinom AP analizirana je Spirmanovom metodom. Binarnom logističkom regresijom utvrđeni su faktori koji utiču na prognozu. Za procenu prediktivne vrednosti svakog biomarkera korišćene su ROC krive.
Rezultati: Nivoi serumskog amiloida A, CRP-a, prokalcitonina i IFN-β2 su bili značajno viši u grupi sa teškim AP u odnosu na grupu sa blagim AP ($P<0,05$). Sva četiri biomarkera bila su pozitivno povezana sa težinom AP ($r=0,774$; 0,678; 0,830; 0,584; $P<0,05$). Nakon 28 dana praćenja, 64 pacijenta (28,57%) je imalo nepovoljne ishode, uključujući respiratornu insuficijenciju (n=20, 8,93%), hipokalcemiju (n=24, 10,71%) i smrt (n=20, 8,93%). Incidencija nepovoljnih ishoda je bila značajno

Address for correspondence:
Kangjian Wang
Department of Critical care medicine, Shulan (Hang Zhou) Hospital
No. 848, Dongxin Road, Gongshu District, Hangzhou City 310000, China
e-mail: 15946985136@163.com

among 224 AP patients, 64 patients (28.57%) had poor prognoses, including 20 patients (8.93%) with respiratory insufficiency, 24 patients (10.71%) with hypocalcemia, and 20 patients (8.93%) who died. The severe AP group also had a higher overall incidence of poor prognosis than the moderate AP group (P<0.05). AP patients' poor prognosis was influenced by the APACHE II score and blood levels of serum amyloid A, CRP, procalcitonin, and IFN-β2 (P<0.05). According to the ROC curve analysis, the areas under the curve for predicting a poor AP prognosis were 0.859, 0.851, 0.811, and 0.802 for blood serum amyloid A, CRP, procalcitonin, and IFN-β2, respectively, all of which had some predictive value.

Conclusions: Serum amyloid A, CRP, procalcitonin, and IFN-β2 levels show a strong prognostic value for AP patients' prognosis and are positively connected with the severity of AP.

Keywords: acute pancreatitis, serum amyloid protein A, C-reactive protein procalcitonin, i nterferon-β2, severity of the illness

Zaključak: Viši nivoi serumske amiloidne A, CRP-a, prokalcitonina i IFN-β2 snažno su povezani sa težinom AP i imaju značajnu prediktivnu vrednost za nepovoljne ishode kod pacijenata sa akutnim pankreatitisom.

Ključne reči: akutni pankreatitis, serumski amiloid A, C-reaktivni protein, prokalcitonin, interferon-β2, prognoza, težina bolesti

Introduction

Acute pancreatitis (AP) is an autoimmune inflammatory response of pancreatic tissue triggered by various factors, characterised by inflammatory cell infiltration, pancreatic oedema, haemorrhage, and necrosis (1–3). Clinical data show that AP can be classified into mild and severe cases based on disease severity. Among them, mild AP has relatively mild clinical symptoms and a good prognosis, and the body can recover after treatment. Severe AP often manifests as secondary inflammation, infection, and organ failure, which can seriously threaten patients' safety (4). Therefore, improving the early diagnosis rate of AP is important for determining patient prognosis. The persistent systemic inflammatory response during the acute reaction period can cause target organ damage and worsen AP. Studies (5–7) have shown that interferon-β2 (IFN-β2), procalcitonin, serum amyloid A, and C-reactive protein (CRP) are important components of the body's immune system and inflammatory response, and they may also contribute to the onset and progression of AP. At present, clinical studies on serum amyloid A, CRP, procalcitonin, IFN-β2 and AP have focused mostly on their relationships with disease severity, whereas relatively few reports exist on the prognostic assessment of AP using these biomarkers.

One prevalent acute abdominal ailment in clinical practice is acute pancreatitis (AP) (8). Its course progresses rapidly, and the prognosis varies significantly. Patients with mild symptoms usually recover on their own, whereas severe acute pancreatitis (SAP) is prone to serious complications such as multiple organ dysfunction and pancreatic necrosis and infection, with a mortality rate as high as 20–30% (9). Early and accurate assessment of disease severity and prediction of patient prognosis are highly important for optimising clinical intervention strategies and improving patient survival outcomes. At present, clinical practice relies on composite evaluation systems, such as the Ranson and APACHE-II scores. However, these systems are complex to operate and have delays (10–12). There is an urgent need to identify biological markers with high sensitivity and strong timeliness to support dynamic monitoring. An important part of the pathophysiology of AP involves serum inflammatory factors. A common inflammatory marker used to assess AP severity is C-reactive protein (CRP) (13). Procalcitonin has a high predictive value for pancreatic necrosis secondary to bacterial infection. Serum amyloid A may more accurately signal the onset of tissue damage due to its increased pace and amplitude (14). However, the synergistic value of the aforementioned markers for prognostic prediction has not been systematically elucidated.

In this investigation, the dynamic changes in serum amyloid A, CRP, procalcitonin, and IFN-β2 levels in AP patients were prospectively analysed, and their relationships with prognostic outcomes, including organ failure, local complications, and mortality, were examined to provide an evidence-based basis for establishing a more efficient disease early warning model.

Materials and Methods

General information

Two hundred twenty-four AP patients admitted to our hospital between February 2022 and February 2024 were selected as research participants.

Inclusion criteria: (1) Those who meet the diagnostic criteria of the »Guidelines for the Diagnosis and Treatment of Acute Pancreatitis (2020)«; (2) Those accompanied by symptoms of varying degrees, such as abdominal pain, abdominal distension, and indi-

gestion; (3) Those with complete clinical data. Exclusion criteria: (1) Those with impaired function of vital organs; (2) Those with concurrent malignant tumours; (3) Those whose time from onset to admission is ≥48 hours.

All the selected patients were divided into a mild AP group (APACHE II score <8, 140 cases) and a severe AP group (APACHE II score ≥8, 84 cases) according to the Acute Physiology and Chronic Health Evaluation II (APACHE II) score. In the mild AP group, 82 males and 38 females were included. The ages ranged from 23 to 80 years, with an average of 52.50±7.86 years. The body mass index (BMI) ranged from 19 to 28 kg/m^2, with an average of 23.66±3.22 kg/m^2. There were 32 females and 52 males in the severe AP group. The age ranged from 24 to 78 years, with an average of 53.46±7.22 years. The average BMI was 23.46±3.03 kg/m^2, with a range of 19–28 kg/m^2. The two groups' general data showed no statistically significant difference (P>0.05).

Laboratory testing methods

Five millilitres of venous blood were drawn from patients with AP after they had fasted for more than 6 hours. The mixture was subsequently centrifuged at 3,000 r/min for 10 minutes with a 10 cm radius. The upper layer of serum was removed and stored at -80 °C until analysis. The levels of procalcitonin, IFN-β2, and serum amyloid A in patients with AP were determined using a quantum dot fluorescence immunoassay. CRP was determined by immunoscattering turbidimetry (the serum amyloid A kit was produced by Nanjing Novozyme Medical Technology Co., Ltd.; Jinwei Biomedical Engineering Co., Ltd., produced the procalcitonin and IFN-β2 kits; and Guangdong Pumen Biomedical Technology Co., Ltd. produced the CRP kit). Every operation listed above was carried out strictly in accordance with the reagent instructions.

Follow-up investigation and analysis

Every patient was monitored for 28 days to assess their prognosis and identify those with a poor prognosis. Poor prognosis was defined as respiratory insufficiency, hypocalcemia and death.

Statistical processing methods

The statistical program SPSS 22.0 was used to analyse the data. The χ^2 test was used to compare groups, and count data are presented as percentages or counts. For group comparisons, an independent-samples t-test was employed, and the measurement data are presented as $\bar{x}\pm s$ values. Using Spearman correlation, the relationships between the severity of AP and the levels of serum amyloid A, CRP, procalcitonin, and IFN-β2 were examined. Binary logistic regression was used to analyse multivariate data, and receiver operating characteristic (ROC) curves were used to assess predictive value. AUC values indicated superior predictive accuracy between 0.7 and 0.9, while good predictive accuracy was indicated by AUC values above 0.9.

Results

Comparison of the serum amyloid A, CRP, procalcitonin and IFN-β2 levels between the two groups

The levels of serum amyloid A, CRP, procalcitonin and IFN-β2 in the mild AP group were significantly lower than those in the severe AP group (P<0.05), as shown in *Table I*.

Patients with acute pancreatitis were divided into mild and severe groups based on the APACHE II score. Serum levels of inflammatory markers, including procalcitonin, C-reactive protein (CRP), serum amyloid A, and interferon-β2 (IFN-β2), were compared between the two patient groups. The findings showed that the moderate AP group's serum levels of serum amyloid A, CRP, procalcitonin, and IFN-β2 were much lower than those of the severe AP group, and that each index difference between the two

Table I Comparison of serum amyloid A, CRP, procalcitonin, and L-6 levels between two groups ($\bar{x}\pm s$).

Group	n	Serum amyloid A (mg/L)	Serum CRP (mg/L)	Serum procalcitonin (ng/mL)	Serum IFN-β2 (ng/L)
Mild AP group	140	342.50±80.29	45.20±13.30	1.85±0.32	12.49±3.16
Severe AP group	84	602.49±121.58	78.46±20.50	3.43±0.46	18.92±4.56
t		13.623	10.343	21.774	9.036
P		<0.001	<0.001	<0.001	<0.001

groups was statistically significant. Among AP patients with varying degrees of disease severity, there are significant differences in the expression levels of these key inflammatory markers. Patients with severe AP generally have higher levels of serum amyloid A, CRP, procalcitonin and IFN-β2, reflecting a more intense systemic inflammatory response.

Spearman correlation analysis

There was a favourable correlation between the severity of AP and the serum levels of amyloid A, CRP, procalcitonin, and IFN-β2, as well as the severity of the disease ($r=0.774$, 0.678, 0.830, 0.584; $P<0.05$).

To thoroughly assess the relationships between the severity of acute pancreatitis (AP) and the levels of serum amyloid A, C-reactive protein (CRP), procalcitonin, and interferon-β2 (IFN-β2), Spearman correlation analysis was employed. The analysis revealed that serum amyloid A, CRP, procalcitonin, and IFN-β2 were significantly positively correlated with the clinical severity of AP. These findings indicate that as levels of these inflammatory markers increase, the severity of the patient's disease intensifies, reflecting their crucial role in the pathological process of AP. This positive correlation further confirms that serum amyloid A, CRP, procalcitonin, and IFN-β2 can be used as reliable indicators of the intensity of the AP inflammatory response, and that changes in their levels can effectively reflect the progression of disease from mild to severe.

Comparison of prognosis between the two groups of patients

After a 28-day follow-up, among 224 AP patients, 64 (28.57%) had a poor prognosis, including 20 (8.93%) with respiratory insufficiency, 24 (10.71%) with hypocalcemia, and 20 (8.93%) who died. The severe AP group had a higher overall incidence of poor prognosis than the moderate AP group ($\chi^2=15.124$, $P<0.05$), as shown in *Table II*.

The risk of adverse prognosis in patients with severe acute pancreatitis was much greater than that in patients with mild acute pancreatitis, and the cumulative incidence of adverse prognosis was significantly greater. The specific manifestations of poor prognosis include multiple serious complications, such as respiratory insufficiency, hypocalcemia and death.

Table II Comparison of prognosis between two groups of patients [n (%)].

Group	n	Respiratory insufficiency	Hypocalcemia	Death	Total
Mild AP group	140	4 (2.86)	6 (4.28)	12 (8.57)	22 (15.71)
Severe AP group	84	16 (19.05)	18 (21.43)	8 (9.52)	42 (50.00)

Table III Univariate analysis of prognostic factors in AP patients [n (%) or $\bar{x}\pm s$].

Item	Poor prognosis group	Good prognosis group	χ^2/t	P
Gender			1.480	0.227
Male	44 (68.75)	90 (56.25)		
Female	20 (31.25)	70 (43.75)		
Age (years)	52.16±7.49	52.89±7.62	0.452	0.642
BMI (kg/m^2)	23.16±3.50	23.50±3.24	0.630	0.520
APACHEI score (points)	10.40±3.16	6.16±1.79	8.717	<0.001
Serum amyloid A (mg/L)	564.46±112.19	405.28±82.89	6.112	<0.001
CRP (mg/L)	92.19±13.20	74.56±11.23	6.930	<0.001
Procalcitonin (ng/mL)	3.46±0.82	2.19±0.69	6.590	<0.001
Il-6 (ng/L)	17.89±4.16	12.28±3.17	4.748	<0.001
Fatty liver	12 (18.75)	20 (12.50)	0.723	0.397
Hypertension	10 (15.63)	22 (13.75)	0.060	0.792
Ddiabetes	16 (25.00)	28 (17.50)	0.819	0.361

Table IV Logistic regression analysis of prognostic factors in AP patients.

Factor	β	SE	Wald	Degree of freedom	P	OR	95% CI	
							lower limit	upper limit
APACHE II rating	-0.806	0.199	17.146	1	<0.001	0.442	-0.806	0.198
Serum amyloid A	-0.015	0.008	8.920	1	0.007	0.983	-0.015	0.008
Serum CRP	-0.079	0.035	5.782	1	0.010	0.922	-0.079	0.035
Serum procalcitonin	-1.895	0.558	11.688	1	0.001	0.155	-1.895	0.557
Serum IFN-β2	-0.279	0.090	8.235	1	0.008	0.753	-0.279	0.090

Table V The predictive value of serum amyloid A, CRP, procalcitonin, and IFN-b2 levels for poor prognosis of acute pancreatitis.

Indicator	AUC	SE	P	95% CI		Truncation value	Sensitivity (%)	Specificity (%)	Yoden Index
				Lower limit	Upper limit				
Serum amyloid A	0.859	0.044	<0.001	0.772	0.937	502.119 mg/L	71.3	90.4	0.613
Serum CRP	0.851	0.045	<0.001	0.772	0.931	82.159 mg/L	84.8	77.9	0.613
Serum procalcitonin	0.811	0.048	<0.001	0.735	0.906	2.549 ng/mL	90.0	83.1	0.447
Serum IFN-β2	0.802	0.049	<0.001	0.724	0.891	13.834 ng/L	81.7	52.9	0.332

Prognostic factor univariate study in AP patients

According to univariate analysis, the poor-prognosis and favourable-prognosis groups did not differ significantly in sex, age, BMI, underlying disorders, etc. (P>0.05). Nonetheless, the bad-prognosis group had higher serum amyloid A, CRP, procalcitonin, and IFN-β2 levels, as well as a higher APACHE II score, than the good-prognosis group. P<0.05 indicated that the differences were statistically significant, as shown in *Table III*.

Logistic regression analysis of prognostic factors in AP patients

Using the APACHE II score and the prognosis of AP patients as the dependent variables (assignment: 0 = poor, 1 = good). Additionally, a binary logistic regression analysis was performed with serum amyloid A, CRP, procalcitonin, and IFN-β2 as independent variables. The findings showed that the poor prognosis of AP patients was influenced by the APACHE II score and serum levels of amyloid A, CRP, procalcitonin, and IFN-β2 (P<0.05), as shown in *Table IV*.

Predictive value of serum amyloid A, CRP, procalcitonin and IFN-β2 for poor prognosis in AP patients

The AUCs of the serum amyloid A, CRP, procalcitonin and IFN-β2 levels for the prediction of poor AP prognosis were 0.859, 0.851, 0.811 and 0.802, respectively, all of which had certain accuracy. The maximum cutoff point of the Youden index in the upper left corner of the ROC curve was used as the cutoff value (serum amyloid A was 502.119 mg/L, CRP was 82.159 mg/L, procalcitonin was 2.549 ng/mL, and IFN-β2 was 13.87 ng/L). The predictive sensitivity and specificity at this point were as follows: the predictive values of serum amyloid A were 71.3% and 90.4%, those of CRP were 84.8% and 77.9%, those of procalcitonin were 90.0% and 83.1%, and those of IFN-β2 were 81.7% and 52.9%. All of these values were good, as shown in *Table V*.

Discussion

Pancreatitis can present clinically as acute or chronic, but acute pancreatitis is more common (15). After its occurrence, it can be complicated by organ dysfunction and failure, seriously threatening the

patient's safety. AP is a common digestive system disease (16). Clinically, it can be classified into mild and severe cases based on the severity of the condition. Mild AP has mild clinical symptoms, mostly manifesting as intermittent or continuous upper abdominal pain, which can radiate to the waist and back (17). After treatment with water deprivation, acid and enzyme inhibition, etc., the patient's clinical symptoms gradually improve, and the prognosis is good. Severe AP involves extensive pancreatic necrosis and may lead to secondary infection. This further leads to multiple organ failure, shock and even death. The fatality rate of AP is approximately 10%, while the fatality rate of severe AP can reach over 50%, and it can be reduced to approximately 20% after early treatment (18–20). Therefore, after the diagnosis of AP, accurately assessing its severity and choosing effective treatment measures are key to improving its prognosis.

Macrophages, monocytes, etc, mainly secrete IFN-β2. An increase in its level can, on the one hand, promote differentiation and downregulate related inflammatory factors, thereby promoting neutrophil apoptosis and reducing inflammation in the body (21). On the other hand, it can cause immune dysfunction, leading to immunosuppression and damage to internal organs. Procalcitonin is mainly a glycoprotein secreted by cells (22). It has good stability and a very low content in normal organisms. However, under pathological or inflammatory conditions, it can be induced to be secreted by toxins, tumour necrosis factors, interleukins, etc., and its levels in body tissues increase significantly. Research reports (23–25) indicate that procalcitonin can serve as a sensitive marker of infection. Especially when hyperlipidemia is present, an increase in procalcitonin levels can compromise the body's defence mechanisms, allowing the infection to spread and affecting prognosis. Therefore, in this study, the differences in the expression of the above four indicators in the blood of patients with AP of different severities were selected for research, and their prognostic value was analysed (26). Analysis of the cause revealed that, after pancreatitis, bacterial infection often occurs (27). The levels of procalcitonin and serum amyloid A in AP patients increase, and the more severe the condition, the greater the increase (28–30). The pathological manifestation of AP is the activation of the mononuclear macrophage system in pancreatic tissue, thus leading to rapid increases in CRP and IFN-β2 levels in the blood. Previous studies (31–34) have shown that CRP levels in patients with pancreatitis are significantly positively correlated with their condition. CRP >150 mg/L 72 hours after disease onset suggests pancreatic tissue necrosis. If IFN-β2 also shows a dynamic and continuous increase, it indicates a poor prognosis. Studies (35–37) have shown that IFN-β2-induced activation and secretion of the peripheral blood mononuclear cell system are important drivers of the progression of AP and infectious multiple organ failure.

Conclusion

Serum amyloid A, CRP, procalcitonin, and IFN-β2 levels have substantial prognostic value for AP patients and are positively associated with the severity of AP. The study's limitations include a limited sample size and the failure to monitor and track the long-term prognosis of AP patients. Moreover, CRP levels may be associated with a patient's BMI and age. However, interfering factors were not excluded in this study, which may have introduced a degree of bias into the research results. Therefore, large-sample, long-term follow-up, and strict quality-control studies are needed for verification.

Authors' contribution

Naibo Yu and Ruxia Han contributed equally to this research

Conflict of interest statement

All the authors declare that they have no conflict of interest in this work.

References

1. Siriwardena AK, Jegatheeswaran S, Mason JM; PROCAP investigators. A procalcitonin-based algorithm to guide antibiotic use in patients with acute pancreatitis (PROCAP): a single-center, patient-blinded, randomised controlled trial. Lancet Gastroenterol Hepatol 2022 Oct; 7(10): 913–21. doi: 10.1016/S2468-1253(22)00212-6. Epub 2022 Jul 19. PMID: 35863358.
2. Song Y, Lee SH. Recent Treatment Strategies for Acute Pancreatitis. J Clin Med 2024 Feb 8; 13(4): 978. doi: 10.3390/jcm13040978. PMID: 38398290; PMCID: PMC10889262.
3. Shuanglian Y, Huiling Z, Xunting L, Yifang D, Yufen L, Shanshan X, Lijuan S, Yunpeng L. Establishment and validation of early prediction model for hypertriglyceridemic severe acute pancreatitis. Lipids Health Dis 2023 Dec 8; 22(1): 218. doi: 10.1186/s12944-023-01984-z. PMID: 38066493; PMCID: PMC10709974.
4. Tarján D, Szalai E, Lipp M, Verbói M, Kói T, Er ss B, Teutsch B, Faluhelyi N, Hegyi P, Mikó A. Persistently High Procalcitonin and C-Reactive Protein Are Good Predictors of Infection in Acute Necrotizing Pancreatitis: A Systematic Review and Meta-Analysis. Int J Mol Sci 2024

Jan 20; 25(2): 1273. doi: 10.3390/ijms25021273. PMID: 38279274; PMCID: PMC10816999.

5. Yin Y, Wei N, Zheng Z, Liang H. Relationship between apoA-I, chemerin, Procalcitonin and severity of hyperlipidemia-induced acute pancreatitis. J Pak Med Assoc 2022 Jun; 72(6): 1201–4. doi: 10.47391/JPMA.3700. PMID: 35751336.

6. Alberti P, Pando E, Mata R, Cirera A, Fernandes N, Hidalgo N, Gomez-Jurado MJ, Vidal L, Dopazo C, Blanco L, Gómez C, Caralt M, Balsells J, Charco R. The role of procalcitonin as a prognostic factor for acute cholangitis and infections in acute pancreatitis: a prospective cohort study from a European single center. HPB (Oxford) 2022 Jun; 24(6): 875–84. doi: 10.1016/j.hpb.2021.10.016. Epub 2021 Nov 1. PMID: 34802942.

7. Ugurlu ET, Yurekli UF. The effect of procalcitonin and immature granulocyte ratio in predicting the development of acute necrotising pancreatitis: evidence from 582 cases. Eur Rev Med Pharmacol Sci 2022 Oct; 26(20): 7514–21. doi: 10.26355/eurrev_202210_30022. PMID: 36314322.

8. He Q, Ding J, He S, Yu Y, Chen X, Li D, Chen F. The predictive value of procalcitonin combined with C-reactive protein and D dimer in moderately severe and severe acute pancreatitis. Eur J Gastroenterol Hepatol 2022 Jul 1; 34(7): 744–50. doi: 10.1097/MEG.0000000000002376. Epub 2022 Apr 5. PMID: 35412505; PMCID: PMC9148668.

9. Cho IR, Do MY, Han SY, Jang SI, Cho JH. Comparison of Interleukin-6, C-Reactive Protein, Procalcitonin, and the Computed Tomography Severity Index for Early Prediction of Severity of Acute Pancreatitis. Gut Liver 2023 Jul 15; 17(4): 629–37. doi: 10.5009/gnl220356. Epub 2023 Feb 15. PMID: 36789576; PMCID: PMC10352050.

10. Zhou H, Li W, Yang S, Yang H, Cai Y. Prediction of acute pancreatitis severity using NLR, procalcitonin, and CT severity score: A retrospective study. Medicine (Baltimore) 2025 Jul 4; 104(27): e43055. doi: 10.1097/MD.0000000000043055. PMID: 40629608; PMCID: PMC12237365.

11. Padula D, Mauro A, Maggioni P, Kurihara H, Di Sabatino A, Anderloni A. Practical approach to acute pancreatitis: from diagnosis to the management of complications. Intern Emerg Med 2024 Nov; 19(8): 2091–104. doi: 10.1007/s11739-024-03666-9. Epub 2024 Jun 8. PMID: 38850357.

12. Wu L, Zheng Y, Liu J, Luo R, Wu D, Xu P, Wu D, Li X. Comprehensive evaluation of the efficacy and safety of LPV/r drugs in the treatment of SARS and MERS to provide potential treatment options for COVID-19. Aging (Albany NY) 2021 Apr 20; 13(8): 10833–52. doi: 10.18632/aging.202860. Epub 2021 Apr 20. PMID: 33879634; PMCID: PMC8109137.

13. Ebik B, Kacmaz H, Tuncel ET, Arpa M, Ucmak F, Kaya M. What does the Procalcitonin Level Tell us in Patients with Acute Pancreatitis? J Coll Physicians Surg Pak 2022 Oct; 32(10): 1272–7. doi: 10.29271/jcpsp.2022.10.1272. PMID: 36205270.

14. Zhu QY, Li RM, Zhu YP, Hao DL, Liu Y, Yu J, Yang X, Zhang YS, Lin TJ, Yan X, Zuo JX, Pan XT. Early Predictors of Infected Pancreatic Necrosis in Severe Acute Pancreatitis: Implications of Neutrophil to Lymphocyte Ratio, Blood Procalcitonin Concentration, and Modified CT Severity Index. Dig Dis 2023; 41(4): 677–84. doi: 10.1159/000529366. Epub 2023 Mar 30. PMID: 36996800.

15. Mann BK, Bhandohal JS, Kalha I, Fox K, Jean B. Relevance of Procalcitonin Levels as a Marker of Severity and Predictor of Mortality, Initiation and Duration of Antibiotics in Patients Admitted with Acute Pancreatitis: A Retrospective Cohort Study. Clin Exp Gastroenterol 2024 Feb 9; 17: 31–9. doi: 10.2147/CEG.S453345. PMID: 38352170; PMCID: PMC10863456.

16. Wu L, Zhong Y, Wu D, Xu P, Ruan X, Yan J, Liu J, Li X. Immunomodulatory Factor TIM3 of Cytolytic Active Genes Affected the Survival and Prognosis of Lung Adenocarcinoma Patients by Multi-Omics Analysis. Biomedicines 2022 Sep 10; 10(9): 2248. doi: 10.3390/biomedicines10092248. PMID: 36140350; PMCID: PMC9496572.

17. Jakkampudi A, Sarkar P, Unnisa M, Patil A, Koutarapu C, Jaggaiahgari S, Naik P, Sarkar S, Prasanna A, Chintaluri S, Reddy DN, Beedu SR, Talukdar R. Kynurenine pathway alteration in acute pancreatitis and its role as a biomarker of infected necrosis. Pancreatology 2023 Sep; 23(6): 589–600. doi: 10.1016/j.pan.2023.07.003. Epub 2023 Jul 5. PMID: 37438173.

18. Mir BA, Majeed T, Chauhan A. Procalcitonin-guided use of antibiotics in acute pancreatitis. Lancet Gastroenterol Hepatol 2022 Dec; 7(12): 1073. doi: 10.1016/S2468-1253(22)00271-0. PMID: 36370735.

19. Samanta J, Dhar J. Procalcitonin-guided use of antibiotics in acute pancreatitis. Lancet Gastroenterol Hepatol 2022 Dec; (12): 1073–4. doi: 10.1016/S2468-1253(22)00272-2. PMID: 36370734.

20. Wu L, Liu Q, Ruan X, Luan X, Zhong Y, Liu J, Yan J, Li X. Multiple Omics Analysis of the Role of RBM10 Gene Instability in Immune Regulation and Drug Sensitivity in Patients with Lung Adenocarcinoma (LUAD). Biomedicines 2023 Jun 29; 11(7): 1861. doi: 10.3390/biomedicines11071861. PMID: 37509501; PMCID: PMC10377220.

21. Badia JM, Amador S, González-Sánchez C, Rubio-Pérez I, Manuel-Vázquez A, Juvany M, Membrilla E, Balibrea JM, Guirao X. Appropriate Use of Antibiotics in Acute Pancreatitis: A Scoping Review. Antibiotics (Basel) 2024 Sep 18; 13(9): 894. doi: 10.3390/antibiotics13090894. PMID: 39335067; PMCID: PMC11428601.

22. Akarsu C, Karabulut M, Aydin H, Sahbaz NA, Dural AC, Yegul D, Peker KD, Ferahman S, Bulut S, Dönmez T, Asar S, Yasar KK, Adas GT. Association between Acute Pancreatitis and COVID-19: Could Pancreatitis Be the Missing Piece of the Puzzle about Increased Mortality Rates? J Invest Surg 2022 Jan; 35(1): 119–25. doi: 10.1080/08941939.2020.1833263. Epub 2020 Nov 2. PMID: 33138658.

23. Wu L, Zheng Y, Ruan X, Wu D, Xu P, Liu J, Wu D, Li X. Long-chain noncoding ribonucleic acids affect the survival and prognosis of patients with esophageal adeno-

carcinoma through the autophagy pathway: construction of a prognostic model. Anticancer Drugs 2022 Jan 1; 33(1): e590–e603. doi: 10.1097/CAD.0000000000001189. PMID: 34338240; PMCID: PMC8670349.

24. Ning F, Han X, Fan M, Tian X, Wen H, Yan X, Gao M, Li X. Arterial partial pressure of oxygen and procalcitonin combined with ROX index predict the timing of tracheal intubation in patients with acute severe pancreatitis. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 2023 Jul; 35(7): 752–6. Chinese. doi: 10.3760/cma.j.cn121430-20230314-00173. PMID: 37545455.
25. Capurso G, de-Madaria E. Procalcitonin-guided reduction of antibiotic use in acute pancreatitis. Lancet Gastroenterol Hepatol 2022 Oct; 7(10): 896–7. doi: 10.1016/S2468-1253(22)00231-X. Epub 2022 Jul 19. PMID: 35863359.
26. Li B, Wu W, Liu A, Feng L, Li B, Mei Y, Tan L, Zhang C, Tian Y. Establishment and Validation of a Nomogram Prediction Model for the Severe Acute Pancreatitis. J Inflamm Res 2023 Jul 8; 16:2 831–2843. doi: 10.2147/JIR.S416411. PMID: 37449283; PMCID: PMC10337691.
27. Ramirez-Gonzalez LR, Ordonez-Forestiery LR, Garcia A, Iniguez-Martin-Del-Campo MC, Llamas-Hernandez FD, Morfin-Meza KD, Gonzalez-Munoz SE, Capetillo-Texson CE, Gomez-Sierra JP, Suarez-Carreon LO, Cervantes-Guevara G, Cervantes-Perez E, Ramirez-Ochoa S, Alvarez-Villasenor AS, Cortes-Flores AO, Gonzalez-Ojeda A, Fuentes-Orozco C. Procalcitonin as a Predictor of Mortality in Patients With Severe Acute Pancreatitis. Gastroenterology Res 2025 Apr; 18(2): 56–62. doi: 10.14740/gr2029. Epub 2025 Apr 20. PMID: 40322192; PMCID: PMC12045753.
28. Wu L, Zhong Y, Yu X, Wu D, Xu P, Lv L, Ruan X, Liu Q, Feng Y, Liu J, Li X. Selective poly adenylation predicts the efficacy of immunotherapy in patients with lung adenocarcinoma by multiple omics research. Anticancer Drugs 2022 Oct 1; 33(9): 943–59. doi: 10.1097/CAD.0000000000001319. Epub 2022 Aug 9. PMID: 35946526; PMCID: PMC9481295.
29. Chen L, Jiang J. The Diagnostic Value of Procalcitonin in Patients with Severe Acute Pancreatitis: A Meta-Analysis. Turk J Gastroenterol 2022 Sep; 33(9): 722–30. doi: 10.5152/tjg.2022.22098. PMID: 36134549; PMCID: PMC9524488.
30. Wollny T, Wątek M, Wnorowska U, Piktel E, Góźd S, Kurek K, Wolak P, Król G, Żendzian-Piotrowska M, Bucki R. Hypogelsolinemia and Decrease in Blood Plasma Sphingosine-1-Phosphate in Patients Diagnosed with Severe Acute Pancreatitis. Dig Dis Sci 2022 Feb; 67(2): 536–45. doi: 10.1007/s10620-021-06865-y. Epub 2021 Feb 23. PMID: 33620599; PMCID: PMC8885474.
31. Lin C, Li J, Liu B, Hong X, Luo T, Ye J, Yu Y, Peng X, Gou S, Tang H, Yuan T, Luo J, Yang M, Feng B, Zhao Z, Ning C, Sun Z, Zhu S, Chen L, Shen D, Huang G. Metagenomic next-generation sequencing, instead of procalcitonin, could guide antibiotic usage in patients with febrile acute necrotising pancreatitis: a multicenter, prospective cohort study. Int J Surg 2024 May 1; 110(5): 2721–9. doi: 10.1097/JS9.0000000000001162. PMID: 38348834; PMCID: PMC11093443.
32. Wu L, Li H, Liu Y, Fan Z, Xu J, Li N, Qian X, Lin Z, Li X, Yan J. Research progress of 3D-bioprinted functional pancreas and in vitro tumor models. International Journal of Bioprinting 2024, 10(1), 1256. doi: 10.36922/ijb.1256.
33. Li X, Zhang Y, Wang W, Meng Y, Chen H, Chu G, Li H, Qi X. An inflammation-based model for identifying severe acute pancreatitis: a single-center retrospective study. BMC Gastroenterol 2024 Feb 5; 24(1): 63. doi: 10.1186/s12876-024-03148-4. PMID: 38317108; PMCID: PMC10840143.
34. Kong D, Lei Z, Wang Z, Yu M, Li J, Chai W, Zhao X. A novel HCP (heparin-binding protein-C reactive protein-procalcitonin) inflammatory composite model can predict severe acute pancreatitis. Sci Rep. 2023 Jun 9; 13(1): 9440. doi: 10.1038/s41598-023-36552-z. PMID: 37296194; PMCID: PMC10256784.
35. Liu D, Ding Y, Wang Y, Huang B, Li F, Cao F, Li J. Clinical Characteristics and Outcomes of Hypertriglyceridemic Acute Pancreatitis Concomitant with Diabetic Ketoacidosis. Dig Dis Sci 2025 Jul 29. doi: 10.1007/s10620-025-09246-x. Epub ahead of print. PMID: 40728594.
36. Zhang H, Li L, Wu J, Xu W, Wu J. Enteral Nutrition Preparations for Blood Glucose Variability and Prognosis for Severe Acute Pancreatitis with Stress Hyperglycemia. Altern Ther Health Med 2023 Jan; 29(1): 163–9. PMID: 36074968.
37. Yu Z, Ni Q, Zhang P, Jia H, Yang F, Gao H, Zhu H, Liu F, Zhou X, Chang H, Lu J. Clinical utility of the pancreatitis activity scoring system in severe acute pancreatitis. Front Physiol 2022 Aug 22; 13: 935329. doi: 10.3389/fphys.2022.935329. PMID: 36072851; PMCID: PMC9441599.

Received: October 23, 2025
Accepted: December 12, 2025